# UAS to Support Airport Safety and Operations: Opportunities and Challenges

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UAS to Support Airport Safety and Operations: Opportunities and Challenges

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Abstract

The promulgation of Part 107 rules in June 2016 by Federal Aviation Administration (FAA) reduces the administrative burden for using unmanned aerial systems (UAS) and provides enhanced opportunities to utilize UAS in a variety of capacities. Previous studies such as the Airport Cooperative Research Program (ACRP) UAS primer have examined the framework for serving UAS as an aeronautical user, and there are anecdotal case studies that present the use of UAS for selected application, however, there has been limited documentation of the opportunities and challenges for the use of UAS for airport activities on airport property. This paper presents potential opportunities for the use of small UAS to enhance safety and operations in the airport environment, and identifies the issues that will need to be addressed.

Keywords: airport operations, UAS, Part 107, drone, UAV
UAS to Support Airport Safety and Operations: Opportunities and Challenges

Unmanned aerial systems (UAS) are currently used in agriculture, real estate, construction and utilities for surveying, photo and videos, and inspection. In June 2016, Federal Aviation Administration (FAA) published the new Small UAS Rule, aka Part 107, effective August 29, 2016. These rules create a framework for licensure and operation of UAS by designation of a certification process and responsibilities for the remote pilot in command (PIC). Since small UAS include all unmanned aircraft under 55 pounds, the impact of this regulation is significant. Activities that would have previously required an exemption by FAA can now be undertaken by a certified remote PIC, and it is expected that the resulting opportunities will translate to more than 100,000 new jobs and $82B in the next decade (Federal Aviation Administration 2016a).

While there has been documentation related to the use of UAS at airports, it has typically addressed issues related to operational issues regarding the integration of larger UAS at airports (Neubauer 2015) and airspace considerations (Borener 2015; Federal Aviation Administration 2015; Maddox 2015; Park 2013). Selected airports, such as Fallon Airport and Silver Springs Airport in Nevada, have even developed master planning projections that incorporate UAS in aeronautical user activity (Worrells 2015). Other airports have included physical facilities for UAS, including Purdue Airport in Indiana, which has a UAS runway in the master plan, and Eastern Oregon Regional Airport, which considers UAS requirements for both airside and landside needs for UAS, with UAS needs identified by group 1 (up to 20 lbs) through 5 (more than 1320 lbs) (Century West Engineering Corporation 2015). In contrast, this paper focuses on the use of small UAS for airport activities, such as those conducted by the airport sponsor, airport tenants, and airport contractors. The objective of this paper is to identify opportunities to
use UAS at airports, as well as challenges that may need to be addressed for successful integration.

**Opportunities for Using UAS at Airports**

Opportunities to utilize UAS at airports include obstruction analysis, pavement condition assessment and inspection, airfield light inspections, wildlife management, security, emergency response and construction.

**Obstruction Analysis**

Maintenance of an obstacle free path for take-offs and approaches is critical for safety and mandated in Federal Aviation Regulation (FAR) Part 77. Part 77 defines imaginary surfaces which must be clear of possible hazards and requires that airports map these surfaces as part of the airport layout plan (ALP) and identify potential hazards due to vegetation growth, construction or other changes nearby. Traditional obstruction analysis uses conventional aircraft photography and ground based surveying equipment, which is expensive due to the specialized equipment and expertise required.

Obstruction analysis utilizing UAS may reduce costs as well as turnaround time, based on the successful demonstration by users such as the South Carolina Aeronautics Commission (SCAC) (Stephens 2016; Garvey 2016). Safety inspections for obstacles on the runway approach may be based on rudimentary methods such a visual check using an Abney level and clinometer, and are typically completed on a periodic basis for compliance with Part 139 requirements at certified airports per specification in Advisory Circular 150/5200-18 (Federal Aviation Administration 2004). If there is an obstacle, then an aerial mapping survey may be conducted, which typically costs $8,000 to $10,000 per runway using traditional aircraft. For an airport with a primary runway and a crosswind runway, the cost to map four approaches may be
$75,000. This one-time expense exceeds the cost of a fixed wing UAS and mapping software; South Carolina used a SenseFlyEBee RTK and ArcGIS (total cost approximately $50,000) to conduct obstacle mapping at numerous airports in their jurisdiction (Garvey 2016). It would also be possible to conduct obstacle mapping with a lower cost system. A quadcopter with geocoding capabilities and mapping through an internet based service would be an inexpensive alternative if a limited number of maps are required and if the maps do not require frequent revisions; this could be accomplished for a couple thousand dollars.

The precision of data collected by UAS would be adequate to meet many airport needs. Garvey (2016) reports precision of 4 inches horizontally and 6 inches vertically, which is generally consistent but slightly higher than manufacturer claims (e.g., 1.2 inch without ground control points (senseFly n.d.) and Siebert and Teizer (2014) reported applications of 0.4 inches horizontally and 1.0 inch vertically.

Data collected by UAS could be used not only for obstacle mapping and airport surveying but also to support instrument approach procedures. The imagery and data would be accepted by the FAA Office of Airports as long as it meets the criteria in the appropriate Advisory Circular (AC), including AC 120-91 for Airport Obstacle Analysis (Federal Aviation Administration 2006), AC 150/5300-17 (Federal Aviation Administration 2011) for remote sensing technologies, and AC 150/5300-18 for aeronautical surveys. The required accuracies (e.g., pixel resolution and scale specified in AC 150/5300-17) are attainable, however, the recommended flying heights that are specified relate to conventional aircraft rather than UAS (e.g., the lowest flying height is 1800 ft). UAS could be used to collect geospatial airport and aeronautical data per AC 150/5300-18 for airport surveying (Federal Aviation Administration, 2009b), as long as the image overlap and sidelap support stereo imagery per the required
standards. Meeting the technical standards using data collected by UAS may be less burdensome than the operational and regulatory hurdles related to collecting the data with UAS at airports in Class B, C, D and E airspace.

It is possible to work through the operational and regulatory issues of using UAS at airports, as demonstrated by South Carolina’s successful collaboration with managers from the FAA Southern Region, the Airports District Office, NextGen and the UAS Program (South Carolina Aeronautics Commission Recognized with Most Innovative State Award 2016). The resulting cost savings due to the use of UAS allow increased frequency of inspections and assure that information is kept up to date (Stephens 2016). General aviation (GA) airports often cannot afford full scale traditional aerial mapping, and data often becomes outdated between updates due to the significant expense. The use of UAS allows mapping and the associated obstruction assessment to be completed in a single day, which facilitates compliance with grant assurances and airport data master record compliance (through form 5010). SCAC estimates that the investment in UAS equipment and software will be recovered after completing five airports, so the system will recover its cost in less than one year (Stephens 2016). The cost effectiveness for UAS for obstruction analysis may be most compelling for a state agency that regulates many airports, or for an airport authority with multiple airports under its authority. The cost effectiveness for UAS may also be compelling if the UAS is used for other applications, as discussed in later sections.

Advantages of UAS to document airport obstructions is not only less expensive, but is also faster and in many cases more precise. With standard data collection, it may be weeks until the data is available and the conventional inspection process using conventional survey equipment may have data entry errors, reduced accuracy at longer distances, and limited data
collection beyond the trees that are visible from the runway end. Use of a UAS and supporting GIS software allows an airport to conduct the inspection, process the data in-house, validate the data using software tools, and use the obstruction profiles and maps in a GIS format that can be accessed through internet applications and exported into other compatible programs (e.g., the 3D map can be accessed via ArcMap and exported to AutoCad). In this regard, the use of a UAS may not just provide a more cost effective solution, but also may allow an airport to have a more robust tool for a variety of uses.

As the UAS industry matures and airport applications become more common, it is likely that UAS will replace conventional aircraft for the outsourcing of obstacle mapping and aerial surveys, and the cost to use contractors to provide aerial surveys will decrease accordingly.

**Pavement Condition and Inspections**

Pavement condition inspections are an important component of a pavement management program and help airports maximize the lifetime and minimize lifecycle costs of pavements. Using conventional pavement condition assessment methods, the runway or taxiway is closed to allow a visual inspection for signs of distress, including deterioration such as cracking (e.g., alligator, block, edge), raveling, rutting, settlement, bleeding, and potholes in asphalt (Asphalt Institute 2016) and cracking (e.g., corner, longitudinal, transverse), joint damage and failure, scaling and other surface defects, and blow-ups in concrete (Miller 2003). During a traditional pavement inspection, inspectors walk over the pavement and identify visible distress within each designated pavement area. Many airports use the pavement condition index (PCI) (ASTM 2012) value, which is assigned based on the distress types, severity and quantity.

Inspection requirements vary depending on airport certification, as well as the pavement management system used, the condition level and rate of deterioration of the pavement. The AC
for the Airport Pavement Management Program (PMP) says there should be annual detailed inspections, and less comprehensive daily, weekly and monthly inspections. If the PCI is used, then the condition inspection interval can be extended until three years (Federal Aviation Administration 2014a). While reducing the inspection interval reduces disruption to airport operations, it may not support the early identification of problems and the associated preventative maintenance, which is important to minimize lifecycle costs. For this reason, a more frequent inspection interval is desirable; the opportunity for a more frequent and less disruptive inspection using a UAS would be beneficial.

Benefits of UAS for pavement condition assessment and inspections include availability of high-resolution photographs that can be used for documentation of pavement condition and development of pavement asset management program. Imaging can be integrated with airport GIS programs and used for documentation of pavement changes over time. The use of high-resolution photographs and advanced image processing that is facilitated by data collected by UAS has been demonstrated to be useful in pavement infrastructure monitoring in other modes, (Koch 2015) (Schnebele 2015) and there are a number of methods that have been developed to provide image processing for condition assessment based on high-resolution photos. In recent years, condition assessment and defect detection have become an essential tool, and build on a variety of techniques including template matching, background subtraction, filtering, edge and boundary detection, region growing, and texture recognition (Koch 2015). Condition assessment can also be enhanced by the use of other remote sensing technologies mounted on a UAS (Schnebele 2015). Remote sensing technologies include laser scanners (including LIDAR), ground penetrating radar (GPR), thermal imaging, and acoustics (Schnebele 2015).
UAS provides one platform by which pavement images data can be taken. It would also be appropriate to consider use of an unmanned ground system (UGS) for pavement assessment. Such a system may provide many of the advantages of a UAS (e.g., autonomous and provide advanced imaging), with the added benefit that it does not require permission to use the airspace in an airport environment. For pavement condition assessment, most conventional ground based systems utilize a vehicle with a driver; these systems are typically fairly expensive, and airports tend to contract out rather than self-perform this function. While a UGS does provide simplification with respect to airspace considerations, UAS provide an advantage because the images can be collected from a height of 20 to 25 feet, and the higher vantage point provides a broader field of view requiring fewer passes and a shorter runway closure time than a traditional runway inspection. This minimizes disruption and the costs associated with temporary closure.

UAS pavement condition assessment has been used at airports in Germany (Hamburg Finkenwerder, EDHI) and France (Charles de Gaulle, CDG). An inspection of the runway for pavement condition via UAS can be completed in 30 minutes, using three runs of 10 minutes eliminates the need for runway and taxiway closure; an analogous inspection via conventional methods may require 6 to 8 hours (Airsight). The primary constraint for the use of UAS for pavement inspections is not the technology to conduct the inspection since automated inspection of pavement cracks is proven technology, but obtaining approval to do so within aviation regulations.

UAS and UGS can also be used for regular pavement inspections such as daily inspections for foreign object debris (FOD). UGS systems for FOD detection have been demonstrated from a technical perspective and are theoretically cost-effective (Ozturk and Kuzucuoglu 2016), however, they are not widely utilized. FOD detection via imaging does
provide potential advantages due to the elimination of errors associated with visual inspection, and imaging techniques using stationary cameras such as gigapixel panoramas have been proposed and tested (Heymsfield and Kuss 2014). Traditional automated FOD detection is based on radar (stationary and mobile), stationary electro-optical, and stationary hybrid radar and electro-optical (Federal Aviation Administration 2009a). These automated systems provide continuous monitoring but are expensive. UAS systems for FOD inspection are potentially a much more cost effective and flexible system. One potential limitation of UAS systems for FOD inspection is that if FOD is identified, personnel still need to be dispatched to remove the FOD.

Airfield Light Inspections

UAS may also be used to conduct light inspections to confirm airfield lighting is operational and adequate to ensure visibility, safety, and compliance with FAA and International Civil Aviation Organization (ICAO) standards. Daily inspections at twilight or night each day confirm that lights are operational, and periodic inspections (e.g., monthly) confirm that intensity is adequate (Federal Aviation Administration 2014b). Light intensity may diminish due to a variety of factors, including the results of aging, dust and dirt, and rubber deposits from aircraft braking. In current practice, photometric measuring devices are typically mounted on a vehicle, which drives the airfield and measures the lumens given off by airfield lights. One advantage of a system on a UAS is that it could easily be flown at different heights, eliminating the need to physically change the height of the vehicle-mounted photometric calibration equipment, in many cases, a time consuming process.

Wildlife Management

In the aviation industry, wildlife strikes occur 26 times per day and cause $950 M of damage per year in the US, and $1.3 B worldwide (Begier 2014). Every airport certified under
Part 139 is required to have a wildlife hazard mitigation program, so wildlife control is now a core component of airport operations. Wildlife control activities include identification of species present at the airport, identification of habitats and food sources that may attract wildlife, and identification and implementation of appropriate control methods including lethal and non-lethal means to remove wildlife from the airport. While a significant component of wildlife management is focused on birds because birds comprise 97% of reported strikes (Dolbeer 2015), other wildlife must also be considered. The integrity of the airport perimeter is typically maintained using a chain-linked fence which not only ensures security as discussed in the next section, but also supports wildlife management by excluding larger animals such as deer.

Potential applications for UAS to support wildlife management activities at airports are extensive. These applications include identification of nests and burrows, habitat evaluations, identification of nuisance wildlife, wildlife tracking and capturing wildlife, obtaining prey abundance indices, determining the age of birds so they can be relocated at the optimal time to reduce the need for fostering, wildlife attractant quality assessments, wildlife hazing and wildlife harassment without an audible deterrent. The US Geological Society (USGS) has used UAS to survey wildlife habitats (Toscano 2014) because UAS provide numerous advantages including safety for wildlife biologists, better data and imagery, ability to access locations inaccessible from the ground, documentation of ground cover (Bird 2014). One wildlife management pilot study found that a UAS survey was able to identify substantially more nests than a ground count (Bird 2014). Identification and removal of nesting sites is an important component of an airport wildlife management plan. Another potential application is UAS imaging of species to confirm identification by wildlife experts that are offsite since allowable mitigation activities vary depending on the species.
UAS may also house powerful sonic devices or may be disguised as a predator to discourage birds on airfields. Pyrotechnic recordings mounted on UAS may provide an excellent opportunity for cost savings. Airports spend many thousands of dollars on pyrotechnic devices, and a single pyrotechnic shell may cost $10 (Oppmann 2009) or more. UAS have also successfully been used to physically dissuade birds from an area. The most successful mitigation strategy varies depending on the species, due to both considerations of both regulations and effectiveness. Some kinds of birds require special permits from federal, state and even local agencies. For example, airports require a special permit to discourage or hunt migratory birds with a UAS not only in the United States, but also in Canada, Mexico, Japan and Russia, due to the provisions of the Migratory Bird Treaty Act (U.S. Fish and Wildlife Services 2015). Bird species that are not protected by federal regulations, such as European starlings and rock pigeons, could be harassed with fewer constraints, and may only require authorization from state agencies.

UAS may also be useful to track individual wildlife, including birds or animals, such as deer or coyotes. Although mammal incidents are less common, they are more likely to result in aircraft damage: land mammals represent only 2.3% of incidents, but cause damage in 59% of the incidents; bird incidents cause damage in 13% of the incidents (Dolbeer, Wright, Weller, and Begier 2012). In some cases, airport operations personnel report challenges finding an animal known to be on airport property. The aerial vantage point provided by a UAS may make this task easier, especially when combined with infrared (IR) imaging technology. UAS manufacturers are increasingly including IR as an optional component that can be purchased. For example, DJI includes a FLIR IR system as an option on a number of quadcopter UAS, and senseFly includes an IR system for hybrid UAS (fixed wing UAS with vertical takeoff and
landing (VTOL). Quadcopter systems are less expensive, however, hybrid UAS have longer ranges and higher speeds. The cost of IR systems vary; $5,000 to $6,000 may be a reasonable value for an IR unit and the mounting equipment for planning purposes. For an IR equipped UAS, the total system cost may be $8,000 to $10,000. Costs would be higher for IR units that are able to discern smaller differences.

The use and characteristics of UAS in wildlife monitoring has been documented previously (Linchant, Lisein, Semeki, Lejeune and Vermeulen 2015), although the focus has not been utilization in the airport environment. In addition to UAS, there are also potential applications for unmanned water systems (UWS), particularly for airports adjacent to large bodies of water. UWS and UAS over water offer a potential mitigation tool to manage waterfowl. Waterfowl have been the focus of numerous wildlife surveys using UAS, since UAS provide access to habitats that are otherwise difficult to access (Chabot and Bird 2015). UAS may also be useful to test and calibrate wildlife detection systems used at airports. Automated bird detection systems may utilize radar and/or infrared technologies (Carter 2016). UAS may be used to test and calibrate aviation radar, as demonstrated at Sea-Tac (SEA) Airport in 2011 (Brand et al. 2011).

UAS have been utilized for wildlife management at selected airports, including Southern Illinois Airport in Murphysboro (MDH) (Brewster 2016) and Salina Regional Airport (SLN) in Kansas (Toscano 2014).

Security

Aviation security is an important activity and the Transportation Security Administration (TSA) is responsible for security at all airports, providing security regulations at certified airports and security guidance at general aviation (GA) airports. Security at individual airports is
important to support national airport security, since even the smallest airport provides access to the national airspace and the larger airport system. One important factor for aviation security is airport perimeter security, and a recent report from the Government Accountability Office (GAO) identified airport perimeter security as a potential vulnerability with an average of 2,500 incidents of unauthorized per year from 2009 to 2015 due to breeches of the airport perimeter and airport access points (Marsh 2016). According to Rep. William Keating from Massachusetts, "The intense scrutiny placed at checkpoints in airports, but not on the perimeter, is the equivalent of locking your home's doors while leaving your windows wide open. The GAO found that in many instances, the windows are open at our airports." (Marsh 2016).

While some of the 2,500 annual breeches would not be addressed by increased perimeter security since they are due to workers exploiting their credentials (US Government Accountability Office 2016), UAS can facilitate fence and gate lock inspections, and may supplement other security measures through perimeter checks at random times throughout the day. Any increase in efficiency for inspections could have a significant annual impact since even a small hub airport may be required to do as many as six inspections a day.

Since many airports have extensive acreage and boundaries may be far from active runways and over area that is not populated, UAS may be an appropriate tool to increase security with minimal risk or impact on aeronautical activity. Advantages of UAS for perimeter security include ability to traverse challenging terrain quickly, surveillance at a faster speed than would be possible on foot, and surveillance of areas not accessible by vehicle. There may also be opportunities for UGS to provide perimeter checks, without requiring airspace approval.

UAS have also been deployed to support airport security by enhancing surveillance and response capabilities. UAS are used for surveillance at numerous airports in England including
Heathrow (LHR), Stansted (STN), Luton (LTN) and Gatwick (LGW) (Beake 2015), as well as Israel (TLV).

Deployments in England occurred after a year and a half of successful use and testing at Gatwick Airport (Beake 2015). The National Counter Terrorism Policing Headquarters noted that UAS can carry out missions seven times faster and at one-tenth the cost of ground based activities, reducing the number of officers needed for patrols and saving £1.2m ($1.5m USD) in three years (Beake 2015). The Aeryon SkyRanger has been used at Gatwick since 2014, and was approved for use by the FAA for enforcement activities by the Michigan State Police. The State Police aviation unit purchased a SkyRanger in 2013 for $158,000 in September 2013 (Greenwood 2015). The SkyRanger quadcopter offers a longer flight time (at 50 minutes it is more than double typical quadcopters), and higher tolerance for wind and temperature extremes (it can handle gusts up to 65 kph and a temperature range from -22 to 122 degrees F) than less expensive UAS. Less expensive UAS are also an option, particularly for smaller airports. For example, the hybrid FireFLY6 PRO UAS (fixed wing UAS and VTOL) could be used for perimeter inspections at a small airport (nominal range of 7 miles) and could be purchased for less than $10,000. A less expensive system has more limited operating conditions not only with respect to range but also with respect to wind tolerance. A basic surveillance system may include video only, whereas a more robust system may include automated video detection and alerts.

Security considerations regarding UAS and airports also include the need to identify unauthorized UAS in airport airspace. UAS detection systems are important since pilot reports of UAS near their flight path are becoming increasingly common; in 2016, FAA received more than 100 reports of UAS citings per month (Lynch 2016). The FAA and the Department of
Homeland Security (DHS) have been working together to develop technologies to detect unauthorized UAS flying near airports. The SkyTracker system was tested in February 2016 at the Atlantic City Airport (ACY) in New Jersey, where the FAA Technical Center is located (Marsh and Patterson 2016), and at the Denver Airport (DEN) in November, 2016 (Lynch 2016). Other evaluation sites include JFK Airport (JFK), Eglin Air Force Base (VPS), Helsinki Airport (HEL) and Dallas-Ft. Worth Airport (DFW). Other technologies being evaluated by the FAA for drone detection include AUDS by Liteye, and AIRFENCE by Sensofusion (Lynch 2016).

The Ohio Department of Transportation and the Air Force Research Lab are also working together to develop a sense-and-avoid system, with research to be conducted at the Ohio/Indiana UAS Test Center at the Springfield Airport (SGH). The new technology, which will utilize ground-based sensors and is being funded with $6.5 million from the Air Force, the State of Ohio and the Ohio Department of Transportation, is being developed by researchers at the Wright-Patterson Air Force Base and aspires to obtain FAA approval to fly UAS beyond line of sight (Bischoff 2016). Drone Guard, a system to detect, identify and disrupt small UAS is used at Ben Gurion Airport (TLV) in Israel and utilizes radar and electro-optical sensors for identification and adaptive jamming systems to disrupt UAS flight and either shut it down (and crash) or return it to the point of origin (Tomkins 2015).

Sense and avoid systems use radio frequency sensors and triangulate the signals to determine the location of the drone and operator without interfering with authorized airport activities. Once drone detection systems are in place, airports will need to use UAS to test the systems on a regular basis. Unauthorized UAS not only cause a risk to aircraft but also threaten airport efficiency, since airport shutdowns due to unauthorized UAS cause delay, inconvenience,
and significant financial loss. The Dubai Airport (DXB) closed at least three times in 2016; a ninety-minute closure on October 29 resulted in numerous diversions to other airports, and costs were estimated to be $1 million a minute (Alkhalisi 2016). Although the breakdown of this cost was not substantiated, other research documents costs to include those incurred by the airport, airlines, passengers, shippers, aeronautical and non-aeronautical service providers, businesses, and the community, as well as indirect costs for business interruptions (Delanghe 2013) and delay to secondary airports. The high cost of airport closure reinforces the value of UAS if it can increase the efficiency of operations and decrease the time required for closures for regular activities.

**Emergency Response**

Emergency response includes incidents on the airfield and incidents elsewhere on airport property including airport access roads. For a number of years, UAS has been proposed as a means to provide rapid and accurate information to first responders, and as a tool to provide real-time visual confirmation to the wide variety of stakeholders who participate in emergency response activities (Ameri 2009). Regulation has historically limited the utilization of UAS in emergencies (Karpowicz 2016), however, it is expected that UAS will be increasingly used in emergency response activities in the future, providing situational awareness (Toscano 2014) and enhancing response capabilities, including the potential to identify the location of injured passengers, potentially reducing accidental death (Terwilliger 2015).

In Europe, efforts have already begun to provide training to emergency responders who will begin by using UAS in emergency drills (Scott 2016). For both aviation and non-aviation emergencies, emergency response is based on procedures, and successful utilization of UAS in emergency response activities will require the development of UAS procedures that integrate
smoothly with the procedures and activities of other responders. There are a number of activities that can be undertaken to support integration of UAS into airport emergency response.

- Identify through case studies how a UAS could be incorporated into the Incident Command System (ICS) that has been deployed during actual airport emergency response activities.

- Document the specific benefits, capabilities and role within the ICS for UAS at non-airport emergencies. For example, document the protocol for UAS video feed and other information that supports response activities including information for stakeholders and the public.

- Develop an Airport Emergency Plan (AEP) that incorporates UAS and defines the specific tasks to be accomplished and the operating framework for UAS at a specific airport.

- Integrate UAS into full scale drills conducted for compliance with Part 139.

Although application in airport emergencies has not been documented yet, UAS could enhance the response capabilities of first responders at incidents such as the Asiana crash at San Francisco International Airport (Terwilliger 2015). As proposed above, documentation of a case study that specifies exactly how the UAS would have been used an emergency, how it would integrate with the ICS, and how this would be reflected in the AEP is an exercise that would illustrate both possible benefits and clarify integration with the emergency response team.

UAS are ideal in that they can potentially provide important information to emergency responders, enhance situational awareness, and reduce risk to responders; potential limitations include safety concerns operating where visibility is limited due to smoke, and the possibility
that the UAS flight path would be over passengers who are exiting the aircraft during an emergency.

The International Association of Fire Chiefs endorse the use of UAS to gather incident information, for tactical planning and for observation of plans as they are executed, and notes that the capabilities for thermal imaging, transmission of real-time data to incident command, and the potential to reduce the exposure of personnel to dangerous environments (International Association of Fire Chiefs 2014). In some cases, public safety agencies have utilized volunteer hobbyists to provide UAS assistance in an emergency situation (Sullivan 2016) which has benefits since the regulations for hobbyists are less stringent under Part 107, however, this is not allowable at public airports due to the airspace restrictions.

Local and state enforcement agencies have acquired UAS for incident and emergency response, natural disaster response, hazardous material accidents, accident reconstruction, photo and video documentation, and search and rescue. Rural enforcement agencies also use UAS to detect illegal crops. One local agency in Indiana with recreational lakes has practiced dropping life vests using UAS during training exercises; this may be useful not only for airports that are adjacent to large bodies of water, but also for airports with large detention and retention ponds on the airport property.

Construction Activities

UAS are used for a variety of tasks in construction, including surveying and pre-construction activities, (e.g., Lidar, 2D and 3D mapping and imaging), documentation of earthwork quantities, documentation of construction progress and activities, inspections, and aerial photographs and video for communication with owners, prospective clients and the public (Kim 2016). UAS may also be a useful tool to support quality control and worker safety (Vlieg
UAS has been widely utilized in construction projects in the building, roadway and offshore sectors, and could be utilized for a variety of construction projects at airports, including airfield and terminal projects, as well as ground access road and transportation projects and tenant construction projects. Large airports may include a variety of construction projects over large areas of land. Denver Airport (DEN) has over 33,000 acres and Dallas/Fort Worth (DFW) has over 17,000 acres with commercial, retail, office and industrial uses in addition to aviation and airport support. To provide some appreciation for the size of land mass, consider that New York’s Central Park is 843 acres, which is larger than many GA airports.

The risks and challenges identified for UAS on construction projects are amplified on airport projects, and include the development of appropriate safety procedures, UAS flight plans, safety for the surrounding areas, and adequate and affordable insurance coverage (Boudreau 2015). Additional considerations, namely approval for operation in Class B, C, D or E airspace, and safe operation near aeronautical users without negatively impacting airfield capacity, are also important considerations that would require resolution.

**Challenges of Integrating UAS into Airport Activities and Potential Protocols**

There is great potential to leverage the capabilities of UAS to improve airport safety and facilitate operations and activities; however, there are a number of potential challenges to implementation. Challenges include regulatory compliance, integration with existing airport operations, development of protocol to ensure safety of aeronautical users and people on the ground, and the development of policies for training, authorization and use, and privacy.

**Regulatory Compliance and Airport Operations**

Regulatory compliance reflects the need for compliance with both UAS regulations and airport regulations. This discussion reflects the current status, with the caveat that since Part 107...
regulations are new, since technology is rapidly changing, and since there is a lot of UAS activity, the policy may be expected to change and evolve. Although Part 107 provides for the use of small UAS under a variety of circumstances with minimal regulation, one of the regulations is the requirement for FAA permission to operate in class B, C, D or E airspace. Thus airports with class B, C, D or E airspace (this includes all towered airports) would typically operate under Part 107 with an airspace authorization and/or a waiver from FAA for permission to operate in airspace outside the requirements of Part 107 (Federal Aviation Administration 2017). The FAA grants this permission with consideration of UAS facility maps (UASFM) provided by the local air traffic control tower; these maps identify airspace constraints based on a grid around each airport. Since the airport itself typically has an allowable height of zero for UAS operation to reflect that UAS should not operate on or near an airport, prior to submitting a request, an airport should coordinate with the local air traffic control tower and note this coordination and approval on the application for a COW.

Airports that have an approved Section 333 exemption may continue to operate until the expiration of their Certificate of Authorization (COA), although all new requests to FAA are directed to Part 107 and associated waivers for authorization.

Part 107 does address operation near airports in Chapter 5.8 (Federal Aviation Administration, 2016b). UAS operations require authorization, and although UAS operations are not subject to Part 91, the communication and coordination with ATC would be similar to the requirements for Part 91 (Federal Aviation Administration 2016b). Furthermore, the remote PIC must be aware of all traffic and approach patterns, and avoid operation that may interfere with aircraft, yielding to all other aircraft (Federal Aviation Administration 2016b).
Communication regarding UAS activities is important not only with ATC but also with other airport users. Just as airport vehicles require special and conspicuous marking and lights (Federal Aviation Administration 2010), and construction vehicles require use of a checkered orange and white flag, perhaps UAS should be clearly marked with an airport logo or similar designation to indicate that their presence in the airport is authorized. Providing appropriate information to airport employees, and potentially to airport passengers who may see a UAS, will assure that authorized UAS do not cause undue alarm, and facilitate prompt reporting of unauthorized UAS.

Regulatory compliance with respect to airport regulations will require that the UAS be integrated into the Airport Certification Manual (ACM) for airports certified under Part 139. This would include documentation of the UAS protocol for any activity or component of the ACM, such as regular inspections, training requirements, and the AEP. This would also require that existing airport protocols be modified to reflect the use of UAS on the airport (e.g., administratively identify responsibilities for licensure of UAS, pilots, crew and authorized users). Detailed protocols can be developed for regular activities, with refinement as UAS capabilities and operational activities change and/or expand.

UAS activities at non-towered airports with Class G airspace (including airports with no instrument approach) can be conducted without additional authorization or air traffic control notification. This provision allows many GA airports to use UAS for airport operations relatively unencumbered. Although there are no formal requirements, it would be appropriate to issue a Notice to Airmen (NOTAM) and monitor the common traffic advisory frequency (CTAF) when UAS are in use at the airport. GA airports in Class G airspace may be the best place to advance and refine the use of UAS for airport operations, both due to simplification in terms of
FAA authorization, and due to the lower likelihood of interference with manned aircraft, due to lower operational volume. Most of the UAS used for airport management activities would not require the runway for take-offs and landings, but would require runway closure when activities center on the runway (e.g., pavement inspection or FOD inspection).

The challenges related to airspace restrictions suggests that the exploration of other autonomous systems for use at airports may be warranted. Pavement, perimeter inspections and other Part 139 inspections could potentially be conducted by UGS, and UWS may be appropriate for wildlife management activities, such as waterfowl hazing, and for waterside inspections and surveillance for airports that abut bodies of water. While functionally there are opportunities to leverage UGS and UWS at airports, the prevalence of UAS makes them attractive from the perspective of widespread availability, proven capabilities, and relatively low cost.

Safety Protocol

Even if not required by FAA (e.g., at a Class G airport or a private airport or an airport not certified under Part 139), it is important and necessary for the airport to develop and document protocol for safe operations, reporting requirements, equipment malfunctions (including lost link events), incident and near miss reporting, NOTAM authorization, coordination requirements, communications requirements, and emergency procedures.

Each component of a UAS program entails additional clarification. For example, development of an operating manual for UAS on airport property might include the following components and documentation requirements (Stephens 2016).

- UAS airworthiness statement for all UAS registered for use at the airport,
- Maintenance procedures and maintenance record keeping requirements,
- Flight ops manual that outlines UAS activities and procedures,
• Pilot ops manual that defines UAS remote pilot in command (PIC) qualifications and record keeping requirements (many airports require a private pilot license, although this is not mandated by Part 107),

• Crew requirements and record keeping requirements covering both visual observer and operator,

• Training manual that provides training requirements and information specific to the airport,

• UAS operational area maps for different UAS activities (e.g., perimeter security, runway inspections, construction, landside activities, etc.)

UAS operational area maps would vary depending on the specific task or activity. It may be appropriate to document the boundaries for UAS operational maps in a formalized letter of agreement between the airport operator, airport traffic control tower, tenants, and other affected users, just as the movement area boundaries are documented in a letter of agreement between the airport operator and airport traffic control tower.

Pilot qualifications and UAS requirements would likely be consistent for all airport applications, and it may be useful to develop a single airport template with checklists and inspection forms, including pre-flight and post-flight checks (Brewster 2016), and activity logs. Although a private pilot license was often required for COA granted under Section 333 exemptions, the Part 107 remote PIC licensure may be the most logical minimum requirement. Additional airport specific requirements would be expected and may include familiarity with the airport layout and operating protocols during regular operations (e.g., communications and operational restrictions) and emergency operations (ICS and AEP). Airports may also require additional documentation (e.g., hours of experience) or testing to demonstrate UAS operator
competency, since there is no flight check required for licensure of the remote PIC or operator through Part 107.

As airports develop Safety Management Systems, it will be logical to include UAS, which will not only include risk assessment and mitigation for possible UAS hazards, but also facilitate integration between UAS and other airport activities. In any case, the development of protocols to ensure safety is the top priority and precedes any other operational benefits. If operations are conducted under Part 107, operations must reflect all regulations including approval from air traffic control, not flying over people who are not participating in the UAS activity, maintaining visual line of sight, and operating during daylight hours only. Safety considerations while operating in the airport environment must also incorporate protocols to assure the safety of aeronautical users. In some cases, such as perimeter fence inspections on large airports, it is possible that activities could be conducted without interfering with aeronautical activities. In other cases, such as runway pavement inspections and obstacle mapping for Part 77, exclusive use of the runway is required, and air traffic would be interrupted. In the case of runway pavement inspections, these activities are already being conducted and the use of UAS rather than conventional ground vehicles would not introduce any new disruption to aeronautical activities.

UAS safety protocol must also include lost link procedures to assure that the UAS does not interfere with other traffic. Lost link procedures typically vary depending on the UAS, as well as the activity and the location of the activity, and include flight termination points. Possible actions for lost link may include remaining in place, returning to base, landing immediately in nearest safe location, or lowering altitude. The most appropriate action would vary, depending on the location of the UAS at the time of the lost link. At an airport, the first
priority is assuring that there is not interference with air traffic. Recognizing the importance of this topic, FAA has included UAS lost link procedures in their air traffic control policy (Federal Aviation Administration 2016c). Although automatic recovery with safe landing following a lost link is generally predictable and safe, the consequences of any failure become dramatic at an airport. For this reason, many airports may choose to integrate UAS carefully, with initial applications in areas farther from the runway (e.g., perimeter checks), at lower altitudes, and during times when air traffic is minimal and runways can be temporarily closed for UAS activities (e.g., inspections).

**Privacy Considerations**

Privacy considerations are especially important and any UAS activity that collects video or photographs must include a framework to assure privacy considerations are met. The National Telecommunications and Information Administration (NTIA) has developed voluntary best practices that include the following (National Telecommunications and Information Administration).

- Limit the collection of covered data; covered data includes any data with identification of specific people.
- Inform other stakeholders when UAS will be used to collect data and what kind of data will be collected.
- Avoid collecting covered and sensitive data when people have a general expectation of privacy.
- Do not retain covered and sensitive data longer than necessary.
- Limit sharing of covered and sensitive data.
- Develop reasonable protocol for securing covered and sensitive data.
Video and photographs may unintentionally document activities pertinent to worker safety, material storage conditions, and other regulated activities, as well as the presence of people both on the airport property and near the airport property, in the case of perimeter inspections. Privacy protocols currently used for airport video cameras may provide one frame of reference for consideration.

**Economic Considerations**

In some cases, the justification for using a UAS to support airport activities must address not only functional capabilities, but also economic justification. It is challenging to address this issue since UAS capabilities continue to increase and since costs are generally decreasing. Moreover, it takes more than equipment to make a system work. Consider the example of obstacle mapping, which has been accomplished with a $50,000 fixed wing aircraft and GIS system. This cost would be less than the cost to hire an fixed wing aircraft and pilot to do the same task. This cost estimate does not, however, reflect the expertise needed to execute the project, which includes not only operating the UAS, and having a license under Part 107, but also managing the resulting data, developing the required safety protocols, and administering a system that would be eligible for the required waiver to operate on an airport. Although some agencies work with FAA directly, other agencies have hired attorneys to assist with the development of procedures required for an exemption to operate in airspace outside the requirements of Part 107 and during nighttime conditions, which is advantageous not only for security and emergency response, but also for routine inspections during night conditions, such as for airfield light inspections. Since many airports have limited flight activity at night, night operations with a well-lit UAS might provide a lower-risk environment for testing and demonstrating UAS capabilities at both larger airports as well as unregulated airfields. Reduced
risk due to reduced aircraft operations may translate to lower insurance costs. Insurance costs associated with the operation of UAS would vary widely depending on the airport characteristics and the proposed use of UAS.

It is notable that the advantages are not just economic, but in some cases functional. A UAS may allow the airport operator to do things better than they were done before. The capability to reduce the danger of wildlife by using UAS, the capability to have enhanced documentation through video collected by UAS, and the capability to increase surveillance and deter a security breach are all examples of the benefits of UAS that are very real, but also very difficult to quantify in terms of economic assessment.

**Conclusions**

The capabilities and applications of UAS are rapidly expanding and it is logical that they may soon become an important tool to facilitate safe operations at airports. Although there are regulatory, safety, and privacy considerations that must be addressed, these factors should not be an impediment to deployment. UAS provide an opportunity to enhance many existing activities due to their capability for photo documentation and geocoding. Applications for UAS include not only obstacle mapping and surveying, pavement assessment, wildlife management, security and construction activities but also runway friction testing, and the assessment and reporting of runway conditions during and following snow and ice events. The expanded use and applications of UAS that will occur under Part 107 will likely spur innovation and advancements in UAS technologies, and will result in more robust technologies that may be utilized at airports. As UAS are implemented, it will be valuable to document case studies and develop best practices to best leverage this technology and facilitate integration at airports.
References


