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Integration of UAS Into the Airport Ecosystem

Master’s Research Paper

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INTRODUCTION

The purpose of this research paper was to explore the potential uses of drones or unmanned aerial system (UAS) technology at airports to support various day to day operations, commercial activities, natural disaster management, and support aviation emergency management and recovery efforts.

The ability of emergency responders to react to man-made or natural disasters is very important in this day and age throughout the world, particularly in the U.S, (i.e., Hurricane Katrina, Hurricane Michael in Florida in 2018, and the 09/11 terrorist attack on the world trade Centre,). The slow and inadequate responses to the devastation caused by Hurricane Katrina in New Orleans have left deep marks in the American emergency response community. (Select Bipartisan Committee to Investigate the Preparation for and Response to Hurricane Katrina, 2006). In order to better respond to any emergency or disaster at an airport, there is a serious need for reliable, accurate, and live data of the event. Due to the severities of the event, it may be hard for humans to physically collect the data, the advent of UAS technologies shown great potential in acquiring crucial information on such events with no physical harm to the disaster management personnel.

This research explores the possibilities of integrating UAS into the airport ecosystem to best serve the various day-to-day functions and tenants of the airport, such as civil aviation authorities, commercial airlines, logistic service providers, different response organizations, multiple levels of government agencies, public authorities like fire and rescue services and police agencies, aircraft maintenance, flight operations, ground handling, fueling services, airside services, and air traffic control commercial entities, national and international aid organizations (Abdussamet Polater Erzincan Binali Yıldırım University, 2018) (Petrin, 2019).

UAS

Unmanned aircraft systems (UAS) is the collective term used to describe what was previously called as descriptors, such as drones, Unmanned aircraft vehicles, remotely operated aircraft, or remotely piloted vehicles. In Unmanned Aircraft Systems (UAS) Frequently Asked Questions, the FAA defines UAS as unmanned aircraft and all of the associated support equipment, control station, data links, telemetry, communications and navigation equipment, and so forth necessary to operate the unmanned aircraft (FAA 2015d). A UAS is an aircraft without the possibility of direct human intervention from or within the vehicle. (National Academies of Sciences, Engineering, and Medicine, 2016).

COMPARISON OF UAS TO TRADITIONAL METHODS OF LAND SURVEYING

Comparing the UAS based surveying with the traditional methods helps to understand the efficiencies of UAS in saving time, cost, and produce desirable accurate data.

In the event of a natural disaster like a hurricane, the volume of debris amassed for collection and disposal could escalate overnight by orders of several magnitudes, in the aftermath of Hurricane Andrew in 1992, the southern Dade County, Florida, had to dispose of a volume of debris equal to what it manages normally over five years (Federal Disaster Management Administration, 1998)

The volume and nature of debris are very crucial in airport facilities and may put first responders at risk and also delay the recovery and reconstruction. Volumetric and cross-sectional surveys are useful to estimate the aftermath of natural or man-made disasters, this provides UAS a scope to operate and increase the efficiency, safety, and cost-effectiveness of the recovery.

A study conducted by (Fitzpatrick, 2016) compared various traditionally accepted survey methods such as the cross-sectional method, terrestrial LIDAR, and manned areal photogrammetry used in land surveying to the UAS based surveying and discussed the advantages of using UAS over the other methods in terms of cost, time, and accuracy.

For this study, two land surveying tests were taken which are volumetric calculation and topographic mapping, and the UAS method was compared with three traditional methods.

The cost and time spent along with the accuracy achieved were compared to evaluate the overall efficiency of the methods.

Table 1: Comparison of UAS to Traditional Methods of Surveying

Test	Traditional method	Time is taken (Traditional method)	UAS Method Time	Cost (Traditional Method)	UAS Method Cost	Accuracy Comparison
Volumetric calculation	Cross sectional method	11 hours	5 hours	$2,235	$1,316	0.09%Difference between calculation results
Topographic mapping	Terrestrial LIDAR	10 hours	7 hours	$4,600	$2,450	41% more accurate
Topographic mapping	Cross-sectional method	16 hours	8 hours	$3,200	$1,944	Less than 0.1 difference between contour lines
Topographic mapping	Manned aircraft photogrammetry	unknown	8 hours	unknown	$1,011	Less than 0.1 difference between contour lines

Comparison of UAS to Cross-Sectional Method for Volumetric Calculation

Firstly, volumetric calculation by cross-sections created through manual surveying in the field is described compared with the UAS based method. A cross-section is basically a profile consisting of latitude, longitude, and elevation of a series of points taken along the land taken perpendicular to the centerline of an area to be surveyed. In recent times the latitudes, longitudes, and elevations are determined using Global Positioning Systems (GPS). The cross-sections in the traditional methods are measured at regular intervals to cover the entire study area. Topographic lines are then drawn by interpolation based on common points of elevation within the survey area. Volumes are calculated by comparing two sets of topographic lines, or by comparing the difference in elevations at the top and bottom of an enclosed area, such as a reservoir or dirt pile.

According to the study, the UAS method took 6 hours in total whereas the cross-sectional method took 11 hours thus UAS method took 5 few hours, or 46% less time to calculate the volume than the cross-sectional method. The volumetric calculations can be crucial in emergency conditions

The cost involved with the cross-sectional method of volumetric calculation is $2,235, whereas the total cost involved in the UAS method was $1,316.50, this makes the UAS method $918 cheaper. Finally, the accuracy was compared and the volume calculated through the UAS method was 5,276 cubic yards. The volume calculated using the cross-sectional method was 5,271 cubic yards and the difference found in these two calculations was just five cubic yards, a 0.09% difference, and according to (Andrew L. Harbin, Land Surveyor Reference Manual, Third Edition), in order to deem the calculation of UAS method accurate, the total volume calculated using UAS had to be within three percent of the volume calculated using land surveying. As the UAS method's volumetric calculation is 99.01% accurate, it's proven that UAS is a good alternative to the cross-sectional method to conduct volumetric calculation.

Secondly, terrestrial LiDAR. The Topographic mapping by terrestrial LiDAR is considered effective and established method to gather highly dense, accurate and reliable topographical data across various topographies like large landscapes, buildings, roadways, coastal region, shallow-water areas, and construction sites, etc. (James B. Campbell and Randolph H. Wynne, 2011)

This active remote sensing technique is similar to radar but uses laser light pulses instead of radio waves. Lidar is typically "flown" or collected from planes where it can rapidly collect points over large areas. The UAS method took 7 hours to complete the data acquisition and analysis. While the traditional method of using terrestrial LiDAR took a total of 10 hours to complete Cost comparison, the UAS method was completed for $2,450 whereas the traditional terrestrial LiDAR cost $4,600. The accuracy of the UAS method, in this case, was lower than the traditional terrestrial method, 41% of the points were within 0.1 feet of each other in the vertical axis, 81% of the points were within 0.25 feet of each other, and 95% of the points were within 0.5 feet of each other.

It is important to note, however, that from a business standpoint, having 95% of the points fall within 0.5 feet of the LiDAR is acceptable for many applications. Not all clients require 0.2-foot accuracy and may prefer a less costly and time-consuming survey that can achieve 0.5-foot accuracy.

Finally, the comparison of the UAS method and manned aircraft photogrammetry for topographic mapping, the UAS method took the author 4 hours to complete and the author couldn't acquire the time manned aircraft flight time. The cost involved to complete the UAS method was $1,960 and the estimated cost to collect data through a manned aircraft was $5,000, which proves the UAS method is cheaper than the topographic method. According to the author accuracy of the UAS topographic map was sufficiently accurate with 1-foot contour lines created by the UAS method line up fairly close to those topographic lines generated by the manned aircraft flight.

The results were very intriguing to see that the UAS method was more efficient in terms of time and cost spent and on the other hand, maintaining the threshold of the accuracy within the acceptable range for each purpose.

BENEFITS AND OPPORTUNITIES OF INTEGRATING OF UAS IN AIRPORT ACTIVITIES

This section explores the potential of UAS in various areas of the airport and various crucial functions to help the airport operator, tenants, and surrounding communities.

UAS has human potential, the severities caused by man-made hazards and natural disasters at airports tend to be more lethal due to accommodating various types of equipment, vehicles, and the large quantity of jet fuel, UAS allows us to execute dangerous or difficult tasks safely and efficiently to prevent life-threatening situations for the airport workers and first responders. UAS also has a larger scope of operation, which will be discussed later in the study.

Besides the federal requirement in Public Law 112-95, Title III, Subtitle B – Unmanned Aircraft Systems to integrate UAS in NAS. UAS has clearly shown cost efficiencies, enhanced mission capabilities, increased safety, and other benefits.

Based on the primer (Kenneth Neubauer et al & P, 2015)P 40, there is no impact on airport certification. The introduction of UAS within or near a certified airport does not affect its certification status. The introduction of UAS is like that of any new manned aircraft or other new tenants at the airport. On the other hand, the airport managers should make sure that all the FAA certification, approvals, and waivers are applied to the UAS operation.

The opportunities for integrating the UAS in the airports can be categorized into three parts. Firstly, in order to strengthen the efficiency of the airport's functions in various areas such as quality, efficiency, and economics of their own operations. The airports that currently employ UAS reap benefits this great technology. Airport operators/managers, as well as contractors and tenants, can expect operational improvements such as the ability to use UAS for labor-intensive activities. Among these jobs that UAS can perform may include but not limited to surveillance for safety including fire and rescue, security and law enforcement, and facilitation of airport operations such as ground vehicle traffic management, collision avoidance, wildlife management, environmental monitoring, surveying (i.e. Obstacle and Terrain evaluation), and even transporting packages within the airport's boundary (C. Daniel Prather et al, Program, Board, & National Academies of Sciences, 2019) Pg27-28.

Secondly, the potential UAS operators of the future may become the customers of the airports. Although most UAS operations may be conducted outside the airport environs, like inspection, wildlife management, etc., airports can still hold some significant UAS operations within its premises. For example, it can be predicted that the smaller package delivery companies might use large aircraft into airports, and the use UAS as a feeder mode to pick-up and dispatch smaller freight from the airport directly to customers in the closer proximities and also use them to transport essential, time-sensitive and life-saving medical products and crucial elements like blood and organs through drones. The process of direct dispatch would potentially save time and expenses associated with the local warehouse, sorting, and road delivery infrastructure. And over time, it may well be that major aircraft cargo carriers and the military that are already residing at airports may convert into optionally piloted and unmanned aircraft.

Thirdly, there is a scope for the distributors in the future to build distribution centers in industrial or business hubs around and from which they could deliver goods by UAS (Suzette Matthews Esq., 2017).

CHALLENGES OF INTEGRATING UAS IN AIRPORT ENVIRONS

This section discusses the various challenges involved in integrating UAS at the airports and potential stakeholders that may be impacted, and other safety and security risks associated.

There are two major technical challenges in accommodating mixed-use operations including UAS in airports: (1) operational accommodation airspace and runway environment, and (2) ground operation and logistical accommodation on the airfield (National Academies of Sciences, Engineering, and Medicine, 2016).

Incorporating various flight operations safely within the airport environs and the airspace can be a challenging task, specifically in the absence of an on-site traffic control operation. Across the US instances have occurred in which the integration of various types of aeronautical activity has resulted in the local community perceiving that an unsafe situation is present at their airport facility.

In order to address the issue of potential conflict over the use of an airfield by UAS users or other mixed-use operations, some airports enact rules and operating procedures to coordinate these activities safely and efficiently. However, this effort drafting guidelines are lacking in many airports in the country. While this lack of guidance may be attributed to pilots of manned flights and UAS operators, many airports are still unsure of the potential issues and risks of UAS operations (National Academies of Sciences, Engineering, and Medicine, 2016).

The partial integration of UAS into the NAS has already resulted in several incidents, from 2007-2017 the FAA has taken action against 518 sUAS operators non-compliant operators. This suggests that serious consideration needs to be given before integrating UAS in NAS full. In 2017, a U.S. Army UH-60M met with a serious accident, while conducting military operations near Hoffman Island, New York. The mid-air collision reportedly damaged the helicopter’s main rotor blade. During the investigation from the wreckage, the NTSB found that the casual actions of the sUAS operator was responsible for the accident. Moreover, the agency determined that the sUAS operator's lack of knowledge of regulations and safe practicing standards were contributing factors to the whole incident. (Wallace, 2018).

Similarly, UAS sightings were recorded in several airports around the world, including the march 2019 UAS sighting near Frankfurt Airport in Germany, the Jan 2019 UA sighting near London Heathrow airport. "encounters between manned and unmanned aircraft are becoming increasingly common events". Unsurprisingly, "the FAA reportedly expects an elevated risk of unsafe UAS operations as more UAS platforms integrate into the NAS". Taking these incidents into consideration, the FAA has been integrating the UAS into the NAS more controlled and stricter rules (Wallace, 2018).

REQUIREMENTS TO MANAGE UAS OPERATIONS IN AIRPORTS

In order to manage UAS in the vicinity of airports, the administrators and managers of the airports must have a general understanding of the requisites and elements of UA operation. This section will discuss the elements of UAS operations that would be instrumental to the airport managers to understand the requirements to manage UAS operations near and within the airport facilities. The elements are the concept of operations, regulations for authorizations, approval, notification, privacy and data challenges, and hyperlocal considerations.

CONCEPT OF OPERATIONS (CONOPS)

The concept of operations for UAS describes the nature of UAS operations and the impacts resulting in relevant stakeholders and the community at large. The development of CONOPS sets a foundation to effectively employ UAS in the airport environment and key to successfully integrate UAS in the NAS. (National Academies of Sciences, 2019). The CONOPS is meant to be the document that defines the UAS's System Architecture to be operated in the airport environs, the airworthiness requirements of the systems, the operational requirements of such systems, the operational plan (e.g., intended missions and operational procedures), and the personnel certification/training requirements to support the operational plan within the target environment. (National Academies of Sciences, 2019)

The first part of the table sets up the goals and objectives, the primary objective of CONOPS includes the seamless integration of UAS in the existing CONOPS architecture of the airports.

To achieve this objective, emphasis should be placed on the following aspects.

THE PRIMARY USE FOR UAS

The operation of UAS at airports require appropriate approval and authorization by FAA through a certificate of authorization (COA) or COA/Exemption issued to the operator of a civil UAS not operating under Part 107. The airports should review the documents such as COA/exceptions and/or authorization waivers which detail the use of the system, and method of UAS operation (Booz Allen Hamilton et al, 2019).

METHOD OF OPERATION

The needs of UAS operations could be vast depending on the types, sizes, and functions of platforms, and support equipment associated with UAS technology. Although not fully inclusive of all the types of UAS, the UAV could be categorized into five basic categories, the figure below describes these categories. Currently, Group 2&3 dominates the commercial UAS operations due to the FAA restrictions and cost; while the DOD and other government agencies operate across the full spectrum of sizes and capabilities. The general infrastructure and support requirements are discussed below.

The COA or other applicable FAA approval may also contain the methods and way the system would be used, this may include information on guidelines and certifications from the FAA. Airports may classify the operation of UAS primarily in two forms, those require take-off surfaces and those do not (CENTURY WEST ENGINEERING, 2016).

INFRASTRUCTURE REQUIREMENTS

RUNWAY REQUIREMENTS

Group 1: Smaller and much easier to handle, because they weigh less than 21 lbs., they can be hand-launched/recovered.

Group 2 & 3: Based on the wide range of functionality and operational advantages that come along with the Group-2 type UAVs, the associated platforms and launch and recovery and control mechanisms that would include Pneumatic Launchers, Skyhook recovery, Bungee or hand launch, hard-packed surface recovery,

Group 4 & 5: As a general rule, group 4 &5 has similar runway requirements of the manned aircraft based on the sizes and types of these drones.

AIRFIELD SUPPORT SERVICES

Group 1: As the group, 1 vehicle is small, mobile, and likely won’t require operation into, or out of the facility. Support services may include Mobile Operation Centre (MOC), radio communication, crew shelter, data-processing space, training space, and secure storage center.

Group 2 & 3: The general services or 2&3 systems will require airfield services such as fuel, UAD pad maintenance, utility support (internet, power, trash, sewer, etc.), transportation, security, and labor associated with safety compliance, and administration support. Memorandums of Agreement (MOA) will be required with the Air Traffic Control Tower (ATCT) for airfield movement and airspace coordination/approval.

Group 4 &5: The requirements of the large UAS would be similar to that of manned aircraft, they would require towing, refueling / de-fueling, deicing, power, security, hangar space, etc. MOA's will be required with the ATCT for airfield movement and airspace coordination/approval.

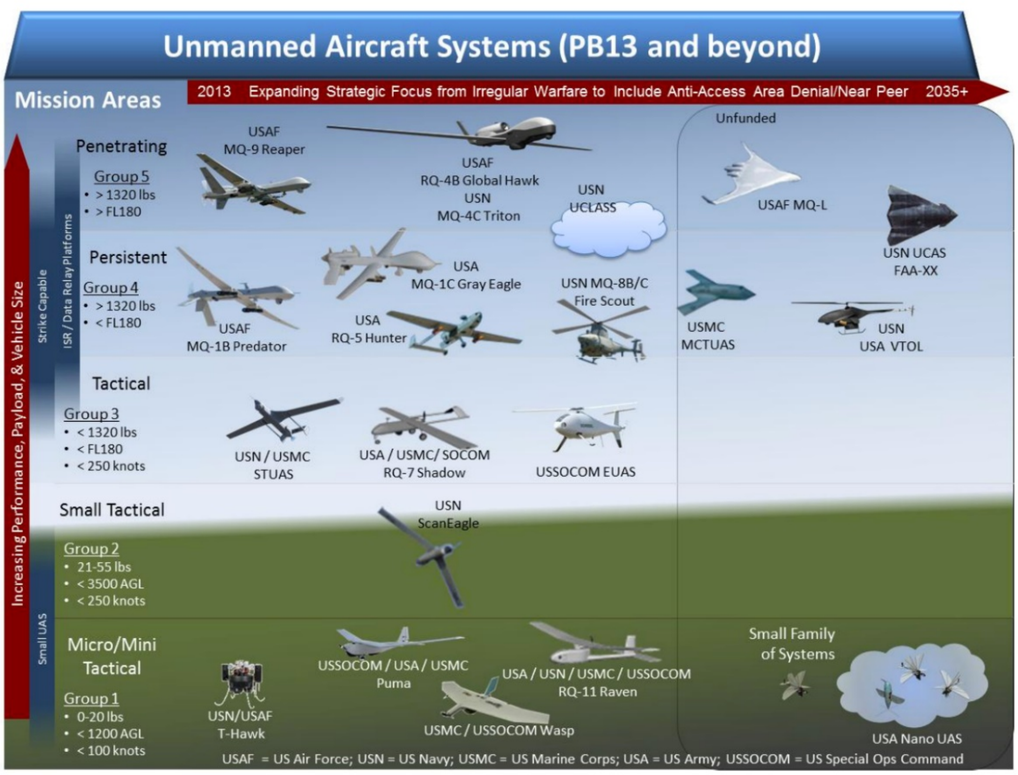

Figure 1: Types of UAS

[1]

CREW AND TECHNICAL ARCHITECTURE FOR UAS

UAS operations are different from other manned aircraft operations, so they may require a different kind of crew setup and infrastructure to support operations. This may include but not limited to the crew required for each UAS type, and the communication systems and infrastructure(including the datalink frequencies, voice communication techniques, and frequencies, placement of UAS operating crew and equipment to support the system operation and regulatory framework), should be considered and identified (National Academies of Sciences, 2019).

THE UAS CREW REQUIREMENTS MAY INCLUDE:

Although each program of UAS has unique approaches to its respective functions, roles, and responsibilities are associated with all current systems. Such generic roles and responsibilities are listed below:

- Operator- controls the flight of a UAS in the absence of automatic systems, take-off, and landing.
- Sensor operator: - handles onboard sensors and records data like videos, LIDAR data, infrared and images, etc. For smaller UAS, this role is merged with that of the UAS operator.

[1] https://missiledefenseadvocacy.org/missile-threat-and-proliferation/missile-basics/unmanned-aircraft-systems-uas/

- Intelligence analyst: - handles the exploitation of data/signals that the UAS gathers. This includes multiple analyst subsets, including video imagery, all-source intelligence, signals intelligence, etc. for larger and more complex UAS, these functions are typically handled by elements of the processing, exploitation, and dissemination (PED) intelligence community (Travis L. Norton, 2016).

KEY COMPONENTS OF UAS:

UNMANNED AIRCRAFT

Unmanned aircraft are available in many models like fixed or rotary-winged aircraft or multi-rotor or lighter than- air vehicles, capable of flight without onboard crew. The generic unmanned aircraft includes the aircraft and integrated technical components (Propulsion, avionics, fuel navigation, and data links) needed for flight.

MISSION/OPERATION PACKAGES

The Mission/operation packages of a UAS contain devices that are crucial for each specific operation they are employed. In the US military, these technical components include sensors, communication relay, and cargo which are mostly external to the UAS, sometimes internal of the UAS (Army UAS CoE Staff, 2010).

SENSOR EQUIPMENT

Sensor equipment may include - LIDAR, EO, Infrared (IR), Synthetic Aperture Radar (SAR), GMTI, Signal intelligence (SIGNIT), Full Motion Video sensor (FMV), and still imagery.

The LIDAR is a very important technology in UAS to operations such as post-disaster damage assessment in airports and surveying. LIDAR device emits up 300,000 pulses each second while surveying, the number of pulses varies depending on the capacity of the devices. The laser pulses reflect off the objects they encounter and return to the emitter device. The LIDAR assigns a latitude, longitude, and altitude value to each return point based on the time taken for the laser to return, the angle of the laser, and the strength of the return signal, this forms a point cloud to make a 3-dimensional map of the area. (James B. Campbell and Randolph H. Wynne, 2011)

Lidar is also collected from ground-based stationery and mobile platforms. These collection techniques are popular within the surveying and engineering communities because they are capable of producing extremely high accuracies and point densities, thus permitting the development of precise, realistic, three-dimensional representations of railroads, roadways, bridges, buildings, breakwaters, and other shoreline structures.

This resolution allows LiDAR collected data to be used to create orthomosaic images, 3D models, point clouds, and digital surface models. The high-resolution data generated provides users with flexibility when using the data. (National Oceanic and Atmospheric Administration (NOAA) Coastal Services Center, 2012).

COMMUNICATIONS:

The communications section provides information on how the airport will establish, maintain, augment, and provide redundancy for all types of communication devices during an emergency response.

In many of the medium-sized airports, they depend on house 2-channel communication frequency, direct telephone line, or cellular call between the airport and the police department and the fire department (SBY Regional Airport, 2018) (Waco Regional Airport, 2018).

THE ROLE OF UAS IN IMPROVING COMMUNICATIONS

The UAS is growing in popularity with the public safety agencies in the United States, who seek to enhance the efficacy of the operations and add an additional layer of safety for first responders operating in dangerous conditions.

Voice and data communications including video and telemetry transmission are emerging keystones for public disaster management operations. The failure of the conventional two-way communications due to coverage deficiencies and damage to the network can put the first responders in great danger. Most agencies continually evaluate their ability to provide continuous and redundant services and strive to improve the radio system's coverage, capacity, and resiliency. The UAS industry has recognized this benefit and UAS technology is being adapted to provide both aerial Land Mobile Radio (LMR) system extension as well as Long Term Evolution (LTE) cellular capabilities (Unmanned Aircraft Systems and Robotics Working Group , 2018).

The FCC's Deployable Aerial Communications Architecture (DACA) vision for disasters involves an aerial capability that is deployable within the first 12 and 18 hours after a disaster has stricken to temporarily restore critical communications, including broadband, for a period of 72-96 hours. This capability would be crucial in response and rescue where the power grid may be inoperable for 3-7 days, depleting back-up power supplies and finally leading to almost complete failure of communication options like a landline, cellular, land mobile radio, broadcast and cable transmissions, as well as Wi-Fi and Internet services. In such cases, the access roads and crucial road infrastructures like bridges may be impassable, preventing communications between the airport manager, repair crews, and fuel suppliers for generators from accessing the location.

According to the FCC White Paper: The Role of Deployable Aerial Communications Architecture in Emergency Communications and Recommended Next Steps, the federal government would provide and coordinate air operations for the aerial platform, which would allow authorized spectrum users to deploy a temporary capability that conforms to and is integrated into existing communications systems. There are certain limitations to UAS capabilities as they are integrated to communications systems as temporary restoration of cellular services, would to limit to wireless priority service (WPS), Government Emergency Telecommunications Services (GETS), and 911 calls while other services, like Wi-Fi and Internet services, could be open for public use. Other capabilities, such as public safety communications, could be supported by the DACA system. The need for a spectrum interference coordination method in place to protect terrestrial communications systems from harmful interference from the DACA systems as they get restored (Federal Communications Commission, 2011).

SCOPE TO INCREASE EFFICACY OF UAS THROUGH INTERNET OF THINGS

The addition of such technologies could make great change aspects in emergency rescue, disaster recovery, damage assessment operations in dull, dangerous, and dirty situations where time, resources and cost could be greatly saved at the same time increase safety of the disaster managing and rescue personnel in airports.

The Internet of things was created by Kevin Ashton in the vision of aiding supply chain management in 1966. According to Atzori, the IoT can be classified into three models- internet-oriented, things oriented, and sematic oriented (Atzori, 2010).

Mark Weiser, the forefather of the ubiquitous computing defines that internet of things is a smart platform in which the physical world that is richly and indivisibly connected with sensors, cameras, actuators, displays, and computational parts, integrated seamlessly in most of the smart objects in our lives and connected through a continuous network (Mohammed Tawfik, 2017).

In recent years, the world has witnessed continuous advancement in the technological development of IoT devices while home automation and security and surveillance services gain popularity in the modern world (Ahmed Osama Basil, 2019).

The integration of various information and communication (ICT) elements in the IoT has boosted its utilities and services to users in new levels. ICT has witnessed an exponential advancement in terms of system design, network architecture, and smart devices in recent years.

For example, ICT has been advanced with the innovations of a software-defined network (SDN)- adopts the concept of programmable networks by using a logically centralized management, which represents a simplified solution for complex tasks such as traffic engineering (Toker, 2018), cognitive radio network (CRN) is a radio that can be programmed and configured dynamically to connect and use the best wireless channel in the wireless spectrum, then accordingly changes the reception and transmission parameters to allow more dynamic and concurrent wireless communications in a given spectrum band in a geographic location using a process called dynamic spectrum management. This requires algorithms and protocols for rapid spectrum sensing, coordination, and cooperation (Tellambura, 2017), cloud computing,

FUTURE OF UAS COMMUNICATION ARCHITECTURE

Mobile computing is also known as mobile edge computing is a breakthrough technology that recently emerged to overcome the computational limits of mobile devices in the era of increasing graphic/computationally intensive applications. Edge computing reduces the computational pressure on the network resources by offloading workload to distributed computing clusters. Although cloud computing enables devices to access a shared pool of connected devices allows them to offload heavy computations to the cloud, the delay caused while trying to connect to cloud servers is considerably still high. (Sukhmani Sukhmani, 2019)

Mobile edge computing provides data storage, computing services with edge devices such as access points (AP), laptops, base stations, IP video cameras at the network edge. As edge computing is closer than cloud computing, edge computing can support the internet of things IoT, unmanned aerial systems, vehicular networks, smart grids, and embedded artificial intelligence by having much lower latency compared to the conventional networking (Liang Xiao, 2018).

Mobile edge Caching exploits the idea of storing content in temporary storage located closer to the user than the content servers over the internet. Such temporary storing can be placed at a macrocell base station or microcell station or other local devices. In short, edge refers to devices located within the radio access network (Sukhmani Sukhmani, 2019)**.** Mobile Edge Caching (MEC) has several potential implications in several potential benefits in UAS operation and data retrieval, it is capable of reducing the latency for retrieving the data and minimized the number of hopes between the drones and the operators and ultimately creating a better link between that reduces loading or buffering time.

The data that's being transferred in UAS operation is high demand/high volume content that can greatly benefit from MEC (Poderys, Artuso, Lensbøl, Christiansen, & Soler, 2018).

HUMAN MACHINE INTERFACE

The human element in UAS is crucial to the successful employment of UAS in any complex operation such as airport management, commercial operations, and disaster response. Although UAS operates with a certain level of autonomy, the human element is core to the overall system. The futuristic UAS are designed to be highly intuitive and highly automated and should be interoperable with several other systems i.e. IoT. Despite the advances in autonomy, the human operators are still projected to have a part in the control loop and operation of the unmanned vehicle (e.g., the man in loop or man on the loop) as well as the interpretation of video and sensor that are collected and transmitted by the UV. (Brent Terwilliger.et.al, 2015) Operators must ensure UAS personnel requirements, limitations, and unit manning are enough to accomplish assigned tasks (Army UAS CoE Staff, 2010).

CHALLENGES FOR HMI IN UAS DESIGN:

There are four major issues facing HMI design in UAS that result in inadequacies in performance. However, the study was published in 2015 and in the recent years, considering the speed of the growth of modern technology, these could be improved and there are many examples in the later sections of the study

- lack of standardization for UAS HMI or Ground Control Stations (GCS)
- lack of optimization of HMI information presented to the user
- lack of HMI flexibility and adaptability, which is essential for the optimization of workload and situational awareness
- sensory deprivation and isolation of the human operator. Lack of standardization across different UAS HMIs leads to extensive training time for one system and a lack of ability to easily transition to other systems. (Brent Terwilliger.et.al, 2015)

CONTROL ELEMENT AND SYSTEM OPERATION

The Control element of UAS encompasses several operational aspects such as control and command, mission planning, UA control, sensor control, and communication control. The control element could be in various forms, like a laptop on-site, a mobile operating station in a vehicle/aircraft, and a large facility within the airport environment (Army UAS CoE Staff, 2010).

The operation of the UAS system is a step-by-step process that gives a complete picture of the UAS operation. The listed elements are meant to be document by the airport administration in coordination with the FAA Airport District Office (ADO) and the air traffic control (ATC).

In outlining the system operation, the following key areas needed to be addressed:

- Airworthiness requirements
- Airspace segregation
- Flight routes and procedures
- 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

The above-mentioned key areas are critical for the stakeholders to ensure smooth integration and operation of UAS at the airports (National Academies of Sciences, 2019).

INTEGRATION OF UAS IN AIRPORT'S SMS PLAN AND AEP

This section discusses the incorporation of UAS elements in various sections of the airport that govern the safety, security, emergency, and disaster management efforts.

INTEGRATION OF UAS IN SAFETY MANAGEMENT SYSTEMS (SMS) PLAN

In order to deal with the challenges and impacts of UAS operations in airports, airport operators should consider including UAS in their SMS plans. An SMS plan provides a management system for integrating various safety activities into the day-to-day operations of business practices (Brown, 2016). It is a formal and a systematic approach to identify the hazards and control the safety and security risks, promotion of the overall culture of safety within the organization, safety risk management(SRM) to address and mitigate potential threats and hazards, and ensures safety assurance policy to ensure long-term safety is maintained as it evolves in the future.

An SMS plan articulates this system so that it can be disseminated to appropriate stakeholders in the facility including airport operators, UAS operators, contractors, and tenants, defines clear instructions on the system/plan and its execution, and can be shared with others like the FAA for further certification, operational approval. (Booz Allen Hamilton et al, 2019)

INTEGRATION OF UAS IN AIRPORT EMERGENCY PLAN (AEP)

Like the SMS plan of the airport, the airport emergency plans (AEP) functions as a crucial document particularly to handle various kinds of crises the airport is susceptible to. An AEP is a manual or framework of guidelines that effectively responding to the individual crises which are categorized as part of crisis management. An AEP is to define responsibilities, identify resources, and establish procedures to be implemented in the event of any emergency at the airport. The

AEP aims to provide a punctual and coordinated response protocol to respond and recover from a crisis at an airport (fairbanks International airport, 2019).

PURPOSE OF THE AIRPORT EMERGENCY PLAN

The AEP documents are generally created with the guidance of the Federal Aviation Administration (FAA), although the Federal Aviation Administration (FAA) does not mandate a particular format for AEP document, the FAA Advisory Circular (AC) 150/5200-31C describes that if the AEP document contains the recommended information and if the users can find it when they need it, either during drilling exercises or during actual response situations, plan reviews, etc.-then the format is fine. Otherwise, the existing format may need to be revised. AEP is meant to be created in order to be followed through coordinated actions of various agencies tasked within the plan. The plan should be developed in correspondence and made available to all responding agencies tasked within the plan (Minnesota Airport Technical Assistance Program (AirTAP)).

COMPONENTS OF AN AIRPORT EMERGENCY PLAN

An AEP is meant to address several types of emergency situations, it is important to develop a basic plan that's comprised of all the common functions used in emergency situations. (Minnesota Airport Technical Assistance Program (AirTAP)). The AEP largely comprises four parts such as Basic Plan, Functional Areas/Plan fundamentals, Hazard-Specific Sections, Standard operating procedures (SOPs), and checklists, each serving critical roles in the emergency management process of the airport. The following section discusses the components of the Airport Emergency Plan.

This process involves conducting a careful airport hazard analysis that identifies all the necessary tasks required; assigning responsibilities for accomplishing each function; and preparing an actionable plan or standard operating procedures and checklists.

After common functional areas are addressed, the types of emergencies and hazard-specific tabs can be developed.

FAA AC 150/5200-31C lists the components in this functional approach as:

A. Basic Plan

B. Functional Areas

C. Hazard-Specific Sections

D. Standard Operating Procedures (SOPs) and Checklists (Minnesota Airport Technical Assistance Program (AirTAP))

A. BASIC PLAN

The basic plan provides an outline of the airport's approach in preparations to address emergency situations. It defines policies, describes the response organizations, and assigns tasks to respective organizations. The primary purpose of the Basic Plan is to provide articulated information from the airport manager to all the agencies involved. It provides an overview of the hazards that will be addressed in the AEP document. The basic plan should also summarize various agencies that function with the help of UAS and define the policies, functions, and operational structure of UAS in the Airport.

B. FUNCTIONAL AREAS

This section of the AEP provides information on tasks and core responsibilities that may be applied to airport emergencies. Detailed information particular to specific emergency scenarios is given in the standard operating procedures for hazard-specific areas.

As a special condition for many general aviation airports that do not have enough staff to designate an individual to cover every function of the crisis management process, FAA advisory circular 150/5200-31C suggests that in many instances these roles may need to be combined or may include off-airport expertise. The integration of UAS would be possible and would fill in the areas with gaps of lower manpower and supplement in response and recovery activities. UAS may become an integral part of the functional areas, as their current potential is identified and future scopes explored to make the airport's operations safer, efficient, and responsive.

This part comprises of ten parts such as Command and Control, Communications, Alert Notification and Warning, Emergency Public Information, Protective Actions, Law Enforcement/ Security, Firefighting and Rescue, Health and Medical, Resource Management, Airport Operations and Maintenance (Minnesota Airport Technical Assistance Program (AirTAP)).

C. HAZARD-SPECIFIC SECTIONS

The hazard-specific section is the most important in the case of natural disasters and in the coastal airports, this section becomes crucial. The hazards-specific section describes additional information regarding the response to each particular hazard or crisis situation. This detailed part of the AEP is meant to be easily located to use for quick reference. In AEP, hazard-specific emergencies include but not limited to Aircraft Accidents/Incidents, Landside Emergencies, Natural Disasters, Fires, Electrical Power Failures, Hazardous Materials, Water/Ice Rescue, Wildlife Management, Security/Criminal Activities, and Overdue Aircraft. The scope of UASin firefighting,

D. STANDARD OPERATING PROCEDURES (SOPS) AND CHECKLISTS

Standard operating procedure (SOPs)

Standard operating procedures (SOPs) and checklists provide detailed instructions on individuals or organizations tasked within the AEP may use to ensure all assigned responsibilities are being performed. They should be easily located within the AEP and should allow the user to provide detailed information useful later for insurance or investigation purposes if needed. (fairbanks International airport, 2019)

COORDINATION WITH LOCAL AND REGIONAL AGENCIES

This section explores the potential UAS belonging to local agencies to aid in airport emergency situations and the airport's UAS to aid in community services.

Airports in many ways function like a typical city. Although there isn't much permanent housing in an airport, it is evident that each day thousands of people visit and use the airport amenities, resources, and commercial establishments like hotels, restaurants, and financial services every day. According to the Telegraph in 2016, around 104 million people visited the Hartsfield–Jackson Atlanta International Airport, which has been the busiest since 1998 (Haines, 2017).

According to the FAA, technically no airport has enough resources to handle every emergency independently. As mentioned in AEPs each airport must depend on the resources from its surrounding communities to some extent. For this reason, each airport operator is recommended to involve local government agencies in the development of the AEP and use the collective expertise and resources for planning, reviews, and exercises—for example, local fire and police departments, hospitals, county emergency officers, sheriff, tenants, and city or county administrators. Establish a contact list that is readily available and update it on an annual basis. The airports could vastly benefit from the UAS at various local agencies like firefighting, wildlife monitoring, and parking and traffic management. (Federal Aviation Administration , 2010) (Minnesota Airport Technical Assistance Program (AirTAP)).

Similarly, airport resources can be incorporated into local/regional emergency plans. The UAS companies could be included as part of the coordination process. The Southern Illinois airport has documented numerous events, projects, and impacts to the airfield and surrounding areas using UAS. For example, the airport used UAS to document environmental and infrastructural damage related to the May 2017 flooding of the Big Muddy River. The airport also assisted the local community in searches, working with Jackson County Sheriff's department utilizing the UAS technology. (Brewster, 2016)

APPROACH TO CONDUCTING UAS OPERATIONS AT AIRPORTS

Once the UAS element is integrated into the SMS plan and AEP and the risks are evaluated and the roles are defined, airports can begin planning UAS operation. The following section would outline an approach that airport managers/operators can take to integrating and conducting UAS operations at their airport.

PRE-PLANNING COORDINATION AND STAKEHOLDER'S ENGAGEMENT

This section has four parts, engagement with stakeholders, FAA engagement, air-traffic control engagement, and waiver and authorization process. In order to effectively implement UAS missions, airports should coordinate with multiple agencies and stakeholders that may be involved or impacted by UAS activity at the airport. The pre-planning is a crucial stage in conducting UAS operations. Successfully and efficiently coordinating prior to the operation would help ensure safety is prioritized, all the necessary resources are at disposal, relevant parties are on the loop, and clear understanding is developed to help guide remaining planning efforts.

STAKEHOLDER AND COMMUNITY ENGAGEMENT

The UAS operations could potentially affect many stakeholders at the airports. Depending on various factors like airport, size, operators, and proximity to any residential or commercial areas, the list of vulnerable parties may vary. For example State Department of Transportation, Fixed Base Operators Air Traffic Personnel and Operations Personnel (Booz Allen Hamilton et al, 2019)Airports will need to consider their role and impact in the community will need to identify the local stakeholders they want to engage for safety as well as public relation, by introducing the UAS technology to the public and explaining the benefits.

FAA ENGAGEMENT

Before any UAS operation, the airport operators should also communicate with the FAA personnel. The Flight Standards District Office (FSDO) and other regional and district agencies should be informed about the planning of UAS operations and its scope. Clear and timely communication with the FAA would help to ensure safety and risk concerns by following the necessary FAA considerations and concerns. The early engagement would also help address the appropriate part 107 waivers, authorizations, or other approvals that may be required for the operation.

AIR TRAFFIC CONTROL ENGAGEMENT

For the Airports with towers, the airport manager should also have an open and fluid communication with the air traffic controllers to execute the operation successfully and have a solid communication plan like types of radio communications, and frequencies for UAS communication. The airport operator and UAS operator should be clear on how to handle the Remote Pilot in Command (RPIC) of the UAS to be in constant communication with the tower.

APPROVALS AND CERTIFICATIONS

In the beginning phases of the preplanning process, the UAS operator needs to consider what parts of 107 authorizations, waivers, or other approvals may need to be pursued for the operation. This consideration should be a result of the airport operator's engagement with the FAA, understanding the operation in detail, and consultation with the airport's legal agencies. FAA offers step-by-step guidance to help identify the waivers they require. The list is as follows:-

Operations from a moving vehicle or aircraft (Fly my sUA while in a moving vehicle: § 107.25)

• Daylight operation (Fly my sUA at night: § 107.29)

• Visual line of sight aircraft operation (Fly my sUA beyond visual line of sight: § 107)

• Visual observer (Working with my visual observer: § 107.33 Visual observers)

• Operation of multiple small unmanned aircraft (Fly multiple sUA at the same time: § 107.35)

• Operation near aircraft (Fly my sUA near other aircraft: § 107.37)

• Operation over people (Fly my sUA over people: § 107.39)

• Operating limitations: ground speed (Fly my sUA faster than 87 knots/100 mph: § 107.51(a))

• Operating limitations: altitude (Fly my sUA higher than 400 feet: § 107.51(b))

• Operating limitations: minimum visibility (Fly my sUA when visibility is reduced: § 107.51(c))

• Operating limitations: minimum distance from clouds (Fly my sUA near clouds: § 107.51(d))

(Federal Aviation Administration , 2019)

FLIGHT PLANNING

In addition to flight planning, which includes engaging with appropriate stakeholders and waivers, airport UAS operators must develop a flight plan that describes how they plan to conduct the actual UAS operation. The flight plan serves as a common ground for all the parties that take part in the mission.

Components of the UAS operation plan are as follows:

- Identify flight logistics, that include the number of flights, flight paths they plan to take, the average time of flight and mission, number of drones, distance above ground level, and ensure adequate payload for the mission, etc.
- Create a mapping resource with the clearly labeled flight plan
- Data collection: - recognize the type such as high-resolution images, video, point cloud, ortho mosaic, 3D model. quality and storage of the data they plan to acquire like on-board storage or cloud storage.
- Identify potential conflicts with normal operations like runway hindrances, delays, etc.
- Establish a solid communication protocol with air traffic control or tower. (nontowered airports may require continuous reporting and monitoring of common frequency) (Booz Allen Hamilton et al, 2019)

EXECUTING THE OPERATION

Proper coordination and planning are fundamental to efficiently execute the UAS. Some of the key steps to the operation planning are outlined here. Executing the operation consists of two parts, preflight and deconfliction procedure and return to home.

PREFLIGHT PROCEDURE: - SAFETY BRIEFING AND EQUIPMENT CHECK

Before beginning the first flight of the operation, a pre-flight briefing should be conducted with the parties involved in the operation. This would ensure safety at the forefront of the operation and the respect to the primary functions like manned traffic and other normal airport activities are upheld. Aspects that should always be incorporated are:

- A high-level detailed briefing the location of each function of the operation at each given point in time of the day with the help of the reference map generated in the previous process.
- Each area of the airport, the UAS operation is permitted to access should be highlighted and the crew should also be aware of the restricted areas.
- It should iterate appropriate behavior of the vehicles affiliated with the UAS operation.
- It should define all communication protocols with appropriate frequencies the UAS operators are designated.
- It should contain the location of the emergency or first-aid kits and contact information to obtain these.
- It should contain weather briefing and limitations of the operation

Before the operations, the UAS operators should make sure all the equipment's proper function. This would help reduce the risk of equipment failures during the operation and reduce the risk of affecting the normal functions of the airport operation (Booz Allen Hamilton et al, 2019).

DECONFLICTION PROCEDURE AND RETURN TO HOME

The Remote Pilot In Command (RPIC) should be aware of the Return to Home protocol throughout the operation. Most UAS platforms are designed to flex to fit in the dynamic environment of an airport. Its important for RTH procedure does not interfere with the approaching or departing flights. Geofencing should help avoid other restricted or sensitive areas. It is very important for the RPIC to maintain visual contact with the UAS and finally, a protocol to communicate with ATC in an event of an RTH procedure.

DEVELOPMENT OF AIRPORT PLANS AND GUIDELINES TO INTEGRATE UAS

Based on the findings of the UAS operation and facility requirements, additional planning and policy guidelines are created to address the identified areas that may need more attention. This section would explore various options to integrate UAS with manned operations at a public-use airport.

- For an airport master plan, UAS infrastructure including launching and recovery needs into the airfield infrastructure. The UAS infrastructure should be considered as part of the airport's long-term development plan. Evaluating both manned and unmanned simultaneously would allow more effective and cost-efficient options to be considered.

- Alternative development within the UAS planning document would focus on the development needed to support UAS operations in the future. On the other hand, a review of existing and planning airport development either to discussions with airport staff and/or review of previous planning efforts is needed to create more options that are flexible and reasonable for holistic airport growth.

- Planners should take into consideration that due to the limiting factors of commercial UAS (i.e., communications, size and speed of commercial UAS, altitude limitations, and facility needs) segregation of manned and unmanned facilities and operating procedures will likely to be the norm for foreseeable future. However, considering the rapidly evolving UAS industry, alternative planning options that preserve future flexibilities are preferable. These may include potential reuse options for existing facilities as well as designing robust infrastructure and other airport facilities that could serve mixed-use aeronautical options.

- Integrate UAS into the facilities implementation plan: The facilities implementation plan shows how the airport sponsor will implement the planning recommendations, the UAS could be integrated similar to the manned counterparts by following their planning and integration framework. The plan could be complex(e.g., UAS implementation for a large scale master plan update) or simple (implementation plan for a limited UAS planning study). As with any proposed airport facilities implementation plan, UAS improvements can be scheduled based on planning activity needs/ demand triggers rather than particular years. The demands could be forecasted into short-term(0-5 years), medium-term(5-10 years), and long-term (10-20 years).

- Further UAS analysis should consider the potential environmental impacts (e.g. noise), land use and zoning implications, grant assurances and funding issues, stakeholder and public engagement, compliance with local and regional comprehensive planning efforts, and airport-specific actors should also be considered (Booz Allen Hamilton.et al, 2019).

LAND USE AND ZONING COMPLIANCE

Land use on and adjacent to airports are managed by federal and state legislative codes and grant assurance requirements, which apply to UAS. According to FAA Grant Assurance 21 and Title 49, United States Code (U.S.C.) § 47107 (a) (10), the airport sponsor and local municipality should adopt zoning requirements that “restrict the use of land adjacent to or in the immediate vicinity of the airport to activities and purposes compatible with normal airport operations, including landing and takeoff of aircraft” (Booz Allen Hamilton.et al, 2019).

As far as the UAS operations are concerned, the fundamental limitation is the airspace and restrictions placed on that airspace. UAS operations-basically falls into one of two categories related to land use; either the UAS operators would need facilities and access to the airfield (hangars, ramps, movement area), or the ones that do not require these facilities.

If the UAS operator does not need the use of the airfield facilities, then the use of property near the airport may become an issue. UAS operators can operate from property not owned by an airport; if they do not violate airspace restrictions and are outside of 5 miles from the airport boundary, then coordination with the airport is not required. According to the (Kenneth Neubauer et al & P, 2015) P.32, there weren’t any notable land-use compatibility issues related to UAS integration in NAS that was mentioned during the making of the primer(Unmanned Aircraft Systems (UAS) at Airports: A Primer).

The primer also mentions that long-range planning for land use and UAS should be approached from a different angle. The Primer (Kenneth Neubauer et al & P, 2015) suggests planners and airport managers take the master planning approach in creating a vision for future UAS operations, where land use planning plays an important role in the approach. Long-term planning about where the UAS support services such as permanent ground-based control stations may be located, as well as storage of equipment and maintenance facilities that may require airfield access, may be important approaches for the airports that plan to attract UAS operators.

PRIORITIES IN 2020

This paper was at its final stages during the month of May 2020, the cases in the U.S has reached 1.3 million and 4.25 million worldwide (WHO, 2020). During a WHO press conference on 13th May 2020, Dr. Michael Ryan, executive director of WHO's Health Emergencies Programme, has cautioned that the Coronavirus may never be fully eradicated and become endemic.

If the Coronavirus becomes permanently a part of the communities across the world, the strategies of transportation must evolve to serve the community with timely, safe, and efficient transportation of medical supplies like emergency blood supplies, vaccines, medicines, PPE equipment, diagnostic samples, and even organs.

The UAS is increasingly looked up as a solution to the transportation challenges of medical goods mentioned above. The Proof-of-concept tests have demonstrated the technical viability of the UAV to safely transport medical supplies and keep them within the required parameters of the clinical viability (Margaret Eichleay et al, 2019).

Few research studies have determined the cost-efficiency of UAS in integrating into medical supply chains or the optimal placement for the UAS hubs.

CASE STUDY- DELIVERING TRANSFUSION BLOOD AND OTHER MEDICAL SUPPLIES ACROSS RWANDA

The East African country of Rwanda has commissioned Zipline, an American medical product delivery company headquartered in South San Francisco, California that designs, builds, and operates drone aircraft.

The focal point of this operation is to handle all blood deliveries to a total of 21 transfusion facilities and serve 11 million people within a 30-minute delivery zone of essential medical supplies. As of June 2017, Zipline has utilized 15 drones at its distribution center in Muhanga.

Each drone apparently makes an average of one trip per hour with delivery times ranging between 15 to 45 minutes. The operation with 15 drones makes 15 shipments/hour or 150 shipments per 10-hour day.

The Zipline cargo drones are operated from a considerably smaller space such as a shipping container that is located in close proximity to the medical warehouses. Each operation center has a service radius of 75 km. The UAS referred to as “Zips”, can carry at most of 1.5 kg cargo, which the drone drops into a marked “mailbox” area using a parachute before it returns without landing to the operation center. Each drone on average delivers 15 shipments per day.

Zipline drones use GPS technology, RTK GPS, which allows them to precisely target and land at the drop point. The UAS systems rely on Rwanda’s cellular network(3G and 4G) as orders are placed by text message to the distribution center. The time efficiency is substantial, within five minutes after receiving the text on the order, the shipment is delivered within 3o minutes even to the farthest locations.

The UAS delivery system is recorded as cheaper compared to motorcycle-based deliveries. Which was previously considered the most efficient for emergency situations. UAS offers safer and efficient deliveries considering the hilly and mountainous terrains (Chemonics International Inc, 2017).

SUGGESTION

Considering the car-dependent urban transportation of the U.S, the major cities like New York City, with a population of around 8,398,748 as of 2018. The need for efficient essential medical supplies becomes crucial to avoid delays in a pandemic situation. A well-established UAS delivery system could be crucial in crowded cities in the U.S may be very crucial and these activities could be carried out in a disaster management activity.

CASE STUDY 5: UAS IN OUT-OF-HOSPITAL CARDIAC ARREST IN STOCKHOLM COUNTY, SWEDEN

The Karolinska Institute in Stockholm, Sweden, together with partners, has tested UASs' ability to decrease response time and to efficiently deliver essential medical products like automated external defibrillators (AEDs) to out-of-hospital cardiac arrests (OHCAs).

Two different multi-rotor UAVs from the German company, HEIGHT TECH GmbH & Co. KG was used in this operation. These drones were operated by two licensed UAS pilots and operated in manual flight command mode. The UASs had a max velocity of 70km/h, with a maximum range of 10km.

GPS coordinates from historical OHCAs in Stockholm County were used in a model using a Geographic Information System (GIS) to find suitable placements and visualize response times for the use of an AED equipped UAS. Two different geographical models, urban and rural, were calculated using a multi-criteria evaluation (MCE) model. Test fights with an AED were performed to these locations in rural areas.

LESSONS LEARNED

The time efficiency of the UAS in urban and rural areas is substantial compared to the EMS. Based on the GIS-simulated model, the UAS arrived earlier than the EMS in 32 percent of the cases. They found that the use of drones in rural areas to deliver an AED in OHCAs may be a safe and feasible option. Although the study is yet to be applied practically, the theoretical implications showed promising results (Chemonics International Inc, 2017).

THE WAY FORWARD FOR THE INTEGRATION OF UAS IN THE MEDICAL SUPPLY CHAINS

The interest in integrating UAS to transport medical supplies is high and growing, however, the health sector lacks structured guidance to systematically consider the feasibility, utility, and the potential of using UAS in their activities. The UAV Delivery Decision Tool is designed to help implementers consider their options and UAV developers to understand the context within which their products need to operate, such tools have the potential to help clear confusion from both sides. If a decision to implement UAV delivery is made, gathering evidence on those activities will enable sustainable and careful integration of this new technology that is likely to revolutionize the transport sector in the next decade (Margaret Eichleay et al, 2019).

Considering the level of severity of the Covid-19 situation, the overwhelming cases in the U.S and particularly the New York State. The COVID-19 situation has put the health industry and workers in a critical position of great stress and danger at the same time. The integration of UAS in the medical industry by outsourcing and proper planning could help the medical personnel better handle the situation.

AIRPORTS CASE EXAMPLES AND LESSONS LEARNT

The case examples would be very helpful in understanding the UAS experiences of airports, contractors, tenants, and state departments of transportation. Firstly, this section will discuss three demonstrations conducted by the Boss Allen team including demonstration details and how it was conducted using the approach discussed in the previous sections.

CENTENNIAL AIRPORT

The centennial airport, Englewood, Colorado have effectively incorporated UAS at their facility. The UAS has operations that are operated by two staff who are FAA certified remote pilots, in compliance with 14 C.F.R. Part 107. The airport has created an MOU between the FAA and the airport authority to ensure safety and risk-free operation. The MOU outlines procedures and safety mechanisms that need to in place before each mission. In the case of non-emergency operations, the airport officially requests FAA approval of the flight through the AirMap app/ FAA LAANC system. To avoid conflicts with regular operations of the airport during UAS missions, the operator utilizes the call sign “Cyclops One” and actively monitors the tower frequencies.

The airport also has plans in place to support the airport’s contractors and tenants to operate UAS on the airport, once the requests are placed to operate UAS on the airport, these operators would need to work under the direct supervision of the airport’s part 107 certified staff and would need to follow all the rules, regulations and safeguard measures outlined in the MOU with the FAA ATCT. (C. Daniel Prather et al, Program, Board, & National Academies of Sciences, 2019)

SOUTHERN ILLINOIS AIRPORT

The Southern Illinois Airport in Murphysboro was one of the pioneers in the country to obtain COAs for operating UAS in their facility. The Southern Illinois airport authorities are the first to use UAS at their airfield for daily part 139 inspections, wildlife management, etc (Brewster, 2016). The airport has documented numerous events, projects, and impacts on the airfield and surrounding areas using UAS. For example, the airport used UAS to document environmental and infrastructural damage related to the May 2017 flooding of the Big Muddy River. The airport also assisted the local community in searches, working with Jackson County Sheriff's department utilizing the UAS technology. The airport also used the technology to document numerous projects and their impacts within and beyond the boundary of the facility using real-time pictures (C. Daniel Prather et al, Program, Board, & National Academies of Sciences, 2019).

KILLEEN-FORT HOOD REGIONAL AIRPORT (GRK)

The Killeen-Fort Hood Regional Airport (GRK) in Killeen, TX is a military airfield with a civilian passenger terminal as an airfield tenant. The facility has been hosting the U.S. Army's UAS operations on a regular basis. MQ-5B Hunter and the MQ-1C Grey Eagle are the two primary UAS flown at GRK. The UAS operations at the facilities are normally conducted four days a week with plans to increase in the near future. The airport supports 26 commercial operations every day.

The following are some of the key lessons

- Airline-UAS schedule deconfliction: GRK UAS operators use the NOTAM system to keep other flying agencies informed of the UAS activity. The NOTAMs also inform general aviation pilots in the area of the UAS operations so they are aware and can include UAS in their schedule.

- Lost link loiter point planning: According to the UAS personnel at GRK, in the event of a lost link, there would be constant communication between the UAS operators, ATC, and the local community would be established. A spot would be selected that is not above a populated area, does not interfere with the airport's traffic patterns, and will not result in land-use issues should an aircraft go down while in their holding.
- Airfield education for UAS maintenance personnel: In light of an incident at the facility involving the UAS personnel, GRK instituted an indoctrination training program for UAS operators to enhance safety on the airfield (Kenneth Neubauer et al & P, 2015).

CONCLUSION

Integration of UAS is a paradoxical topic where most of the general public as well as the airport community views the UAS operations as a threat to the primary manned operations of the airport. But by considering the potential of UAS in the hands of the trained, structured, and safely operating professionals, they could perform vital time-sensitive tasks that could accelerate disaster and crisis management by aiding in the response and recovery processes.

Considering the role, the airports play in the community, as a transportation hub in normal times, and supporting the community in emergency situations. UAS when systematically integrated with the airports could greatly aid the airports in serving the local and regional needs when the situations occur.

Moving forward, the planning community should take into consideration, the various roles and functions UAS can perform at the airports to the airport administration as well as the tenants (e.g.

Ground and infrastructure Surveying, construction management, wildlife monitoring, damage, and debris assessment, small package delivery, etc.) include the UAS elements in the Airport Master Plan, Safety Management Systems (SMS)plan, Airport Emergency Plan(AEP) and Facilities Implementation Plan(FIP), etc.

The accountability of data collected by the UAS in the form of images and videos should be regulated and monitored through appropriate laws and regulations to make sure that the fair use of the UAS's abilities is assured.

The federal and state policies evolve every year to integrate UAS in the airports. FAA has introduced several policy options and waivers for this purpose. The planners at the local community should incorporate these elements into their land use and zoning law to accommodate these policies. Similarly, considering the ever-evolving nature of the UAS through technological advancement, planners should systematically develop the policies.

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ANNEXURE

Element	Description

Goals and Objectives	At a minimum, the objective of a CONOPS includes the seamless integration of the UAS into the already existing CONOPS architecture at airports. To achieve this objective, emphasis should be placed on the (1) primary use for the UAS, (2) the method of operation, and (3) the required crew and infrastructure necessary to operate the UAS. • Primary use for the UAS: The operation of UAS at airports may require prior approval and authorization by the FAA in the form of a certificate of authorization (COA) issued to a public aircraft operator or a COA/Exemption issued to the operator of a civil UAS not operating under Part 107. For sUAS operated under Part 107, if the airspace in which the sUAS is to be operated is Class B, Class C, or Class D airspace or within the lateral boundaries of the surface area of Class E airspace designated for an airport, the operator will be required to have ATC approval in the form of an airspace authorization or an airspace waiver issued by the FAA. Airports should review the contents of the COA, Exemption and/or airspace authorization/waiver which detail among other things, the use of the system, and the method of operation. • Method of operation: The COA or other applicable FAA approval may also contain the method and manner in which the operator intends to use the system, including information on 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 to 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, and 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 UAS would be operated), should be considered and identified.
Key Components of the System	The CONOPS should define what components would be integrated into the system as well as those systems not needing integration, but may still 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 (PIC)/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

System Operation	The operation of the system is a step-by-step process that gives 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 • 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. These include: • Command and control datalink • Voice communication equipment • Navigational Aid (NAVAID) utilization by UAS
Limitations of UAS Operations	There may be an initial desire to treat UAS as traditional manned aircraft, but the inability of UAS to meet many requirements and restrictions placed on manned aircraft is of particular concern to ATC and other airspace users. Integration of UAS and manned aircraft operations requires evaluation and consideration of certain procedures. 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) • Notices to Airmen (NOTAMs)