USING DRONES IN DISASTER AREAS: PERSPECTIVES OF DISASTER RESPONDERS IN NORTH CAROLINA, VIRGINIA AND MARYLAND

by

Victoria Tanner

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Director of Thesis: Dr. Erol Ozan

Major Department: Technology Systems

Drones are pilotless aircraft and are more formally known as either unmanned aerial vehicles (UAVs) or unmanned aircraft systems (UAS). Drones, as they were referred to in this study, have the capability of being remotely controlled or flying autonomously through software-controlled flight plans that are embedded as part of their navigation systems. The navigation systems include onboard sensors and GPS that provide options to expand the range of responses in dealing with emergencies. Although, drones have been more widely used for military operations, they are increasingly being used as part of emergency response and public safety operations. This aspect of emerging drone use in North Carolina, Virginia and Maryland is the overarching purpose of this study.

This study explores factors that influence the effectiveness and efficiency of using drones for disaster preparedness and response operations including assessment of damage following disasters, re-establishing critical communication channels, rescue and evacuation of victims, and the delivery of much needed supplies. It also analyzes specific disasters involving flooding due to hurricanes, and damage as a result of tornadoes and brush fires in North Carolina, Virginia, and Maryland. Due to the impact of climate change, extreme temperatures, rising sea levels, extreme hurricanes and decreased water

resources, the fact that these three states have been affected by billion-dollar level disaster damage is cause for concern.

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Victoria Tanner

APPROVED BY:

DIRECTOR OF THESIS: _____
Erol Ozan, Ph.D.

COMMITTEE MEMBER: _____
Leslie Pagliari, Ph.D.

COMMITTEE MEMBER: _____
Kanchan Das, Ph.D.

CHAIR OF THE DEPARTMENT OF TECHNOLOGY SYSTEMS _____
Tijjani Mohammed, Ph.D.

DEAN OF THE GRADUATE SCHOOL _____
Paul J. Gemperline, PhD

DEDICATION

In loving memory of my mother, my guardian angel, Joyce B. Powell, who supported me with her love and prayers, and instilled in me the belief that I could achieve whatever I wanted to achieve.

To my family, who prayed for me without ceasing throughout the research for this study and encouraged me continuously with the meme, “you got this.”

In memory of my childhood friend, my inspiration, Benjamin D ’Angelo (Angelo) Gibbs, who lost his life in the 1974 Super Tornado Outbreak in Huntsville, AL (Madison County), and developed in me a heightened curiosity of natural disasters.

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CHAPTER 1

INTRODUCTION

Obtaining crucial information following a disaster is essential for effective disaster assessment and management of recovery operations. The capacity for rapid data collection has often been an issue as post-disaster environments can be challenging due to delayed access to impacted areas (Morton, 2011, p. 1). Reducing response times for the delivery of critical services to victims of natural disasters is a key aspect of managing the response effort. At present, emergency management agencies in North Carolina, Virginia, and Maryland are in the early stages of using drones to provide faster and more efficient data collection from disaster areas. To date, there is limited research on the specific benefit of drone technology to emergency management. To analyze the effectiveness of the drones to emergency management, a survey will be administered to key emergency responders and public safety officials on their current processes for the collection of vital information to include observations from aerial imagery needed to assess costs, response times, and the amount of time needed to reach remote areas and to ascertain if drones are utilized as part of the process.

Management of disasters follows a general lifecycle pattern of three phases involving preparedness, assessment, and response. (Erdelj et al., 2017) classify particular disasters into the three broad categories as indicated on Table 1.1.

Disaster Type	Description	Examples
Type A	Geophysical	Earthquakes, Tsunamis, Volcanos, Landslides, Avalanches, Flashfloods
Type B	Climatological involving extreme temperatures	Droughts, wildfires
Type B	Human induced hazards	Structural collapse, Power outage, Fire or hazardous material contamination
Type C	Meteorological	Tropical storms, Hurricanes, Sandstorm, Heavy rainfall

Table 1.1 Types of Disasters

The most powerful of Type C natural disasters are hurricanes due to their size and potential for destruction. In a recent publication about hurricanes, Drye (2017) stated that "Hurricane Harvey is the most serious storm to make landfall in the U.S. since Hurricane Wilma in 2005 and has been branded as an emergency management director's nightmare" (p. 1). Similar to hurricanes of its kind, a critical aspect of the emergency management focused on detecting damage to seawalls and piers, locating submerged debris (mooring, handrails) and determining safe lanes for sea navigation (Murphy et al, 2008). During recovery operations from Harvey and Wilma, critical infrastructure including utility networks had to be repaired while providing shelter, either temporary or transitional housing. During both emergencies, there were significant public relations efforts and a commitment to victims in damaged neighborhoods to restore various public services.

In this sense, supply chains were vital for two key reasons. First, there was an aspect of business continuity for construction repairs that relied on the flow of goods and services. Emergency planners viewed these repairs as an aspect of production that needed to be completed within a specific timeframe. Another aspect of the response was the efficiency of the production. As an example, production as reconstruction of housing stock often involves difficult choices about qualified builders, acceptable build sites, and monitoring of pricing to avoid excessive jumps due to demand for not only services, but also materials. Depending on the magnitude of displaced victims, temporary housing as prefabs could involve logistics issues such as the amount of space allotted for families.

Equally destructive, tornadoes as another Type C disaster are brief, violent storms and can cause winds in excess of 300 kilometers per hours. “In 2011, an EF-5 tornado (more than 200 mph wind-speed) was responsible for the widespread devastation in Joplin, Missouri” (Knox, 2017, p. 1). Tornadoes are on the rise as the outbreaks of F-5 tornadoes have worsened over the last few years. The most common natural disaster is flooding and although it is a slowly developing disaster, people can still be trapped in oversized areas. Often tornadoes hit small rural communities where they destroy a large percentage of structures. During tornadoes, many residents hide in their basements and emerge to find not only their homes, but entire neighborhoods destroyed. The lasting effects of a tornado are the impact of survivor uncertainty and the related loss of perceived control. Aldunce et al. (2014) argue that the threat to self, the condition of one’s home, and the threat to financial security, and neighborhood unleash a host of uncertainties that may be mitigated by information as an antidote that may lead to communal ways of coping with the disaster.

The role of information in mitigating such uncertainties is crucial for wildfires as Type B disasters. Wildfires have increased in recent years and prediction has become an essential tool in coping with the related uncertainty. Understanding the behavior often involves predicting the fire intensity, rate of spread, and the spread direction. Simulating large scale wildfires is a challenging computational task because the complexity of the spread, size of the fire, and longtime duration (Guo, 2011, p. 111). The recent events in Paradise, California is an example of the devastation of wildfires as a disaster, and the unpredictability of the rate of spread and direction of spread contributed significantly to the tumult.

While the time-scale for flashfloods as Type A disasters vary, managing flooding as a disaster category is also information intensive and relies on geomorphological mapping. Such mapping involves collecting landform data and river morphology as a dynamic landscape entity (Rusnák et al., 2018). Because flooding is a slowly developing disaster, “drone observation can predict how flooded the area is, which buildings are at risk, and where to evacuate citizens.” (Restas, 2015, p. 319). Specifically, photogrammetry from drones provides real-time landscape monitoring and photogrammetrically-derived digital elevation modeling.

In each of the major categories the preparedness phase could be developed over a period of years before the actual disaster occurs and may not have a specific timeline. The assessment phase takes place during the actual disaster and may not allow for travel to affected regions to provide support and/or treatment to those who may be trapped or injured, and while determining the needs and delivery service to the affected region.

The final phase occurs during search-and-rescue operations, generating repairs to power lines, restoration of vital utility services (water, electricity, gas) and removal of debris from critical transportation networks. In responding to the emerging role for drones, the African Utilities Technology Council stated:

> Drones are uniquely suited to assess damage to utility infrastructure in the aftermath of natural disasters, such as a flood, tornado or hurricane. Utility maintenance and outage restoration efforts are greatly enhanced by using many kinds of smart technologies and drones are a key piece of this new story ((AUTC), 2017, p. 2).

In assessing the perspectives of emergency managers and public safety officials on the use of drones, the goal of this study is to determine how they perceive the performance and design of drones, and related sensors and battery technology. In this context the approach is to assess common views on how drones improve cost effectiveness and efficiency in terms of the allocation of resources needed such as the appropriate number of ground crews, necessary equipment, and communicate pertinent information such as blocked roads, unsafe bridges and areas that need repairs the most.

Within the various agencies responsible for emergency management, there is hope that drones will become an increasingly invaluable source for relaying critical information when the communications infrastructure fails. Agencies such as the regional Emergency Management Office, law enforcement, and fire departments all have varying demands and ways of assessing the use of drones in their response effort. Another goal of this study is to utilize a common framework for assessing the effectiveness and efficiency of drones in terms of factors that impact the various stakeholders as emergency

managers. Beyond the performance factors, this approach also includes demographic factors involving experience categories with or without the use of drones, and compliance and regulatory factors for operating drones. In establishing this approach, the goal is to integrate the various phases of emergency management including the final phase that involves search-and-rescue operations, generating repairs to power lines, restoration of vital utility services (water, electricity, and gas) and removal of debris from critical transportation networks.

This study utilizes a mixed method approach to collect both qualitative and quantitative data using a survey instrument administered to state emergency managers, emergency responders, and local public safety officials across North Carolina, Virginia and Maryland. Survey questions will be framed from four themes: demographic factors, operational and performance factors, manufacturing design factors, and regulatory and compliance factors. Demographic factors include information on where participants support emergencies, the types of emergencies they are faced with, and whether or not drones are used as part of the process. Operational performance factors involve participants' perspectives on data quality and integrity, and manufacturer design factors that include acquisition costs and the effectiveness of flight controls. Lastly, regulatory and compliance factors involve perspectives on FAA no-fly restrictions and certifications.

Although, North Carolina, Virginia and Maryland face many of the same emergencies including hurricane, tornadoes, wildfires, and flooding, there are significant differences in lifestyles and political views regarding privacy issues, the role of law enforcement and priorities for funding of the state government.

This study examines how these elements impact the perspectives of emergency managers and public safety officials on operational factors and related compliance factors for drone technology. Similarly, the research examines how experience with different types of emergencies and use of drones influenced those perspectives.

This research focused on three research questions (RQs). They are as follows.

RQ1: How are drones typically used in disaster areas?

RQ2: Does the current drone technology meet the needs of the disaster responders?

RQ3: What are the regulatory and compliance factors, issues, and challenges surrounding the drone use in disaster areas?

In summary, drones have evolved to provide emergency managers the capacity for rapid data collection that has helped reduce the response time for delivery of critical services to victims of natural disasters. Managing these disasters follow a general lifecycle pattern involving preparedness, assessment, and response. Each state operates regional emergency management offices, law enforcement, and fire departments wit drones that have varying demands and uses of drones. The goal of the study is to explore the effectiveness and efficiency of drones among various agencies during a disaster response effort.

CHAPTER 2

LITERATURE REVIEW

This chapter identifies the potential uses of drones for disaster management, assessment, and response. Following the occurrence of the disasters such as tornadoes, hurricanes, earthquakes, landslides, floods, wildfires, tsunamis and volcanic eruptions; rapid retrieval of real-time aerial imagery is needed to assess affected areas. Gathering essential data is challenging as the methods currently used are time consuming and the data collection is often inefficient. In addition, the physical accessibility of the impacted area is crucial in locating persons who are trapped and injured during a disaster, to deliver much needed supplies and restore damage to power lines and the communication infrastructure. In the past, drones have been more commonly used in military operations for surveillance and reconnaissance, and as recreation by hobbyists; however, the use of drones is now being explored for more humanitarian work and aid. Drone technology is constantly evolving and with their numerous and varied applications, the use of drones in the future may be limitless.

The Roles of Drones in Disaster Management

In the past, drones have been used more frequently in the military as smart intelligence for surveillance and reconnaissance objectives; however, the numerous and multi-faceted capabilities of drones are now being evaluated for use in civilian applications. “Drones have received increasing interest for environmental and natural disaster monitoring, border surveillance, emergency assistance, search and rescue missions, and relay communications” (Yanmaz, 2017, p. 1). There is rich literature to

support that drones not only have the capability to offer support in humanitarian actions, but it has already been proven in many areas. The drone's varied applications been used to assist in the rescue of civilians, aerial imagery of inoperable equipment, impassable bridges and roads, logistics and planning, and survey of the disaster zones. Acquiring information quickly is essential in disaster management and relief efforts during natural disasters. Because of their distinctive attributes and data collection abilities, drones are being looked at with a new perspective. Future generations of drones may prove to be effective in enhancing situational awareness and evaluating information (Tanzi et al., 2016). There are advantages to using drones in the disaster management field, but there are also challenges that they need to overcome. Drones need to achieve the appropriate level of autonomy in terms of navigation and the interpretation of data by sensors. Secondly, the reliability of these systems is in question with respect to safety and security. New approaches and technology are needed for more efficient risk management.

We are living in an age of drones and they are being used for everything from hobbies to commerce. It is estimated that a million drones equipped with cameras were purchased in 2015 and have the ability to be controlled with cell phones. The drone industry is steadily growing and manufacturers continue to improve the current features and capabilities that they offer. Drones are being used in many areas to include utilities for inspections and repair to power lines. They are being used by the military, police and fire departments, and other public safety organizations for search and rescue and disaster recovery.

Drones are enabled to provide assistance and mitigate the impacts of communication failure, damages to the infrastructure and transportation systems, and the

collapse of healthcare facilities. In developing countries, drones are being evaluated as an alternative means of transporting relief supplies because traditional transportation methods such as trucks and helicopters are unable to get into remote locations during disasters. Nedjati et al., (2006) reported that drones are an additional means of transportation to mitigate last-mile distribution logistics problems involving delivery of necessary supplies such as water, medicines and other light disaster relief items to cut-off regions. They also offer potential in terms of costs and are more expedient in comparison to other modes of transportation.

Recently, U.S. Sen. Mark R. Warner and Tim Kaine announced that a grant of $876,913 has been awarded to Virginia Tech in addition to the 1.7 Million from the National Science Foundation (NSF) to research drones to help Virginia develop an approach to disaster compliance that integrates physiological and infrastructure response in the event of the loss of critical services such as utilities, transportation systems due to a natural disaster. Senator Warner also stated that “first responders are already using drones to help respond to natural disasters, battle wildfires, conduct search-and-rescue, and assess environmental and infrastructure damage” (Publications, 2016). The funding will provide Virginia Tech with resources to further advance the use of unmanned technology in emergency response. The goal is to accelerate the recovery of communities and to facilitate normalcy to families and business productivity in a timelier manner following a disaster.

Drones and Disaster Management

Drones have many capabilities to improve and augment disaster management and recovery. In any crisis management scenario, the collection and use of information is critical for an appropriate emergency management response. These responses are especially critical in heavily populated areas such as Jacksonville, Alabama where a tornado touched down in February 2018. The response to the tornado in Jacksonville was an example of emergency management with Disaster Cells coordinating responses for all four phases of the disaster management cycle including preparedness, response, recovery, and reconstruction. The response in Jacksonville demonstrated that despite the rapid flow of information to these Disaster Cells, observations and related assessment of the affected regions are limited by low visibility at night and cloud cover.

The operations in Jacksonville involved limited use of drones which can be equipped with different types of sensors. Since drones operate at heights that limit the impact of clouds, drones have emerged as tools that accelerate the flow of information to Disaster Cells. The use of drones is expanding rapidly, and there has been a sharp increase in the number of commercial drone pilots. The Federal Aviation Administration (FAA) has granted more than 59,000 U.S. certificates to commercial drone pilots since they began issuing certificates in 2016 (Goss, 2017, p. 2). With natural disasters becoming increasingly more common, the demand for drone pilots is likely to grow, especially as the use of drones has continued to rise for disaster management and damage assessment.

Oklahoma State University (OSU) researchers are confident that drone technology has the capability to enhance weather forecasting. Scientists at OSU are currently in the

process of designing flying storm chasers to fly into the storm cells of tornadoes and send back information to meteorologists. This effort, if successful, could be vital in tornado preparedness initiatives by providing more precise information on the strength and course of tornadoes, therefore, allowing for advance notice in regions of America that are prone to tornadoes to evaluate sooner. A storm chaser, currently in operation, was sent up by storm trackers and was able to capture images of the devastation caused by April 2014 tornadoes. (Monaghan, 2014, p. 1).

Drones are revolutionary and are making a definite impact on public and commercial arenas. As the technology advances, there are more and more applications that drones are equipped with for the numerous tasks that they are assigned. Three commercial drones, an AirRobto AR100Bquadrotor, an Insitu Scan Eagle, and a Precision Hawk Lancaster, were deployed to the 2014 SR-530 Washington State mudslide. These flights would allow geologists and hydrologists to evaluate the risk of loss of life to responders from further slides and flooding as well as gain a clearer understanding of exactly what occurred. Together, two of the drones were able to create a 2D and 3D reconstruction of the inaccessible “moonscape” region. The reconstruction would produce a real-time remote assessment of the river mitigation project. This was the first time that drones were able to fly within the same airspace as manned-aircraft during a disaster. Although the initial flights were cancelled due to privacy concerns, it proved to be a lesson pertaining to operational concerns such as terrain, trees and power lines. The deployment provides lessons on operational considerations imposed by the terrain, trees, power lines and accessibility. According to Murphy et al., (2008), the SR-530 mudslide killed 43 people and 49 homes were also destroyed. The ground was

inaccessible by foot or a ground vehicle due to mud which was very much like quick sand, and the manned aircraft could not acquire a complete survey because they had to stay at a safe attitude of 500 feet. A narrow canyon produced gusts of wind that could present a danger if debris got sucked into the rotors of the helicopter and caused a crash. The manned aircraft could not be used on a daily basis due to the cost of $250 (10 times more an hour) than the cost of the drones at $25 per hour.

Hurricane Harvey, a category 4 storm made landfall in Texas in August 2017, and sets a context for Type C meteorological disasters. The FAA authorized the use of drones for federal, state, and local officials to assess damage and establish priorities for response and recovery efforts. As an illustration, the City of Houston issued temporary flight restrictions for nongovernment drones within 100 miles of Houston for the early days of the Harvey response efforts (Goss, 2017, p. 2). Such restrictions are not uncommon for the use of drones and other technologies by law enforcement. Although drones are acknowledged for providing law enforcement with unique capabilities that are not available with helicopters, privacy advocates have raised concerns that drones may be used to conduct surveillance and lead to the abuse of technology. Similarly, other advocates worry that drones may be armed with lethal weapons. (Gettinger, 2017, p. 5).

Roads blocks and the time limits create difficulties for the response effort following earthquakes. In many cases, damage to roads, buildings, and bridges prevent transportations networks from functioning efficiently. For the evacuation of victims, traditional airplanes and helicopters continue to provide the main pathway to safety, but for areas that cannot be reached by conventional aircraft, drones are proposed as an integral part of the emergency response phase. By providing much needed information

to assess damages quickly and the delivery of critical supplies for affected people in non-accessible areas, drones may become part of a relief distribution system as they can supply a large amount of demand in the least amount of time and can work without disrupting the ground transportation systems (Nedjati, 2016, p. 1669).

The Volcan Project brought about awareness that drones equipped with remote sensing technology would be able to sense the plume in the proximity of the crater of a volcano. “A navigation system has been realized with the aim of making the drones autonomous and able to perform a complete gas sampling mission without human intervention” (Astuti, 2009, p. 480). There is evidence that measuring the chemical composition of gases inside the plumes can be beneficial in forecasting volcanic eruptions. In situ gas sampling is not an easy operation and posed serious risks to scientists, whereas a drone equipped with sensor units for gas analysis can collect data during eruptions that can used as input data for computer simulated volcanic activity. This would enable scientists to significantly improve their forecast of long-lived volcanic phenomena.

While a massive wildfire raged out of control in Bel Air, California, the Los Angeles Fire Department made the decision to bring in two drones. The drones had the ability to detect, contain and extinguish fires faster and with greater safety (Baggaley, 2017, p. 2). The drones were equipped with cameras and provided firefighters with a clear view of where they were needed the most and also determined which communities would need to be evacuated. This is just one instance in which drones were used to fight wildfires and facilitated in saving lives.

Types of Drones

The Center at Bard College (2017), reported on the make and model of drones being used by the 347 public safety departments they studied. The Center at Bard College indicated that there were 35 different types of drones made by 23 manufacturers. Of the 315 public safety departments providing drone data, the Center found that 252 departments acquire the DJI Phantom or DJI Inspire. Cost has emerged as an important element in how drones are being adopted by public safety departments because the DJI drones are typically marketed to consumers and hobbyists while high-end, specialized drones targeted for public safety departments have had much less success. The researchers at Bard College could not verify information on how the majority of public safety departments acquired their drones, but the study determined that 82 public safety offices acquired their drones through several means including donations, grants, special funds, and civil forfeiture.

Drones are being evaluated for use in a lot of different areas because of the varied applications they offer. The RQ-4 Global Hawk Drone, impressed in the restoration of the infrastructure from the effects of Hurricane Matthew, September 2016. The drone monitored Hurricane Matthew for the National Oceanic and Atmospheric Administration (NOAA).The drone's sensors recorded the temperature, humidity, wind speed, and direction. It was also able to examine the formation, structure and intensification of the storm and deliver real time data to the National Hurricane Center. The Small UAS Rule (FAA regulation Part 107) went into effect August 29, 2016 approving commercial drone operators to fly with exemptions under Section 333 of Public Law 112-95, and they were able to fly storm recovery missions. The RQ-4 Global Hawk belongs to NASA, and is no

ordinary drone with a flight time of over 30 hours and can fly at attitudes of 60,000 ft. The RQ-4 Global Hawk clearly demonstrates what is possible with drones and their applications without having to put manned pilots in harm's way. Other commercial drones were also used by utility companies in Florida and Georgia to identify areas that needed to be cleared of fallen trees and debris in order to reach the source of power outages instead of using power company employees which may be endangered by damaged power lines. Airborne technology is proving to be cost effective and improve the reliability of utility companies with its inspection and monitoring capabilities.

Using Drones for Search and Rescue

People often get displaced during natural disasters, and drones are frequently used for Search-and-Rescue because their ability to can get into tight areas that helicopters cannot get into. Another advantage that drones have is the ability to be to find the missing person or persons a lot more quickly and if needed deliver food, water, medicine or small relief items until someone can get in to area and get them out. Conducting search-and-rescue missions the old way is not as efficient and a person could possibly lose his/her life if not found in a timely manner. However, a remote pilot and a preplanned trajectory for the search-and-rescue mission is used to optimize the search. An estimation considering various factors is based mainly of fuzzy logic is completed to determine the potential risk/occupancy degree of the gridding map. There are four way used to calculate the drone discrete path planning. These methods are an original proposal called attraction, fuzzy logic, ANFIS and a PSO algorithm and they determine the location of the waypoints to be followed by the drones. This minimizes the distance and risk that the person may be exposed to. A swarm formation of drones may be tested

in a real simulation scenario and evaluated to see which method would be the best for the search-and-rescue mission.

Drones were used for a Search and Rescue (SAR) operation in Wahclella Falls Trailhead, a 1.6-km box canyon in the Columbia Gorge National Scenic Area in Oregon to find a missing person. Rescue crews were brought in and searched for several days, and portable UAS were brought in to offset the ground search and were able to acquire images of areas that were hard to reach or were difficult to search especially at the bottom of the cliff and stream. Van Tilburg notes emphatically the multiple ways that drones can be deployed:

Drones can be used for a variety of applications: as weapons or to carry weapons; for reconnaissance, surveillance, and search; for logistics such as delivering supplies and equipment; for research and data collection such as with agriculture, land survey, and weather; for communication; and for aerial photography (Van Tilburg, 2017, p. 116).

Drone technology is rapidly evolving and with its numerous applications and should be considered as another tool for SARs.

Developments in FAA Regulations and Compliance for Drones

As transformational as drones have been and have expanded in many areas, there are still issues such as regulations, safety and privacy that are being addressed. Disaster managers are working continuously to ensure that FAA regulations address the specific roles in emergency management. Drone researchers are working with manufacturers to optimize the features of drones and integrate the new technology into practices and procedures. Although drones have obvious benefits, it has not been smooth sailing with

the exemption process or in getting certificates of authorizations (COAs) in shared airspace. Drone operators as well as DOD must apply for exemptions and COAs under Section 333 of the FAA Modernization and Reform Act of 2012. A group of Senators have concerns regarding the delays in the rule-making process and are trying to get an update from the Federal Aviation Administration (FAA). The DOD is particularly interested as they want to expand the use of small drones. The Senators are not confident that the FAA will formalize a strategy to meet the congressionally mandated deadlines to safely integrate drones into the national airspace. Although the exemptions and the COAs under Section 333 are an alternative until the regulations have been finalized, it is an arduous and extremely frustrating process. That means that manufacturers of drones have a lengthy wait on getting approval, while on the other hand drone operators may wait or take a chance and fly their drones with a certification. For these two reasons, the senators have concerns about the overall process for getting the COA and the Section 333 application process and the repeated delays (Lehrich & Rifkind, 2016).

The FAA is concerned about drones flying in the nation's airspace, safety, and citizens being concerned about privacy issues and people are worried about the potential for monitoring and the government's ability to regulate drones. To date, state and local are not permitted to regulate any type of aircraft operations, such as flight paths or altitudes, or the national airspace.

As of 2015, the FAA established a registration task force, the Unmanned Aircraft Systems Registration Task Force Aviation Rulemaking Committee (the Task Force) to develop recommendations for a registration process. Within a month, the committee

submitted its recommendations to the FAA and the Interim Final Rule went into effect December 2015. Although the Interim Final rule was a streamlined web-based registration process, the FAA is currently in the process of fine-tuning the process of being able to obtain a Certificate of Waiver or Authorization (COA), as the process is lengthy and frustrating. The Small UAS rulemaking is classified under the FAA Modernization and Reform Act of 2012. Under Section 333 of Public Law 112-95 the Secretary of Transportation was governed to establish whether certain unmanned aircraft systems may operate safely in the national airspace system. The proposed Small UAS rules defined a baseline limitation, but there are still a lot of restrictions in the use of drones and especially for public safety organizations. While the FAA realizes the considerable benefits to the public, they still have proposed a way to balance security, safety, and privacy.

A how-to manual was created by the North Carolina Emergency Management Association (NCEMA) office to assist other public agencies in integrating drone technology into their emergency management operations and discusses how to obtain the Certificate of Authorization or Waiver (COA) or Special Government Interest (SGI), formally the Emergency COA (eCOA). It also gives a detailed description of the minimum safety attitudes and night small drone operations. The manual provides a description of the various types of drones that NCEMA is currently using and the advantages of each, and how drones can assist with each phase of emergency management at each level of government. Lastly, NCEMA is in the process of creating a statewide deployable remote pilot database for available emergency and disaster support missions. Contact information is provided for additional questions and information.

Drone Technology and the Concept of Autonomy

Drones feature varying levels of autonomy, ranging from non-autonomous to fully autonomous. There are distinct differences between automatic and autonomous systems. Automatic systems are preprogrammed to perform assignments on their own, whereas autonomous systems can deal with unexpected situations by using a preprogrammed rule set to help them make choices. “The United States Department of Defense distinguishes four levels of autonomy in their roadmap for unmanned systems” (Vergouw, 2016, p. 25). The basic level of autonomy for an unmanned system is a human operated system with all the decisions being made by the person regarding drone operation and has no autonomous control over the environment. A higher level of autonomy is a human delegated system that can perform many functions independently but must be activated or deactivated by a human controller. The third level of autonomy is a system that is supervised and given directions by a human. This system along with the supervisor can initiate actions based on sensor data, but only within the scope of the current task. The final level of autonomy is a fully autonomous system. This system receives commands input by a human, translates the commands in specific tasks without human interaction with the exception being in case of an emergency.

Summary of the Findings of the Literature Review

As the literature indicates, drones are being used for a myriad of applications to include, law enforcement capabilities, delivery of commercial packages, delivery of medicines and medical supplies, and for humanitarian actions such as search-and-rescue missions and data collection for assessment and emergency response. Fortunately, the perspective on drones is starting to shift as drone technology is rapidly expanding and

the benefits of using drones are more clearly defined. Although, the FAA has authorized the use of drones for use by federal, state, and local officials to assess damage and establish priorities for response and recovery efforts, however, there are still numerous concerns regarding drones. The FAA is working with the Department of Homeland Security to ensure that drones are used in a manner that is consistent with aviation safety and the provisions of safe air navigation. They are becoming commonplace in our society, and improving drone reliability and safety are paramount to the drone industry. Building safer, more reliable drones, equipped with the latest technology is a priority for drone manufacturers as they are being more widely used by businesses and federal, state and local government agencies to include emergency management and law enforcement. Drones are being integrated into these operations and as they improve, they will become an integral part of disaster management.

CHAPTER 3

METHODOLOGY

As discussed earlier, the methodology for this work consisted of a survey administered to state emergency managers, emergency responders, and other relevant public safety officials in North Carolina, Virginia, and Maryland. In developing the survey, the approach focused on exploring how Disaster Risk Management (DRM) teams viewed the significance of drones in 'facilitating and expediting" the flow of information and reducing response times and operational costs for related activities. The survey questions were developed using four broad themes identified from Bard College's *Drone at Home Report* (2017) and leveraged demographic factors including information on where participants supported emergencies which suggested different approaches to the adoption of drone technology. This study examined whether participants in the survey used drones in any of their operations. The study also reviewed operational performance factors that emerged as a result of the use of low-cost drones prompted by funding limitations. The researcher asked participants' perspectives on the following elements; quality and integrity of the data gathered by drones; key operational factors; design specifications of the drones; impact of funding; flight controls; and the ease of operating drones. Lastly, the researcher asked participant's perspectives on regulatory and compliance factors on FAA no-fly restrictions and certifications for drones that may be targeted for hobbyists instead of public safety or emergency managers.

During this study an online Qualtrics survey instrument was used to gather participants' responses. This was a one-time cross-sectional survey (Creswell & Creswell,

2018, p. 149) where data was collected over a 60-day period. The primary purpose was to determine whether emergency managers and public safety officials across three states were uniform in their perspectives on drone technology and if differences in funding and compliance, and experience influenced perspectives. Given the vast differences in lifestyles and political leanings in terms of privacy, approaches to law enforcement and funding for state government, the grouping of North Carolina, Virginia, and Maryland provided a context based on voting patterns and political leadership.

The survey sample population included a total of 20 emergency managers and public safety personnel involved in Emergency Risk Management. All the respondents were recruited from the group of emergency managers and public safety officials in each state including North Carolina, Virginia and Maryland. The survey data was collected using the Qualtrics survey tool available at East Carolina University. The survey instrument (Appendix B) was developed as part of the study and was administered over the internet. In determining the sample population, the Internet provided a way to draw a random sample (Creswell & Creswell, 2018, p. 150). This research employed survey questions that have not been used anywhere else before. The questions addressed ten key items grouped in the technical and socio-political aspects of drone operations.

In developing the construct for technical capability of drones, the goals were to determine how emergency managers and public safety officials viewed drones in terms of performance, operational elements and costs. Similarly, the construct for socio-political factors asked emergency managers and public safety officials how they perceived drones in terms of certification of drone pilots as emergency managers, and no-fly zones.

Respondents used a five-point rating scale for the survey. The design of the survey instrument is summarized in Table 3.1 and variables are related with the research themes so that it is easily determined how the data collection addresses the research questions.

Table 3.1 Design of Survey Instrument

Factor	Measures by Factor	Convergence
Demographic	Locality: North Carolina, Virginia and Maryland. Drone use in response to hurricanes, tornadoes, earthquakes, flooding, wildfires Experience during hurricane, tornadoes, earthquakes, flooding, wildfires	Establish concurrent and convergent validity analysis of each factor. Examine 11 measures.
Performance	Reporting with drones Assessing with drones Planning with drones Data integrity and reliability of drone data	Establish concurrent and convergent validity analysis of each factor. Examine 4 measures.
Design	Cost and expectations Flight planning/training	Establish concurrent and convergent validity analysis of each factor. Examine 2 measures.
Regulatory and Compliance	Certification Autonomy	Establish concurrent and convergent validity analysis of each factor. Examine 2 measures.

In designing the survey instrument, there was an examination of the extent to which the locality of respondents, their experience with drones, and the types of drones used, and the impact of regulations influenced their perspectives on drone for emergency response operations. Independently, each of these factors might create substantial influence on perspectives; therefore, it was determined that the survey should be

organized around each of these distinct themes as a means to minimize the threats to internal validity and establish an appropriate profile for respondents who could be viewed as similar in terms of each of these factors. Threats to internal validity (Creswell & Creswell, 2018, p. 153) and the various approaches to mitigate threat to validity are summarized in Table 3.2.

Table 3.2 Threats to Internal Validity and Mitigation Approaches

Types of threats to Internal Validity	Description of threat	Actions to mitigate threat
Locality	Funding, training, and compliance may vary by region.	Add questions to determine locality and identify bias due to locality.
Experience with Drones	Participants without direct drone experience may exhibit bias.	Add questions to determine experience and identify bias due to experience.
Experience by type of emergency	Participants without direct experience with particular emergencies may exhibit bias.	Add questions to determine Experience and identify bias due to experience.

Summary of the Approaches Involved in the Research Methodology

The survey to 20 participants was administered using an online Qualtrics survey tool. The one-time cross-sectional survey was open for 60 days to determine whether emergency managers and public safety offices officials across North Carolina, Virginia, and Maryland were uniform in their perspectives on drone technology and if differences in funding and compliance, and experience influenced perspectives.

The survey link, using the Qualtrics survey tool, was administered statewide to Virginia Emergency Management Association (VEMA), and individuals from Maryland

Emergency Management Agency (MEMA), and North Carolina Emergency Management Association (NCEMA). Prior to the official survey being sent out, a pilot survey went out to four people in order to test the link to ensure that it worked properly and those responses were deleted before the official launch. A test survey link was also sent out to VEMA Public Affairs to ensure that everything went smoothly before releasing the survey to such a large number of people, and the Qualtrics survey tool was impressive and it was indicated that it had worked out very well.

The sample email of the survey went out in every email along with the recruitment email. A few people actually emailed back completed copies of the sample survey. The response rate was not at all what was expected, and some of the surveys were started but never completed. The summer turned out to be the time when NCEMA was involved in training exercises. As an agency, VEMA had the least amount of participation even though the survey link went out a second time with a reminder. Over 300 opened the email and only 39 clicked on the email.

In identifying potential survey participants, initial contact was made by reaching out to emergency managers (Emergency Management State offices, and public safety officials to include law enforcement (Police Departments and County Sheriff's Offices), Fire and Rescue, and the Department of Transportation to obtain approval to administer the survey to the various agencies within these states. Numerous calls were made throughout Virginia, Maryland and North Carolina to inquire as to who should be contacted regarding the use of drones, drone operators and those who managed the drone programs.

In talking to the various agencies/offices, it was communicated that there were only a select few within each state that were actually involved in using drones for their programs, and that for the most part whenever assistance was needed using drone they would request a drone from another agency or office. Some either didn't have the resources or were in the developmental stages of acquiring drones. Those who were involved with using drones were happy to provide leads to others in their states that also participated in drone programs. Newspaper articles also turned out to be a good source for actually determining who had hands-on experience with drones.

The number of potential participants was about 500 people, but a more accurate estimate of the target population turned out to be approximately 60 people who were actually involved in drone operations in disasters within North Carolina, Maryland and Virginia.

CHAPTER 4

RESULTS AND ANALYSIS

In this chapter, the results of the 16-question survey are presented and discussed in the context of the three broad research questions, presented earlier and shown again below.

RQ1: How are drones typically used in disaster areas?
RQ2: Does the current drone technology meet the needs of the disaster responders?
RQ3: What are the regulatory and compliance factors, issues, and challenges surrounding the drone use in disaster areas?

Within each of the three states involved in the study, the most frequently recurring emergencies set a context for the use of drones and the relevance of the drones and related sensors to meet the needs of the responder. Similarly, the capability of drone operators and the need to manage the risk to civil aviation was another important factor in analyzing and interpreting the results of the survey.

As discussed in chapter 1, timely collection of information is essential in disaster management and relief efforts, and the results of the survey confirmed that fact.

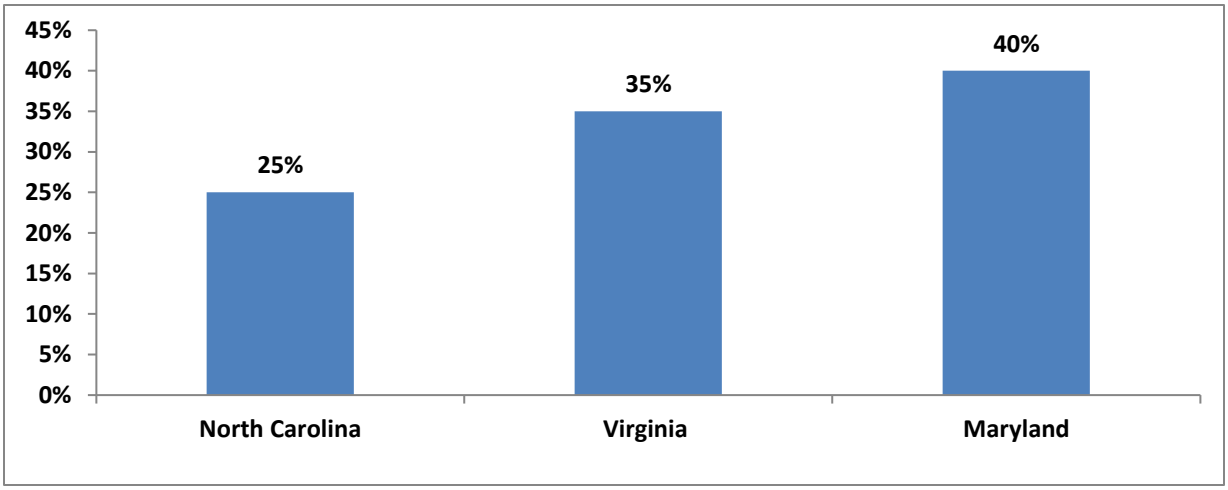

Figure 4.1 Distribution of Emergency Managers and First Responders within North Carolina, Virginia and Maryland.

Overall, emergency managers and first responders confirmed that drones provide distinctive data collection abilities that are transforming approaches to emergency management. 25% of respondents reported from North Carolina, 35% from Virginia and 40% from Maryland.

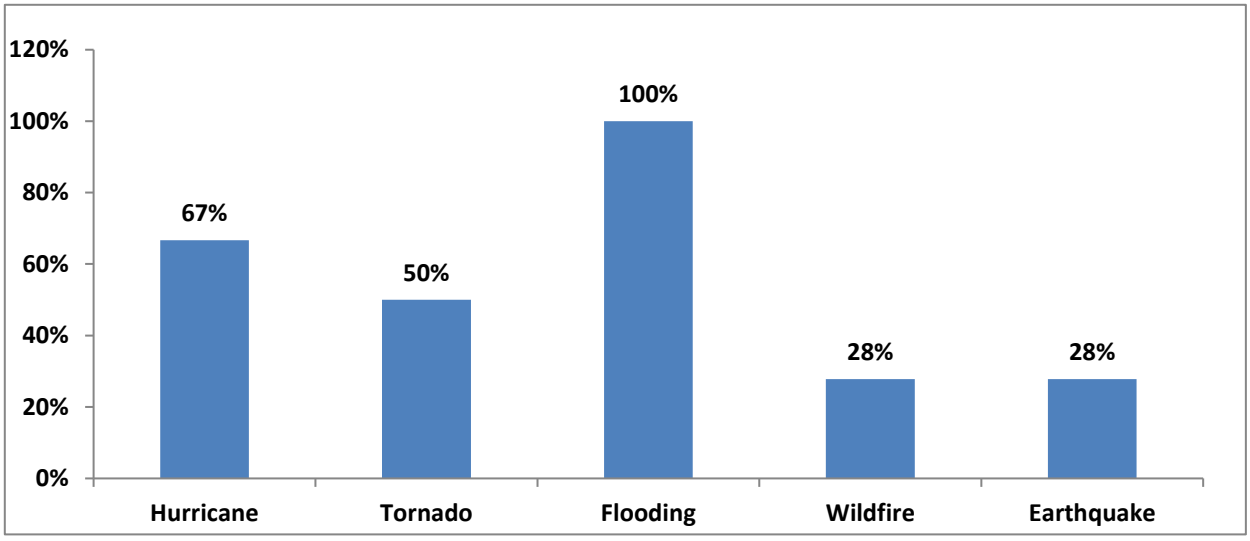

Figure 4.2 Distribution of Experience among Emergency Managers and First Responders within North Carolina, Virginia and Maryland.

Typical Uses of Drones in Disaster Areas

This section provides the findings of the study as they relate to RQ1, which focuses on identifying typical disaster scenarios where drones are often used.

In terms of experience among respondents from all three states, the majority of responders reported (Figure 4.2) that flooding (100%) was among the most frequent emergency followed by hurricanes (67%) and tornadoes (50%). It was anticipated that the similarity of experience would influence the similarity of attitudes among survey participants from all three states, especially as investigation was extended to the level of drone use by emergency category.

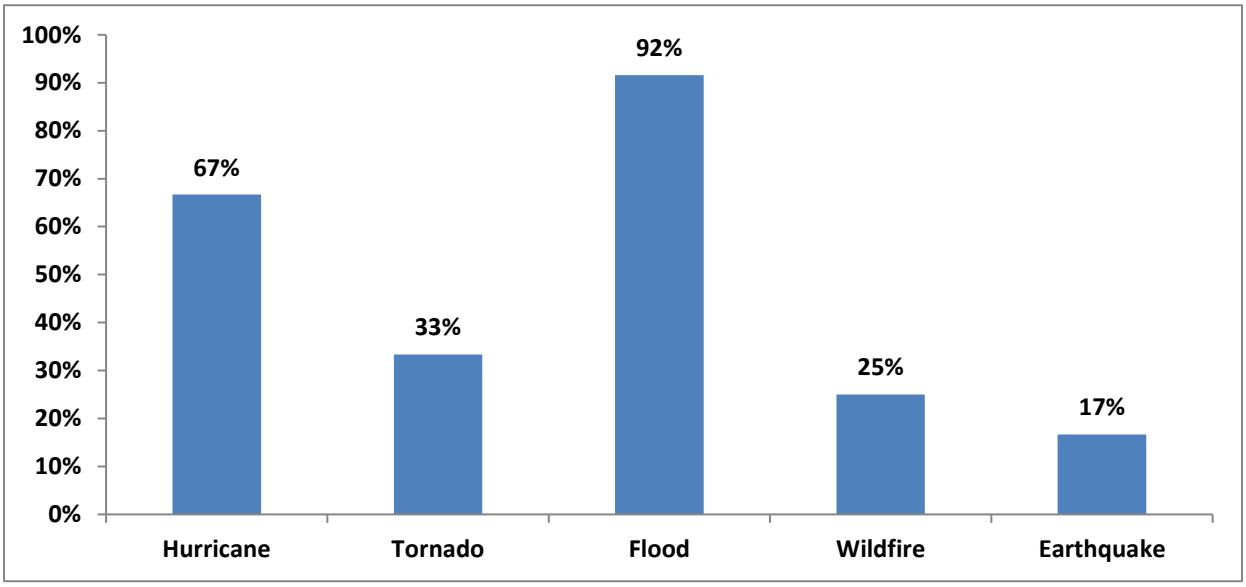

Figure 4.3 Distribution of drone use by emergency category among Emergency Managers and First Responders within North Carolina, Virginia and Maryland.

The result in Figure 4.3 confirmed the trend shown with experience; however, the percentages were higher. Considering experience by drone use, (Figure 4.3), 92% of responders reported drone use during flooding, followed by drone use during hurricanes (67%) and drone use during tornadoes, earthquakes, and wildfires.

Extending the inquiry to specific emergency management tasks, emergency managers and first responders were asked to comment on how drones enabled specific tasks including preparedness, damage assessment, and search-and-rescue operations. In a general trend toward similar experience and similar attitudes about drones, survey respondents reported using drones for search-and-rescue, and crime scene recreation. Drones provided advantages for searching hard-to-reach areas that may be difficult to access by traditional means. Some of the advantages included efficient and economical ways for specific tasks like capturing aerial photos for both preplanning and damage assessment. For search and rescue operations drones provided infrared technology that performed a wider range of detection during day or night operations while moving much faster than people. Respondents reported that drones provided a quick, safe means of determining the extent of damage, the limitation of access to affected areas, and the number and identity of injured individuals and the extent of their injuries.

Maryland-based survey respondents reported that the use of drones provide aerial views of streets, neighborhoods, and land that help the City of Annapolis conduct planning and pre-disaster projects. During a disaster response, the City of Annapolis leverages this information to help Incident Commanders gain situational awareness during search-and-rescue missions, preliminary disaster assessments, security during special events, and other missions reviewed and approved by the Director of Emergency Management.

Among the specific examples where aerial views (photogrammetry or live) gave emergency managers a common operating picture were the following mission types:

Table 4.1 Examples of Aerial Views for Mission Types

Emergency/Response	Impact Area
Flooding by hurricane	Town
Damage by hurricane	Dam
Drained lakebed	Replacement Dam
Base Camp	Large Forest Fire
Landslides	Mountains
Protest/Counter Protest	University

Evaluating Drones' Performance in Disasters

This section provides an analysis of the survey results to address RQ2, which evaluates disaster responders' satisfaction with current drone technology. Results showed that emergency responders in all three states agreed that drones improve response times and permit emergency managers to rapidly deploy aerial vehicles at the scene of natural or man-made disasters, crime scenes, and search-and-rescue operations. Survey respondents reported that drones are an invaluable tool in completing damage assessment during natural disasters and drastically decreases the manpower needed for damage assessment. The responses supported evidence (Murphy, Duncan, Collins, & Kendrick, 2016) that the use of drones provided savings that allowed resources to be reallocated to other search and rescue operations and other life-saving tasks.

In summary, survey respondents felt that drone technology was cost efficient, reliable, and readily available.

In examining operational performance factors (Figure 4.4), survey respondents in all three states *strongly agreed* (mean 1.25), that drones were effective in reporting and assessing risks from various emergencies including flooding, wildfire, and damage from

tornadoes, hurricanes, and chemical spills. Data analysis of the results showed that among the 20 responses, opinions ranged from *strongly agree* (1) to *agree* (2) with a standard deviation of 0.43 (see appendix D) which suggests that respondents shared the same opinion. Results also showed the same trends in Virginia, North Carolina, and Maryland suggests that there were no differences in opinion due to geographic locations.

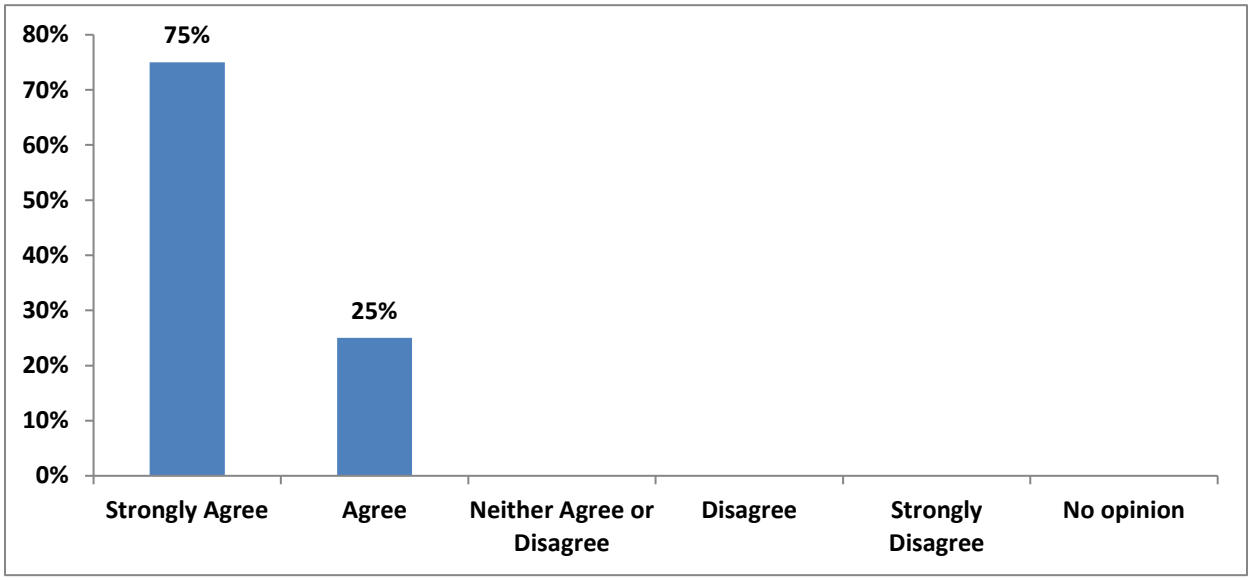

Figure 4.4 Assessment of Operational Performance Factors for Drones among Emergency Managers and First Responders within North Carolina, Virginia and Maryland.

Table 4.2. Breakdown of the Assessment of Operational Performance Factors for Drones among Emergency Managers and First Responders within North Carolina, Virginia and Maryland.

State	Strongly Agree (1)	Agree (2)	Neither Agree or Disagree (3)	Disagree (4)	Strongly Disagree (5)
Virginia	6	2	0	0	0
North Carolina	4	2	0	0	0
Maryland	4	2	0	0	0
Total	14	6	0	0	0

With respect to specific operational features (Figure 4.5), survey respondents in all three states *strongly agreed* (mean 1.53), that drones provided a safe, reliable, and cost-effective means for planning and coordinating responses with high-quality video, GPS locations and other data products.

Evaluation of the results indicated that among the 20 responses, opinions ranged from *strongly agree* (1) to *neither agree or disagree* (3) with a standard deviation 0f 0.60 (see appendix C, table 4.3) which suggests that respondents vary in their opinions about the quality of drone equipment. Results also indicated the same views in Virginia, North Carolina and Maryland suggesting that the perspectives on drones may depend heavily on the quality of drone equipment available to respondents within each locality. This disparity may also be a result of economic disproportion that exists between the regions and within the localities themselves.

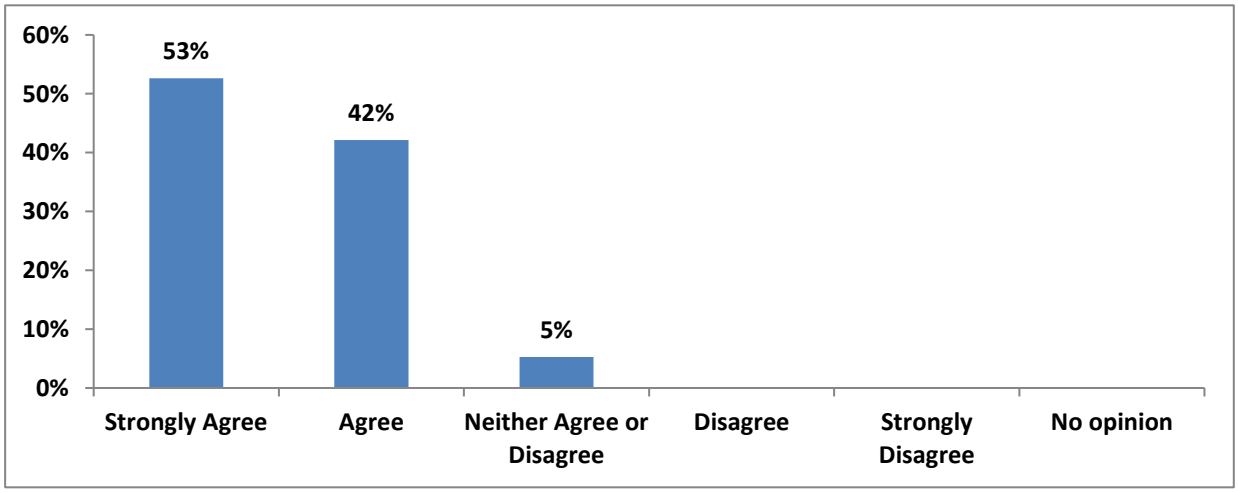

Figure 4.5 Assessment of Specific Operational Factors including video, GPS, and other data among Emergency and First Responders within North Carolina, Virginia and Maryland.

Table 4.3 Breakdown of the Assessment of Specific Operational Factors including video, GPS, and other data among Emergency and First Responders within North Carolina, Virginia and Maryland.

State	Strongly Agree (1)	Agree (2)	Neither Agree or Disagree (3)	Disagree (4)	Strongly Disagree (5)
Virginia	4	3	0	0	0
North Carolina	1	3	0	0	0
Maryland	5	2	1	0	0
Total	10	8	1	0	0

In examining acceptable data integrity and quality factors (Figure 4.6), survey respondents in all three states *strongly agreed* (mean 1.47, see Appendix D) that the information from drones have acceptable data integrity and quality. Evaluation of the results showed that among the 20 responses, opinions ranged from strongly agree (1) to neither agree or disagree (3) with a standard deviation of 0.68 which suggests that respondents differ in their opinions about the quality of the data from drone equipment. The responses resulted in like viewpoints on the cost effectiveness of drones and were parallel across Virginia, North Carolina and Maryland. These trends suggest that the quality of availabile drone equipment within the respondents' locality may contribute to their perspectives on drones. The difference may also be a result of economic inequalities that exist between the regions and within the various localities.

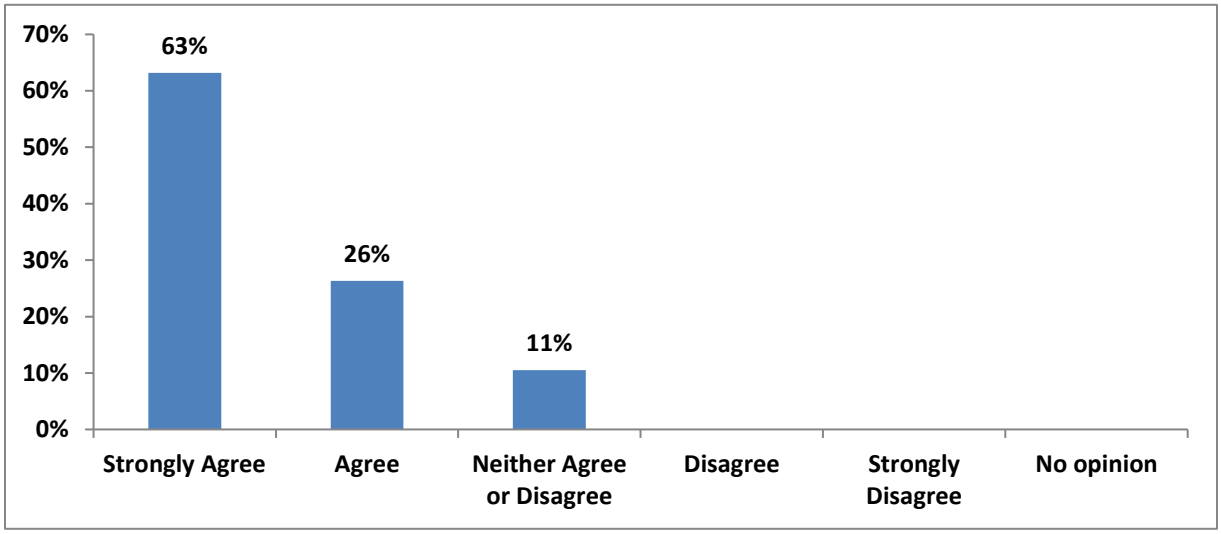

Figure 4.6 Assessment of Acceptable Data Integrity and Quality Information from Drones during weather and other emergencies within North Carolina, Virginia and Maryland.

Table 4.4. Breakdown of the Assessment of Acceptable Data Integrity and Quality Information from Drones during weather and other emergencies within North Carolina, Virginia and Maryland.

State	Strongly Agree (1)	Agree (2)	Neither Agree or Disagree (3)	Disagree (4)	Strongly Disagree (5)
Virginia	5	2	0	0	0
North Carolina	3		1	0	0
Maryland	4	3	1	0	0
Total	12	5	2	0	0

In comparing drone-based damage assessments of emergencies including hurricanes, tornadoes, and wildfires compared to traditional assessment methods, emergency managers and first responders agreed that drones are just as effective. In addressing RQ2, differences in locality do appear to create slight differences in perspectives. Overall emergency managers and first responders across all three states *agreed* (mean 1.80, see Appendix D**)** that drones are an efficient and economical way

(Figure 4.7) to capture aerial photos for damage assessment. Data analysis of the results showed that among the 20 responses, opinions ranged from strongly agree (1) to neither agree or disagree (3) with a standard deviation of 0.87 which suggests that respondents are divided in their opinions that drone-based damage assessments of emergencies including hurricanes, tornadoes, and wildfires are just as effective as tradional assessment methods. These results reflect similar responses on the quality of drone data and the cost effectiveness of drones. Results showed that these opinions are comparable across Virginia, North Carolina, and Maryland. Again, the regularity of these trends suggests that these perspectives on drones may depend largely on the quality of drone equipment accessible to respondents within each locality. This disparity may also be a result of the economic differences that exist between the regions and within the localities.

In terms of RQ2 and the relevance of drone technology to meet needs, emergency managers and first responders reported that the cost per hour to fly a drone are significantly less compared to traditional manned-aircraft. For wildfires specifically, the ability to pinpoint hotspots as a feature of drones that provide the capability to direct crews to hot spots more quickly and directly reduces the time required to bring a wildfire under control.

In addition to pin-pointing hotspots, drones also provide a capability to quickly access affected areas that would otherwise be inaccessible due to damaged or blocked roads or waterways that limit the use of motor vehicles or boats. In any of these scenarios, drones provide the capability for live stream video data for managers to access damages and coordinate search-and-rescue operations.

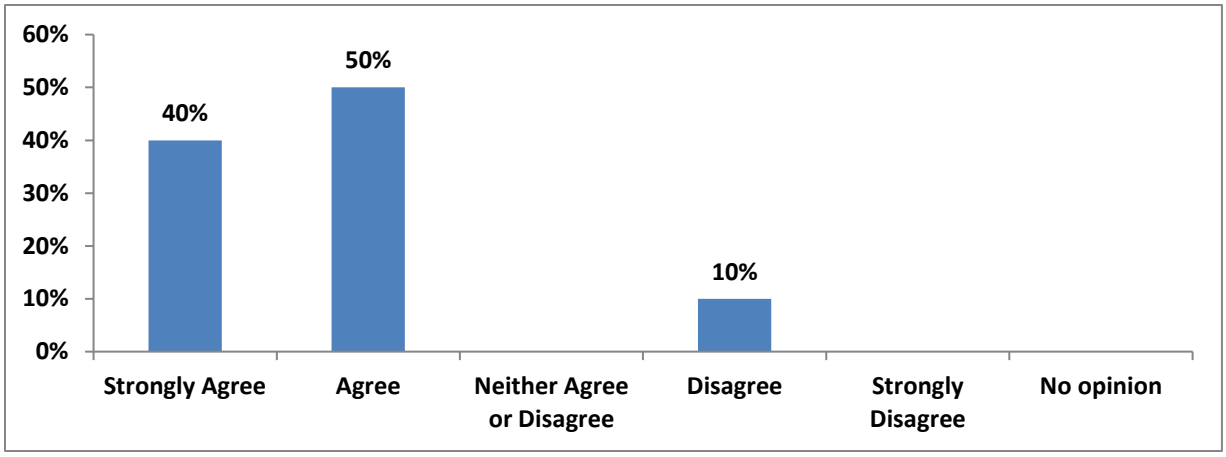

Figure 4.7 Assessment of the cost to acquire drones appear to match expectations for performance including flight controls, battery life, data storage and processing within North Carolina, Virginia and Maryland.

Table 4.5 Breakdown of the Assessment of the cost to acquire drones appear to match expectations for performance including flight controls, battery life, data storage and processing within North Carolina, Virginia and Maryland.

State	Strongly Agree (1)	Agree (2)	Neither Agree or Disagree (3)	Disagree (4)	Strongly Disagree (5)
Virginia	4	3	0	0	0
North Carolina	0	3	0	2	0
Maryland	4	4	0	0	0
Total	8	10	0	2	0

In an analysis of sensor technology (Figure 4.8), available on drones, respondents agreed (mean 1.70, see Appendix D) that drones appear to have adequate sensor technologies (including heat sensors) to improve and extend search-and-rescue operations especially during night flight.

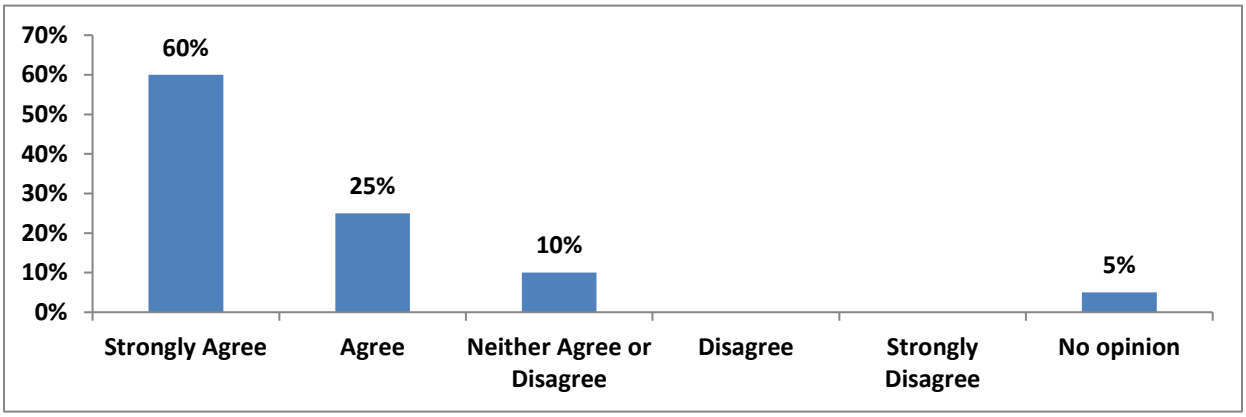

Figure 4.8 Assessment of sensor technology and other data among Emergency Managers and First Responders within North Carolina, Virginia and Maryland.

Table 4.6 Breakdown of the Assessment of Drones appear to have adequate sensor technologies (including heat sensors) to improve and extend search-and-rescue operations especially at night within North Carolina, Virginia and Maryland.

State	Strongly Agree (1)	Agree (2)	Neither Agree or Disagree (3)	Disagree (4)	Strongly Disagree (5)
Virginia	5	1	1	0	0
North Carolina	4	0	1	0	0
Maryland	3	4	1	0	0
Total	12	5	3	0	0

Data analysis of the results showed that among the 20 responses, opinions ranged from strongly agree (1) to no opinion (6) with a very large standard deviation of 1.19 which suggests that respondents varied strongly in their opinions that drones have adequate sensor technologies to extend search and rescue operations. This broad difference in opinion among respondents was surprising, although there were similar views related to operational effectiveness, data quality, and the cost effectiveness. Despite factors related to locality and economic resources, there was an expectation that the drones in all

localities were equipped with baseline sensor technologies that provided a common perspective on sensors themselves. As an example, several respondents reported that the ability to pinpoint hotspots as a specific feature of drones provided the capability to direct crews to hotspots more quickly was effective in reducing the time required to bring wildfires under control. Perhaps, these vast differences on the quality of sensors is further evidence that perspectives on drones may again depend heavily on the quality of drone equipment and the suite of sensors available to respondents within each locality. The shift may also be a result of economic inequality that exists between the regions and within the localities themselves.

With reference to how drones might be improved to better support preparedness, damage assessment, and search-and-rescue operations in the context of RQ2, emergency managers felt the improvement in battery technology would allow for extended flight times. Some of the suggestions for improvements included better sensor technology (both EOS and Thermal) and better methods for relaying multiple low latency live feeds via a secure VPN IP address. Such low latency live feed would allow incident commanders and other involved persons to view the video that drones were capturing in real time. In this regard, emergency managers did not advocate improvements in drone technology, but felt the need for better understanding of drone capabilities among responders who use drones to support their operations. Overall, emergency managers felt that the primary limitation to current drone operations was battery technology. Survey participants felt that better battery life would extend flight times. Another obstacle reported by emergency managers is the decision process for City Governments to identify qualified candidates to train and license as pilots. One emergency manager indicated

that his agency has two licensed pilots in the Fire Department. The manager disclosed tremendous investment in study and training to develop a licensed pilot that is trusted and able to respond around the clock. This investment has to be weighed against technological advances that provide almost anyone the ability to maneuver a drone, and take high quality pictures. Despite these technological advances, the majority of emergency managers felt that the cost of high-end products was an issue for government entities who want quality products for their investment. As the technology advances, emergency managers felt the need to explore drone capabilities to send GPS locations to other drones to avoid collisions. Drone technology has an impressive range of capabilities and applications and are extremely useful in law enforcement operations. The stability of the aircraft and quality of the cameras available are invaluable as it relates to gathering evidence, public safety, and officer safety. One concern is the lack of flight time offered by most batteries (15-20 minutes max). Improving uninterrupted flight time is imperative to ensuring the mission at hand can be carried out without interruption and reduces overall downtime for a battery swap. Drone training sessions for preparedness are organized. Emergency managers indicated that they took part in preliminary training to use drones to monitor radiation plumes from nuclear reactors. Drones should be included in the Incident Command System (ICS) structure as with any other resource used for emergency management.

As it relates to RQ2, emergency managers felt that weather is a big obstacle when it comes to drones. In the context of post-disaster recovery, many of the drones are not water resistant and high winds will make it impossible for them to fly. Emergency managers related that drones need to be equipped with a means to broadcast its position,

make/model, remote pilot information for Unmanned Aircraft System Traffic Management (UTM) purposes, and more powerful cameras with a physical zoom. Enhancing drones with these features will improve the drone's performance, but the real problem is the FAA and the excessive red tape that you have to cut through in order to fly in the National Airspace System (NAS). Because drones do not have any type of radar identification, it is difficult to fly in the NAS around airports. Technology improvement are needed that will allow drones to fly in the NAS without going through all the FAA hurdles. Another emergency manager expressed that there are concerns regarding the expense of commercial drones, and with new technology advances they are becoming even more expensive.

Regulatory and Compliance Factors

This section focuses on the research findings that are closely related with RQ3, which addresses the regulatory, and compliance factors, issues, and challenges surrounding the drone use in disaster areas. Flight plans constitute a significant aspect of drone operations since they are often required by FAA or other applicable authorities.

Examining RQ3 for regulatory and compliance factors (Figure 9), survey respondents *agreed* (mean 2.20, see Appendix D) on the need for flight plans and trained pilots who are also certified emergency responders.

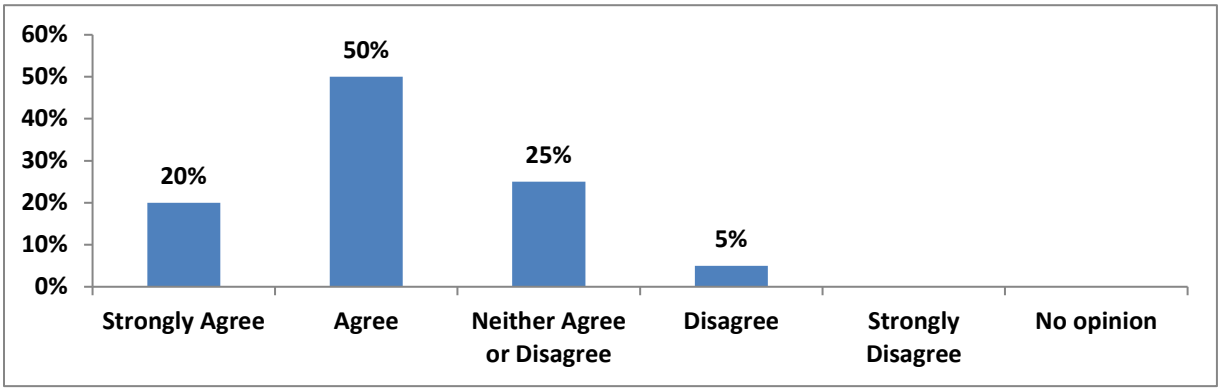

Figure 4.9 Assessment of the need for flight plans among Emergency Managers and First Responders within North Carolina, Virginia and Maryland.

Table 4.7 Breakdown of the Assessment of effective Emergency Operations involving Drones require flight plans that should be coordinated and carried out with trained pilots who are also Emergency Responders.

State	Strongly Agree (1)	Agree (2)	Neither Agree or Disagree (3)	Disagree (4)	Strongly Disagree (5)
Virginia	2	5	0	0	0
North Carolina	1	2	2	0	0
Maryland	2	3	3	0	0
Total	5	10	5	0	0

Data analysis of the results of Figure 4.9 showed that among the 20 responses, opinions ranged from *strongly agree (1) to strongly disagree (5)* with a large standard deviation of 0.93 which suggests that respondents are divided in their opinions on the need for flight plans and trained pilots who are also certified emergency responders. This expansive difference in opinion among respondents was not surprising given similar trends in opinions related to operational effectiveness, data quality, and cost effectiveness. There is also some evidence that localities within Virginia and Maryland

that are close to secure facilities may have additional regulatory and compliance restrictions that are not imposed elsewhere.

In examining RQ3 on regulatory and compliance factors involving flight operations and no-fly restrictions (Figure 4.10), survey respondents agreed, (mean 2.30, see Appendix D) that regulatory agencies including the FAA should oversee flight operations involving drones during emergencies and impose no-fly restrictions if necessary.

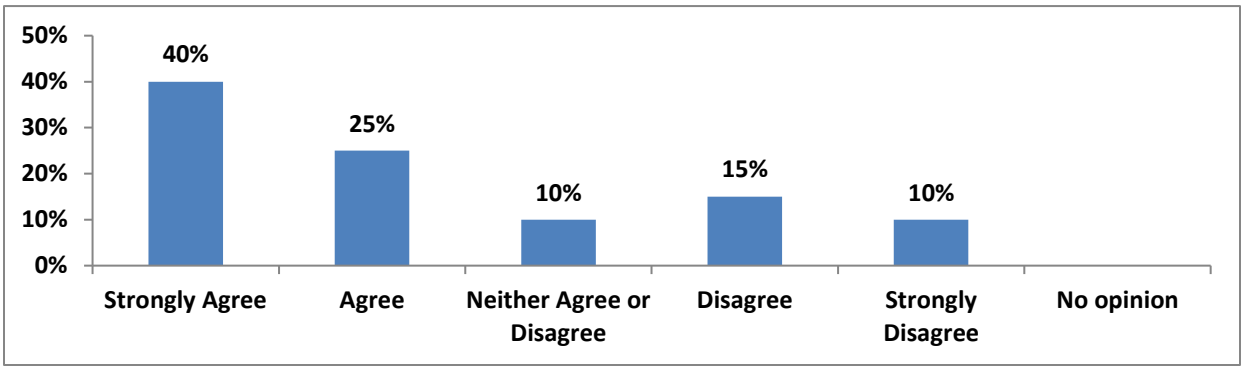

Figure 4.10 Assessment of the need for regulatory agencies including FAA to oversee flight operations among Emergency Managers and First Responders within North Carolina, Virginia and Maryland.

Table 4.8 Breakdown of the Assessment of Regulatory agencies including the FAA should oversee flight operations involving Drones during emergencies and impose no fly restrictions if necessary.

State	Strongly Agree (1)	Agree (2)	Neither Agree or Disagree (3)	Disagree (4)	Strongly Disagree (5)
Virginia	1	2	1	1	2
North Carolina	4	0	0	0	1
Maryland	3	3	1	1	0
Total	8	5	2	2	3

In evaluating the results, Figure 4.10 showed that among the 20 responses, opinions ranged from strongly agree (1) to strongly disagree (5) with a very large standard

deviation of 1.38 which suggests that respondents are varied in their opinions on the need for regulatory agencies including the FAA to oversee flight operations and impose no-fly restrictions if necessary. This tremendous difference in opinion among respondents was not surprising given similar trends in opinions related to the need for trained pilots, operational effectiveness, data quality, and the cost effectiveness. There is also some evidence that localities within Virginia and Maryland that are close to secure facilities may have additional regulatory and compliance restrictions that are not imposed elsewhere.

As it pertains to the need for training (Figure 4.11), emergency managers *agreed* (mean 1.47, see Appendix D) that they should oversee training and certify Drone Pilots for operations involving emergencies including wildfires, flooding, and damage assessment of transportation networks (roads/rail) and utility infrastructure (power, water, gas, drainage).

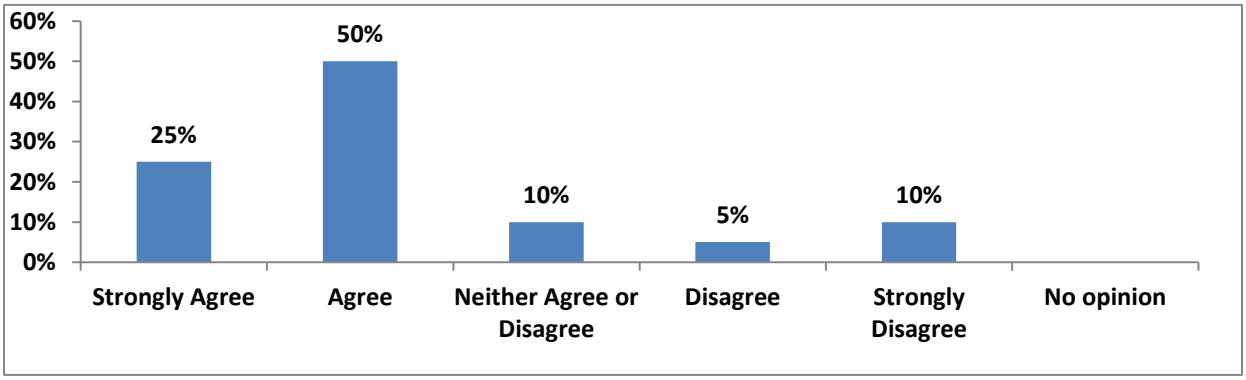

Figure 4.11 Assessment of the need to oversee training of Emergency Managers and First Responders within North Carolina, Virginia and Maryland.

Table 4.9 Breakdown of the Assessment of local Emergency Managers should oversee training and certify Drone Pilots for operations involving emergencies including wildfires, flooding, and damage assessment of transportation networks (roads/rail) and utility infrastructure (power, water, gas, drainage).

State	Strongly Agree (1)	Agree (2)	Neither Agree or Disagree (3)	Disagree (4)	Strongly Disagree (5)
Virginia	1	5	0	0	1
North Carolina	3	1	1	0	0
Maryland	1	4	1	1	1
Total	5	10	2	1	2

Concerning networked drones operating in autonomous swarm formations above the 400-foot FAA altitude (Figure 4.12), emergency managers could not agree (did not agree or disagree, mean 3.15, see Appendix D), if networked drones provide advantages over single-operator line-of-sight drones operating below the 400-foot limit.

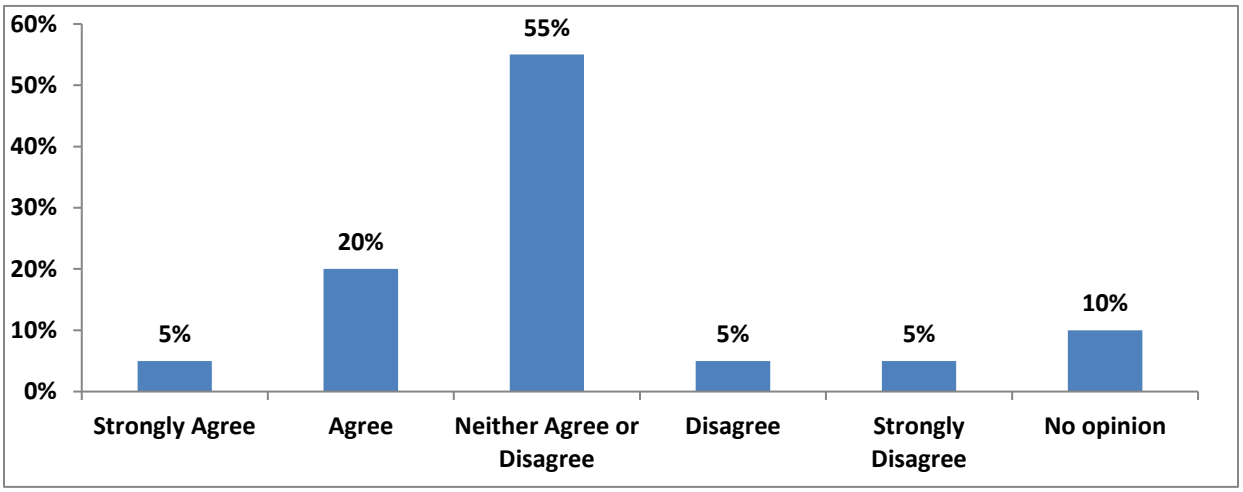

Figure 4.12 Comparison of networked drones to single operator drones among Emergency Managers and First Responders within North Carolina, Virginia and Maryland.

Table 4.10 Breakdown of the Assessment of networked Drones operating in autonomous (pilotless) swarm formations above the 400 foot FAA altitude limit may provide advantages over single operator line of sight drones operating below the 400 foot limit.

State	Strongly Agree (1)	Agree (2)	Neither Agree or Disagree (3)	Disagree (4)	Strongly Disagree (5)
Virginia	2	0	5		0
North Carolina	0	1	3		1
Maryland	0	2	5	1	0
Total	2	3	13	1	1

The written comments captured by the survey questionnaire provide further insights from emergency managers in terms of how they saw issues and challenges related to FAA regulations and compliance concerning the use of drones for emergency preparedness, damage assessment, and search-and-rescue operations. Some emergency managers mentioned challenges with the "line of sight" restriction. They reported that the process of obtaining a Certificate of Authorization (COA) was conflicting. As an example, in order to obtain Certificate of Authorization (COA) applicants must have a registered drone to apply. If applicants decide not to obtain a COA, the fees are non-refundable. Some respondents also mentioned being located within the no fly zone of Washington, DC and are limited in the use of drones altogether. Respondents from Annapolis Maryland expressed concerns over the ability to get personnel in the City of Annapolis trained on the FAA Regulations Part 107 to understand what is allowed and not allowed in the airspace. Several respondents also suggested that there is a need to have certified pilots notify airports, and other pilots of their flights. The suggestion was that an app or website would help report flight positions in order to manage airspace. Respondents felt that the FAA's expertise and understanding of emergency flights provide

the basis for leveraging past experience with established regulations that take emergency flights into consideration. Current FAA regulations strictly limit the functions that may be carried out by the operator. In order to bypass certain regulations, a certificate of waiver must be applied for and granted. The waiver process is extremely burdensome and slow which reduces the overall availability of the drones in public use. Several emergency managers reported that their agencies developed a document, *How to Legally Incorporate Unmanned Aircraft System (UAS) Technology into your Public Agency's Operations*, (Ramsey & Johnson, 2018) to assist public agencies with two different FAA routes (COA vs. Part 107) that a public agency can use to implement drone technology into their operations. The Certificate of Waiver or Authorization (COA) is issued by the Air Traffic Organization and has more flexibility than the Part 107 small drone rule. It supports specific drone activities such as search-and-rescue missions is a good choice for fire departments, local municipalities, schools and police departments. The purpose of the small drone rule is to issue a Part 107 Operator's Certificate or "drone license" to ensure that remote pilots are in compliance with the drone rules of the sky, and the process for obtaining the Part 107 is easier. The Part 107 waiver permits pilots authorization that the COA does not, for example flying multiple drones at the same time, flying above 400 ft. above ground level, and flight beyond the visual line of sight, etc. In addition, they presented and attended drone conferences/workshops to assist other public agencies. One emergency manager felt that many of the regulations should be reassessed and special consideration should be given to Law Enforcement, Fire/EMS Departments and Emergency Management. Through proper FAA compliance training, these responders can benefit greatly from the proper and safe use of drones. While some emergency

managers felt that the biggest challenge for the FAA will be policing hobbyists who do not follow regulations, the managers felt that because drone usage in Public Safety is so new and constantly changing, the regulations and compliance can be daunting and confusing to an agency starting a program. Emergency managers who did not experience issues with current FAA regulations reported that they operate in concert with a local military testing facility and authorizations have been seamless. Within these parameters, such agencies operate in controlled airspace for military flight testing and have found the military to be very accommodating in-flight clearance as needed. Under this approach, the agency hired a contractor to assist with FAA regulations during the startup of the program. The contractor navigated the FAA regulations and assisted in obtaining the necessary waivers. Such waivers also point to the need for the FAA to consider broader definitions of what constitutes a COA operation. The waiver might apply if a remote pilot thinks he/she is conducting a COA operation and has an accident. The FAA may deem that operation as a non-COA operation, and charge that person with violating Part 107 regulations.

Summary of Results and Research Findings

In conclusion, emergency managers and public safety officials across North Carolina, Virginia and Maryland report strong agreement that drones extend capabilities for disaster response and provide efficient, cost effective alternatives for specific tasks including preparedness, damage assessment and sear-and-rescue operations. The results of the 16-question survey are summarized in Table 4.11 below. As indicated in Table 4.11, respondents showed general agreement along four theses including demographics involving range of experience using drones, operational and performance

factors involving reliability, data integrity, and manufacturing and design factors involving acquisition costs and sensor technologies. Responses related to regulatory and compliance factors were less uniform.

Table 4.11 Summary of Survey Results

Demographic Factors		
#	Question	Results
1	Percentage of Responders in each State	North Carolina: 25% Virginia: 35% Maryland: 40% Figure 4.1
2	Responder Experience by Emergency Category	Hurricane: 67% Tornado: 50% Flooding: 100% Wildfire: 28% Earthquake: 28% Figure 4.1
3	Responder Drone Experience by Emergency Category	Hurricane: 67% Tornado: 33% Flooding: 92% Wildfire: 25% Earthquake: 17% Figure 4.1
4	Comment on how Drones benefit specific Emergency Management tasks	Drones provide advantages for searching hard-to-reach areas. Economical and efficient ways for capturing aerial photos for preplanning and damage assessment. Figure 4.1
Operational Performance Factors		
5	Drones are effective in reporting and assessing risks from various emergencies including flooding, wildfires, and damage from tornadoes, hurricanes, and chemical spills.	**Strongly Agree** Mean: 1.25 Standard Deviation: 0.43 Figure 4.1
6	Drones are safe and reliable for planning and coordinating responses.	**Strongly Agree** Mean: 1.53 Standard Deviation: 0.60

		Figure 4.1
7	In reporting and assessing weather and other emergencies the information from drones have acceptable data integrity.	**Strongly Agree** Mean: 1.47 Standard Deviation: 0.68 Figure 4.1
8	Comment on how drone-based damage assessment of emergencies including hurricanes, tornadoes, and wildfires compare to traditional assessment methods	Drones are just as Effective
Manufacturing Design Factors		
9	The cost to acquire drones appear to match expectations for performance including flight controls, battery life, data storage, and processing speed	**Agree** Mean: 1.80 Standard Deviation: 0.87 Figure 4.1
10	Drones appear to have adequate sensor technologies (including heat sensors) to improve and extend search-and-rescue operations especially at night	**Agree** Mean: 1.70 Standard Deviation: 1.19 Figure 4.1
11	Effective Emergency Operations involving Drones require flight plans that should be coordinated and carried out with trained pilots who are also Emergency Responders	**Agree** Mean: 2.20 Standard Deviation: 0.93 Figure 4.1
12	Please comment on how Drones might be improved to better support preparedness, damage assessment, and search-and-rescue operations	Drones will benefit from better battery technology and sensor technology for thermal imagery.

Regulatory and Compliance Factors		
13	Regulatory agencies including the FAA should oversee flight operations involving Drones during emergencies and impose no-fly restrictions if necessary	**Agree** Mean: 2.30 Standard Deviation: 1.91 Figure 4.1
14	Local Emergency Managers should oversee training and certify Drone Pilots for operations involving emergencies including wildfires, flooding, and damage assessment of transportation networks (roads/rail) and utility infrastructure (power, water, gas, drainage).	**Agree** Mean: 2.20 Standard Deviation: 1.08 Figure 4.1
15	Networked Drones operating in autonomous (pilotless) swarm formations above the 400 foot FAA altitude limit may provide advantages over single-operator line-of-sight drones operating below the 400 foot limit.	**Neither Agree or Disagree** Mean: 3.15 Standard Deviation: 1.24 Figure 4.1
16	Comment on issues and challenges related to FAA regulations and compliance concerning the use of drones for emergency response involving preparedness, damage assessment, and search-and-rescue operations.	The process for obtaining a COA is cumbersome. Applicant must have a registered drone to apply. If applicants decide not to obtain a COA, fees are nonrefundable. Applicants within a no-fly zone cannot obtain a COA and have restricted opportunities for training.

CHAPTER 5

CONCLUSIONS AND FUTURE WORK

In relation to demographic factors, the results and analysis in Chapter 4 showed that flooding as the major common factor for emergency experience and drone use within North Carolina, Virginia and Maryland shaped perspectives and minor variations among the states. Twenty-five percent of the respondents reported from North Carolina, 35% from Virginia and 40% from Maryland reported that flooding was the most frequent disaster that they had encountered, with hurricanes being the second highest. In addition to similar experiences with disasters and their use of drones across their locations, the study suggests that the common geography and mid-Atlantic shorelines within North Carolina, Virginia and Maryland creates vulnerabilities to hurricanes that are reflected in the common experiences and perspectives of respondents.

Flooding is the number one disaster in these areas due to large amounts of rainfall and storm water surges resulting from hurricanes such as recent Florence in North Carolina and Michael in Florida. Given the predictability of likely flooding damage, the results suggest that emergency managers are confident that drones are beneficial in the pre-planning phase of disaster management, damage assessment and various phases of disaster management and not as a replacement for traditional approaches, but as an efficient way to support emergency management. The study suggests that emergency managers strongly agree (Figure 4.4) that drones provide the operational performance factors to meet expectations during flooding which is by far the most common of their disaster management experience. In analyzing the opinions of the 20 respondents about the performance factor for drones, at 0.60 the standard deviation suggests that there may

be significant differences in the way respondents see the use of drones during flooding operations. One aspect of these differences might be how experience shapes how respondents see the return on investment for trained pilots who can be trusted to respond around the clock. Although advances in drone technology provide the means for almost anyone to fly drones and take high quality pictures, there are serious concerns about the risk to privacy.

In weighing the benefit of technological advances to the investment in trained pilots, the aspect of flooding as shaping experience may influence the perspectives on how drones access regions that are likely inaccessible and the corresponding demand for high-end products that expand the range of operations including search-and-rescue at night. This demand for high-end technology during flooding might also influence comments on the need for drones to send its GPS locations to other drones as a means to avoid collisions. As drones hover for search-and-rescue operations in flood damaged areas, respondents also suggested that night-vision cameras also provide benefits as to gathering clues about missing people. This shaping of perspective by experience was confirmed by strong agreement (Figure 4.5) on the quality of operational features. Drones are absolutely an essential tool because they provide the capability to quickly provide aerial photos and vital information that can reach remote or inaccessible area. This study confirms that emergency managers and first responders strongly agree that drones have an unmatched capability to improve emergency management through cost savings and enhanced technology.

Geography and Perspectives

Overall, differences in locality do appear to create slight differences in perspectives. While emergency managers and first responders across all three states agreed (mean 3.0, see Appendix D), that drones are an efficient and economical way (Figure 4.7) to capture aerial photos for damage assessment, this seemed to be mostly driven by cost advantages of drones over traditional modes such as manned-aircraft. As the influence of the other emergencies and the location of impact areas varied, the study suggests that emergency managers had a wider range of applications such as being able to pinpoint hotspots across large regions to direct crews to reduce the timed needed to bring events under control.

In examining the influence of geography on perspective, the influence of drones on specific emergency management tasks appears to vary by locality. As an example, drones cover a wide range of applications involving emergencies including preparedness, damage assessment and search-and-rescue operations. Within rural communities, respondents reported using drones for search-and-rescue while respondents from urban communities reported wider applications such as pre-planning for emergencies and crime scene analysis. Overall, respondents from both urban and rural communities suggest that drones provide advantages for searching hard-to-reach areas that may be difficult to access by traditional means. Despite the context, rural or urban, respondents in all three states agreed that drones provide efficient and economical ways for specific tasks such as capturing aerial photos for both pre-planning and damage assessment of emergencies. For search-and-rescue operations in urban communities, the infrared technology provides opportunities for a wider range of detection during day or night

operations with the advantages of covering broad ranges of cities more efficiently than traditional means. While the same is true in rural communities, respondents suggest that drones provide a quick, safe means of determining the extent of damage across vast and sometimes remote regions, including those with limited access, and the number and identity of injured individuals and the extent of their injuries.

As an example of the impact of locality, respondents in Maryland reported that the use of drones provides aerial views of streets, neighborhoods, and land that assists cities conduct planning and pre-disaster projects. Within these urban communities, results suggest that the information from drones provide a capability for situational awareness during search-and-rescue missions, preliminary disaster assessments, security during special events and other missions that may not be as prevalent within rural communities.

Overall, the results of this study suggest that drones provide rapid access to areas whether inside or outside cities; however, within cities drones provide and added feature for situational awareness. This aspect of differences based on geography also emerged as respondents reported on the need for flight plans (Figure 4.9) While emergency managers agreed (mean 2.0) the results suggest that the difference in locality does impose additional factors such as no-fly zones in heavily congested urban areas where privacy or protected air space around federal buildings limit access to the airspace.

Impact of Locality on FAA Regulations and Challenges

Emergency managers and first responders strongly agreed (Figure 4.10) that there is a need for FAA and other regulatory authorities to oversee flight operations involving

drones to ensure the safe use of drones, protect national security and privacy rights of citizens. Results suggested that differences in locality where FAA regulations were enforced created differences in how emergency managers and first responders saw specific regulation. Respondents had mixed (Figure 4.11) perspectives based on their locality. Some respondents indicated that the FAA regulations had not hampered their operations, while others viewed the Certificate of Waiver (COA) process as being arduous due to it being extremely slow, and sometimes waivers are not issued. The impact of regulation based on locality was strongest near Washington, D.C. where there is “no drone zone” designation. Results suggested (Figure 4.12) that emergency managers and first responders believe that training and certification should be overseen by local emergency management agencies to ensure that preparedness, damage assessment, and search-and-rescue operations emergency operations are effective.

These results may be influenced by existing FAA regulations that prohibit agencies from flying because they do not have certified remote pilots. It is likely that such prohibition will prevent effective coordination of emergency management agencies with first responders including local law enforcement and fire departments with search and rescue operations. As a group, emergency managers and first responders (regardless of locality) felt that it is crucial that training provide the means for establishing proper procedures to obtain certifications as needed. Despite the agreement on the need for training as an avenue for certification, results showed that emergency managers and first responders in different localities had mixed perspectives (Figure 4.12) regarding networked drones operating in autonomous (pilotless) swarm formations above the 400-

foot FAA altitude limit may provide advantages over single-operator line-of-sight drones operating below the 400-foot limit.

Recommendations for Further Work

Overall, there was general agreement among respondents in all three states; however, at 20 the number of respondents was small. Future work would aim for larger sample sizes, which would typically require longer times to complete. The scope of this study was limited by the time constraint. A more flexible timetable would provide additional time to reach out to larger portions of the target population. During the restricted time of the study, several emergency management agencies within the three states that approvals would need to be obtained to administer the survey. In approaching future work, it is doubtful that Qualtrics would provide the most flexible approach for administering surveys because various state agencies including North Carolina Emergency Management Association (NCEMA), Virginia Emergency Management Association (VEMA), and Maryland Emergency Management Agency (MEMA) preferred a centralized in-house approach for administering the survey.

For future work, the survey collection should allocate a timeline of 360 days or more to account for likely emergencies and training schedules that prevent potential participants from completing the survey. During the current study, it was apparent that training schedules seemed to lead to the low response from the North Carolina Department of Public Safety (NC DPS). As another aspect of the work, there is an opportunity to expand the survey to address the influence or geography. As an example, this future work might explore “no drone zones” and FAA regulations within urban areas.

An added dimension to future work might leverage the use of drones in recent flooding due to Hurricane Florence. During Hurricane Florence, North Carolina, Virginia and Maryland were all declared as state of emergencies. As of today, the Carolinas continue to be in a state of recovery and the impact of post-disaster drone assessment will be a natural extension of the current study.

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APPENDICES

APPENDIX A: SAMPLE SURVEY INSTRUMENT

The following are sample questions from each of the respective categories of responses.

Theme 1: Demographic Factors

1. I am an Emergency Manager or Responder in one of the following states (choose one).

   ____ North Carolina ____ Virginia ____ Maryland

2. I have participated as a manager or responder in each of the following emergencies (choose all that apply).

   _____ Hurricane ____ Tornado ____ Flooding ____ Wildfire ____ Earthquake

3. I have participated in each of the following emergency responses that utilized drones in a significant way (choose all that apply).

   _____ Hurricane ____ Tornado ____ Flooding ____ Wildfire ____ Earthquake

4. Please comment on how drones benefit **specific emergency management tasks** including preparedness, damage assessment, and search-and-rescue operations in your area.

Theme 2: Operational Performance Factors

5. Drones are effective in **reporting** and **assessing** risks from various emergencies including flooding, wildfire, and damage from tornadoes, hurricanes, and chemical spills.

Strongly Agree	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**	**No opinion**
5	4	3	2	1	N/A

6. Drones are a safe, reliable, and cost effective means for **planning** and **coordinating responses** by delivering video, GPS locations and other data products.

Strongly Agree	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**	**No opinion**
5	4	3	2	1	N/A

7. In reporting and assessing weather or other emergencies the information from drones have acceptable **data integrity and quality**.

Strongly Agree	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**	**No opinion**
5	4	3	2	1	N/A

8. Please comment on how **drone-based damage assessment** of emergencies including hurricanes, tornadoes, and wildfires compare to **traditional assessment methods** without drones.

Theme 3: Manufacturer Design Factors

9. The **cost** to acquire drones appear to match **expectations** for performance including **flight controls, battery life, data storage and processing speed**.

Strongly Agree	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**	**No opinion**
5	4	3	2	1	N/A

10. Drones appear to have adequate **sensor technologies (including heat sensors)** to improve and extend **search-and-rescue** operations especially during night flight.

Strongly Agree	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**	**No opinion**
5	4	3	2	1	N/A

11. **Effective** Emergency Operations involving Drones require **flight plans** that should be coordinated and carried out with **trained Pilots** who are also certified **Emergency Responders**.

Strongly Agree	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**	**No opinion**
5	4	3	2	1	N/A

12. Please comment on **how drones might be improved** to better support preparedness, damage assessment, and search-and-rescue operations.

Theme 4: Regulatory and Compliance Factors

13. Regulatory agencies including the **FAA** should oversee flight operations involving Drones during emergencies and impose **no-fly restrictions** if necessary.

Strongly Agree	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**	**No opinion**
5	4	3	2	1	N/A

14. Local Emergency Managers should oversee training and certify Drone Pilots for operations involving emergencies including wildfires, flooding, and damage assessment of transportation networks (roads/rail) and utility infrastructure (power, water, gas, drainage).

Strongly Agree	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**	**No opinion**
5	4	3	2	1	N/A

15. Networked Drones operating in autonomous (pilotless) swarm formations above the 400 foot FAA altitude limit may provide advantages over single-operator line-of-sight drones operating below the 400 foot limit.

Strongly Agree	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**	**No opinion**
5	4	3	2	1	N/A

16. Please comment on issues and challenges related to **FAA regulations and compliance** concerning the use of drones for emergency response involving preparedness, damage assessment, and search-and-rescue operations.

APPENDIX B: QUALTRICS OFFICIAL SURVEY

USING DRONES IN DISASTER AREAS: PERSPECTIVES OF DISASTER RESPONDERS IN NORTH CAROLINA, VIRGINIA AND MARYLAND

Start of Block: Theme 1: Demographic Factors

Q1 I am an Emergency Manager or Responder in one of the following states (choose one).

- ○ North Carolina (1)
- ○ Virginia (2)
- ○ Maryland (3)

Q2 I have participated as a Manager or Responder in each of the following emergencies (choose all that apply).

- ☐ Hurricane (1)
- ☐ Tornado (2)
- ☐ Flooding (3)
- ☐ Wildfire (4)
- ☐ Earthquake (5)

Q3 I have participated in each of the following emergency responses that utilized drones in a significant way (choose all that apply).

- ☐ Hurricane (1)
- ☐ Tornado (2)
- ☐ Flooding (3)
- ☐ Wildfire (4)
- ☐ Earthquake (5)

Q4 Please comment on how drones benefit **specific emergency management tasks** including preparedness, damage assessment, and search-and-rescue operations in your area.

_____

Page Break

End of Block: Theme 1: Demographic Factors

Start of Block: Theme 2: Operational Performance Factors

Q5 Drones are effective in **reporting** and **assessing** risks from various emergencies including flooding, wildfire, and damage from tornadoes, hurricanes, and chemical spills.

- ○ Strongly agree (1)
- ○ Agree (2)
- ○ Neither agree nor disagree (3)
- ○ Somewhat disagree (4)
- ○ Disagree (5)
- ○ Strongly disagree (6)
- ○ No opinion (7)

Q6 Drones are a safe, reliable, and cost effective means for **planning** and **coordinating responses** by delivering video, GPS locations and other data products.

- ○ Strongly agree (1)
- ○ Agree (2)
- ○ Neither agree nor disagree (3)
- ○ Disagree (4)
- ○ Strongly disagree (5)
- ○ No Opinion (6)

Q7 In reporting and assessing weather or other emergencies the information from drones have acceptable **data integrity and quality**.

- ○ Strongly agree (1)
- ○ Agree (2)
- ○ Neither agree nor disagree (3)
- ○ Disagree (4)
- ○ Strongly disagree (5)
- ○ No opinion (6)

Q8 Please comment on how **drone-based damage assessment** of emergencies including hurricanes, tornadoes, and wildfires compare to **traditional assessment methods** without drones.

_____

Page Break

End of Block: Theme 2: Operational Performance Factors

Start of Block: Theme 3: Manufacturer Design Factors

Q9 The **cost** to acquire drones appear to match **expectations** for performance including **flight controls, battery life, data storage and processing speed**.

- Strongly agree (1)
- Agree (2)
- Neither agree nor disagree (3)
- Disagree (4)
- Strongly disagree (5)
- No opinion (6)

Q10 Drones appear to have adequate **sensor technologies (including heat sensors)** to improve and extend **search-and-rescue** operations especially during night flight.

- ○ Strongly agree (1)
- ○ Agree (2)
- ○ Neither agree nor disagree (3)
- ○ Disagree (4)
- ○ Strongly disagree (5)
- ○ No Opinion (6)

Q11 **Effective** Emergency Operations involving Drones require **flight plans** that should be coordinated and carried out with **trained Pilots** who are also certified **Emergency Responders**.

- ○ Strongly agree (1)
- ○ Agree (2)
- ○ Neither agree nor disagree (3)
- ○ Strongly disagree (4)
- ○ Disagree (5)
- ○ No opinion (6)

Q12 Please comment on **how drones might be improved** to better support preparedness, damage assessment, and search-and-rescue operations.

_____

Page Break

End of Block: Theme 3: Manufacturer Design Factors

Start of Block: Theme 4: Regulatory and Compliance Factors

Q13 Regulatory agencies including the **FAA** should oversee flight operations involving Drones during emergencies and impose **no-fly restrictions** if necessary.

- Strongly agree (1)
- Agree (2)
- Neither agree nor disagree (3)
- Strongly disagree (4)
- Disagree (5)
- No opinion (6)

Q14 Local Emergency Managers should oversee training and certify Drone Pilots for operations involving emergencies including wildfires, flooding, and damage assessment of transportation networks (roads/rail) and utility infrastructure (power, water, gas, drainage).

- Strongly agree (1)
- Agree (2)
- Neither agree nor disagree (3)
- Strongly disagree (4)
- Disagree (5)
- No opinion (6)

Q15 Networked Drones operating in autonomous (pilotless) swarm formations above the 400 foot FAA altitude limit may provide advantages over single-operator line-of-sight drones operating below the 400 foot limit.

- Strongly agree (1)
- Agree (2)
- Neither agree nor disagree (3)
- Strongly disagree (4)
- Disagree (5)
- No opinion (6)

Q16 Please comment on issues and challenges related to **FAA regulations and compliance** concerning the use of drones for emergency response involving preparedness, damage assessment, and search-and-rescue operations.

_____

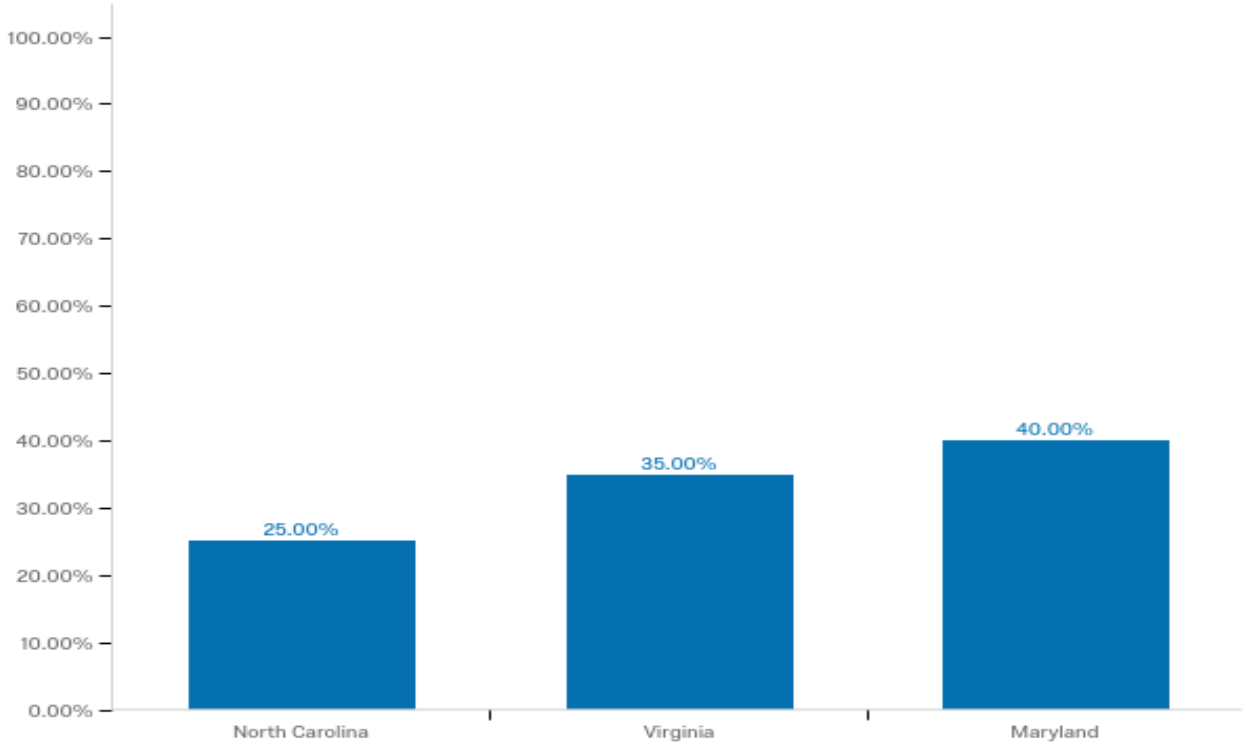
End of Block: Theme 4: Regulatory and Compliance Factors

APPENDIX C: QUALTRICS SURVEY RESULTS

Using Drones in Disaster Areas: Perspectives of Disaster Responders in North Carolina, Virginia and Maryland

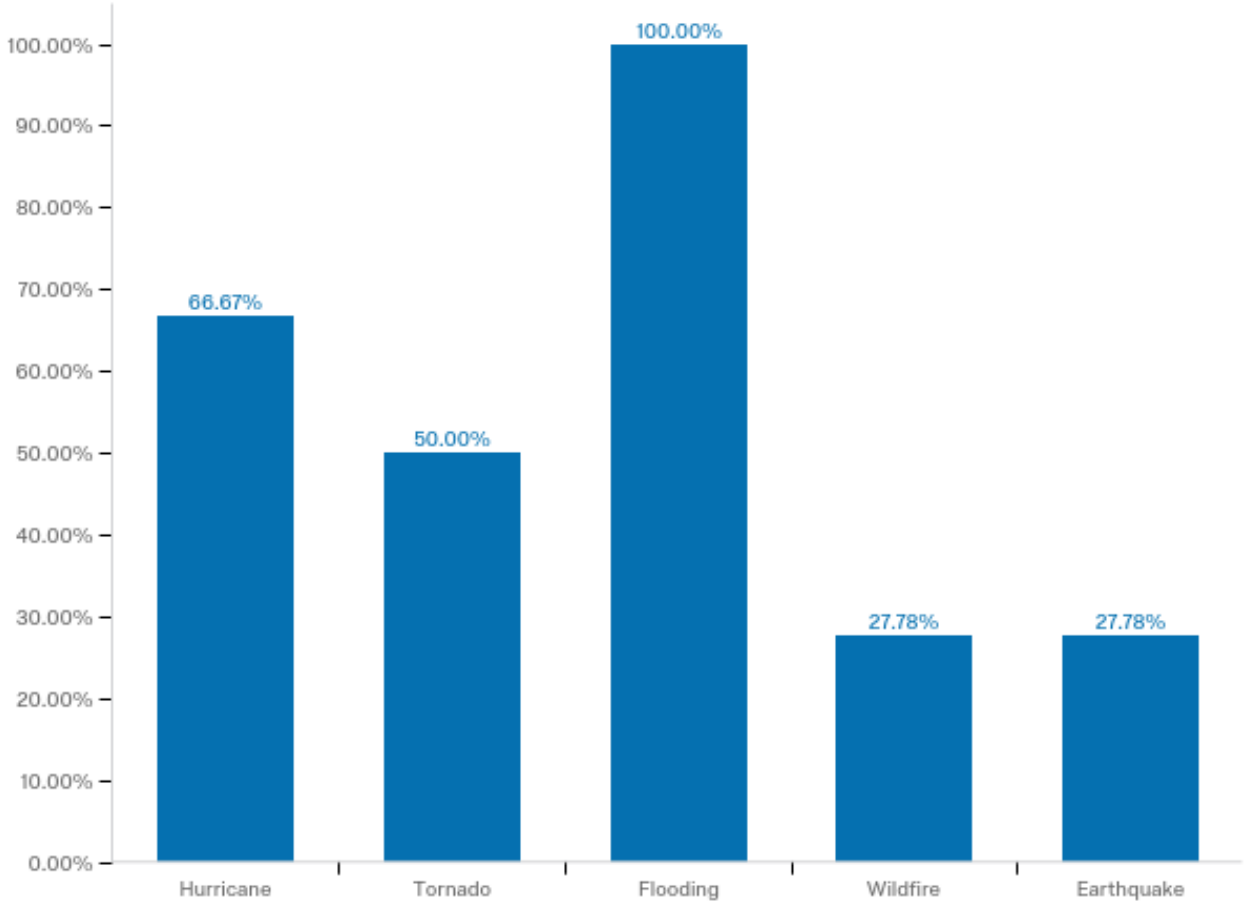
October 27th 2018, 3:00 pm MDT

Q1 - I am an Emergency Manager or Responder in one of the following states (choose one).

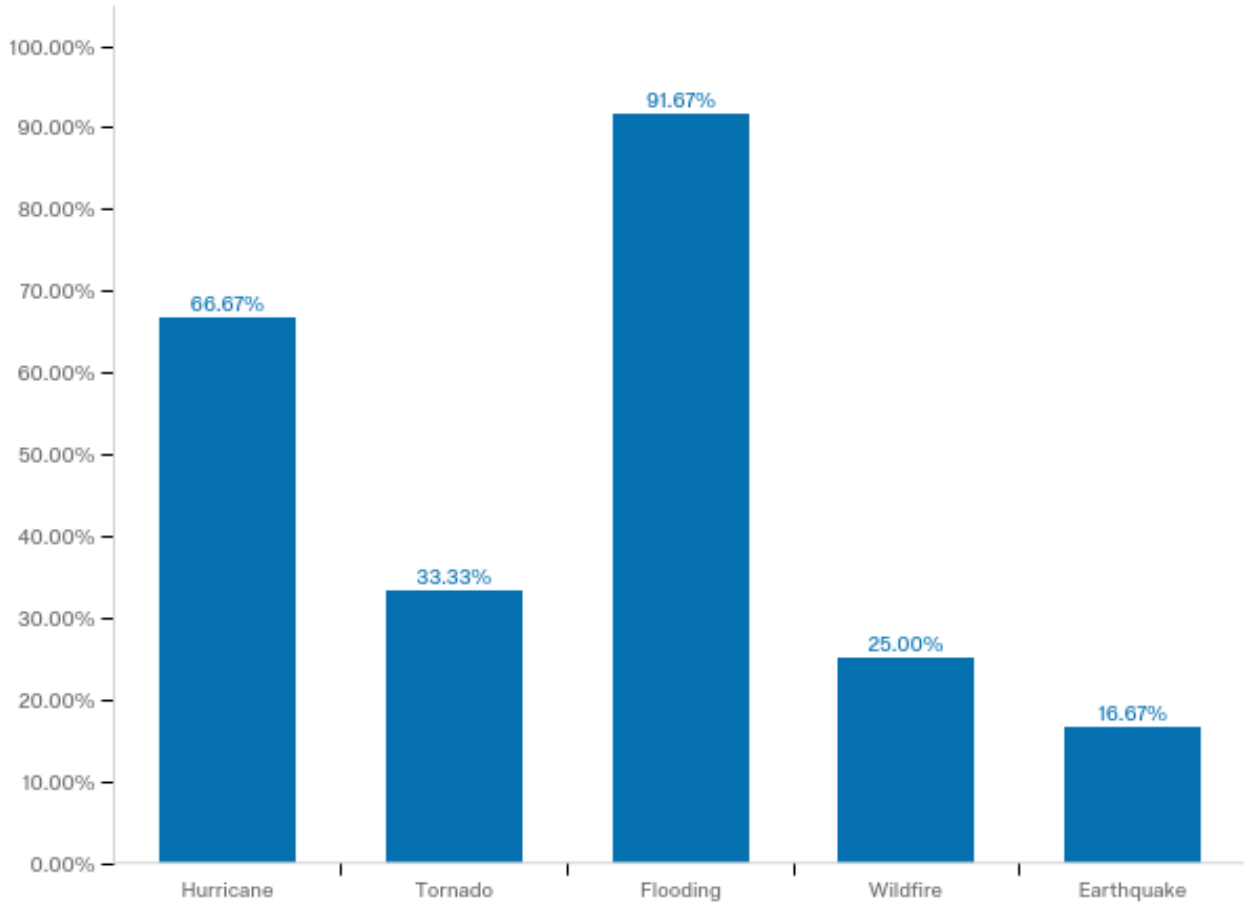


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	I am an Emergency Manager or Responder in one of the following states (choose one).	1.00	3.00	2.15	0.79	0.63	20

Q2 - I have participated as a Manager or Responder in each of the following emergencies (choose all that apply).



Q3 - I have participated in each of the following emergency responses that utilized drones in a significant way (choose all that apply).



Q4 - Please comment on how drones benefit specific emergency management tasks including preparedness, damage assessment, and search-and-rescue operations in your area.

Please comment on how drones benefit specific emergency management tasks including preparedness, damage assessment, and search-and-rescue operations in your area.
An aerial drone is a crucial element of use. It provides a safe alternative to those hard to reach areas. In some instances first responders may not be able to obtain the necessary knowledge to access certain locations. Drones provide an added safety net ending with a positive result in every case (i.e.search of suspects, fire & police investigations, canvassing problem areas, added surveillance for court security and Swat aerial security.
Great for damage assessment and has some limited capability for search and rescue.
We utilize them for search and rescue and crime scene reconstruction. They can benefit by allowing us to search areas in which it may be difficult for personnel to get to.

Drones are an efficient and economical way to capture aerial photos for both preplanning and damage assessment. Search and rescue uses using infrared technology can move a lot faster than an individual while looking for lost or injured people.

They provide a quick, safe means of determining the extent of damage, limitation of access to the affected areas and can locate and identify individuals that need to be rescued and often times determine the extent of their injuries.

The use of drones allows for aerial views of streets, neighborhoods, and land to help the City of Annapolis conduct planning and pre disaster projects. During a disaster response, the City of ANnapolis has the ability to provide Incident Commanders an aerial view for situational awareness during search and resccue missions, preliminary disaster assessments, security during special events, and other issions reviewed and approved by the Director of Emergency Management.

Drones permit the emergency responder to respond and rapidly deploy an aeriel vehicle at the scene of a natural/man-made disaster, crime scene, and/or search and rescue scene in a timely manner. The technology provides the emergency responder with a vantage point unlike any other. The technology is very cost efficient, reliable, and readily available.

UAVs can greatly benefit emergency management tasks by providing an aerial view (photogrammetry or live) of a site, which gives decision makers a common operating picture.

We are developing a drone program and I am very much aware of the benefits. They are significant

Though I've never seen a drone used because of the area that I work and responded in, I would assume that it would be very useful in all of the previously listed operations. A drone would benefit each of these with the abilit to safely assess situations where it would be hard and sometimes impossible to get an objective view of the incident, damages, and possibly aid in the location and rescue of persons in areas restricted by access and damage from the incident. It would be a great tool for planning whereas you could literally get a bird's eye view of things that you can't do or perform from ground level.

We use our drones on search and rescue quite often. Just this weekend they were used to search for a missing swimmer in the water. They allow for us to search from a new perspective without the exorbitant costs of a helicopter. The further allow us to search areas that may not be accessible normally

Our plan is to use drones to conduct damage assessments when assessing infrastructure as well as conducting final site inspections on FEMA Public Assistance projects.

Search and Resuce

UAVs can greatly benefit emergency management tasks by providing an aerial view (photogrammetry or live) of a site, which gives decision makers a common operating picture. We are at the beginning stages of our UAS program. So far, we have used UAVs to conduct the following mission types: a). Photogrammetry of a town flooded by a hurricane; b). Photogrammetry of a dam that was weakened by a hurricane; c). Photogrammetry of a drained lakebed, which will be used to construct a replacement dam; d). Photogrammetry of a major base camp for a large forest fire; e). Photogrammetry of rain caused landslides in the mountains; and f). Assisted with providing a live view of a protest/counter protest at a university As for preparedness, we organize UAV training sessions. We took part in preliminary training to use UAVs to monitor radiation plumes from nuclear reactors. We developed a document for assisting public agencies on the two different FAA routes (COA vs Part 107) that a public agency can use to implement UAS technology into their operations. In addition, we present and attend UAS conferences/workshops as well as assist other public agencies. We are working on developing live streaming capability to our EOC.

Drones have been an invaluable tool in completing damage assessment during natural disasters in our City. It drastically decreases man power for damage assessment allowing that saved man power to help with S&R and other life saving tasks.

Damage assessment

Please comment on how drones benefit specific emergency management tasks including preparedness, damage assessment, and search-and-rescue operations in your area.

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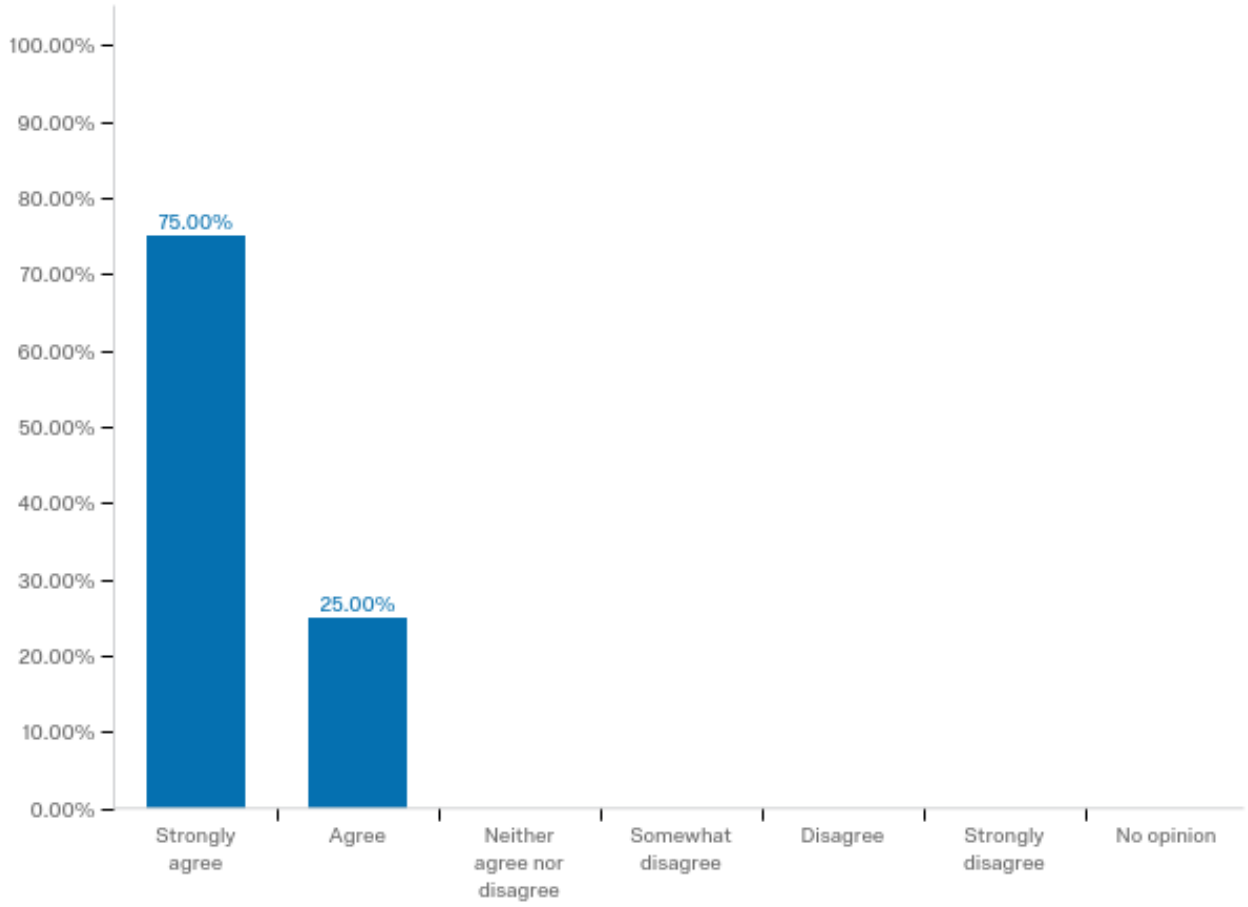
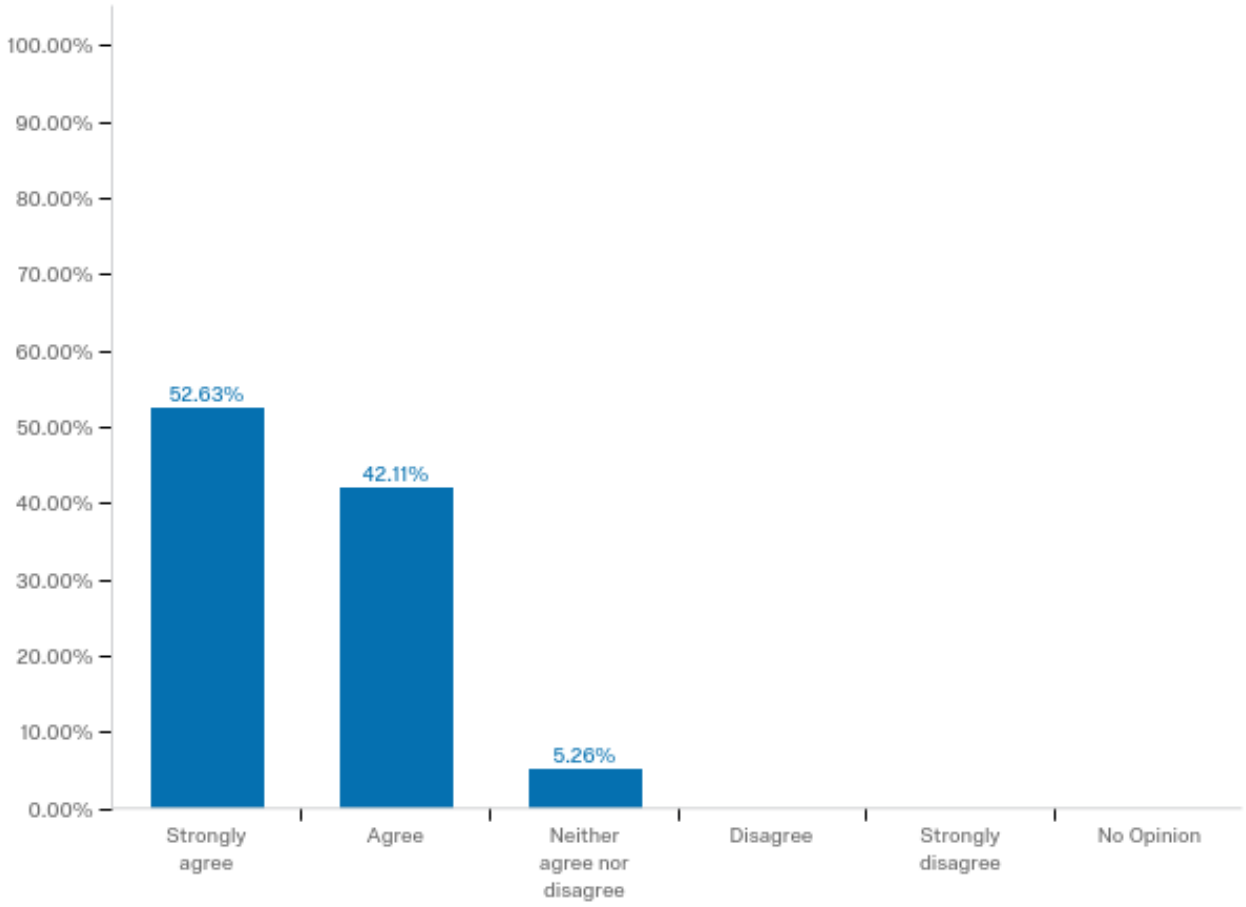
Damage assessment

Q5 - Drones are effective in reporting and assessing risks from various emergencies including flooding, wildfire, and damage from tornadoes, hurricanes, and chemical spills.



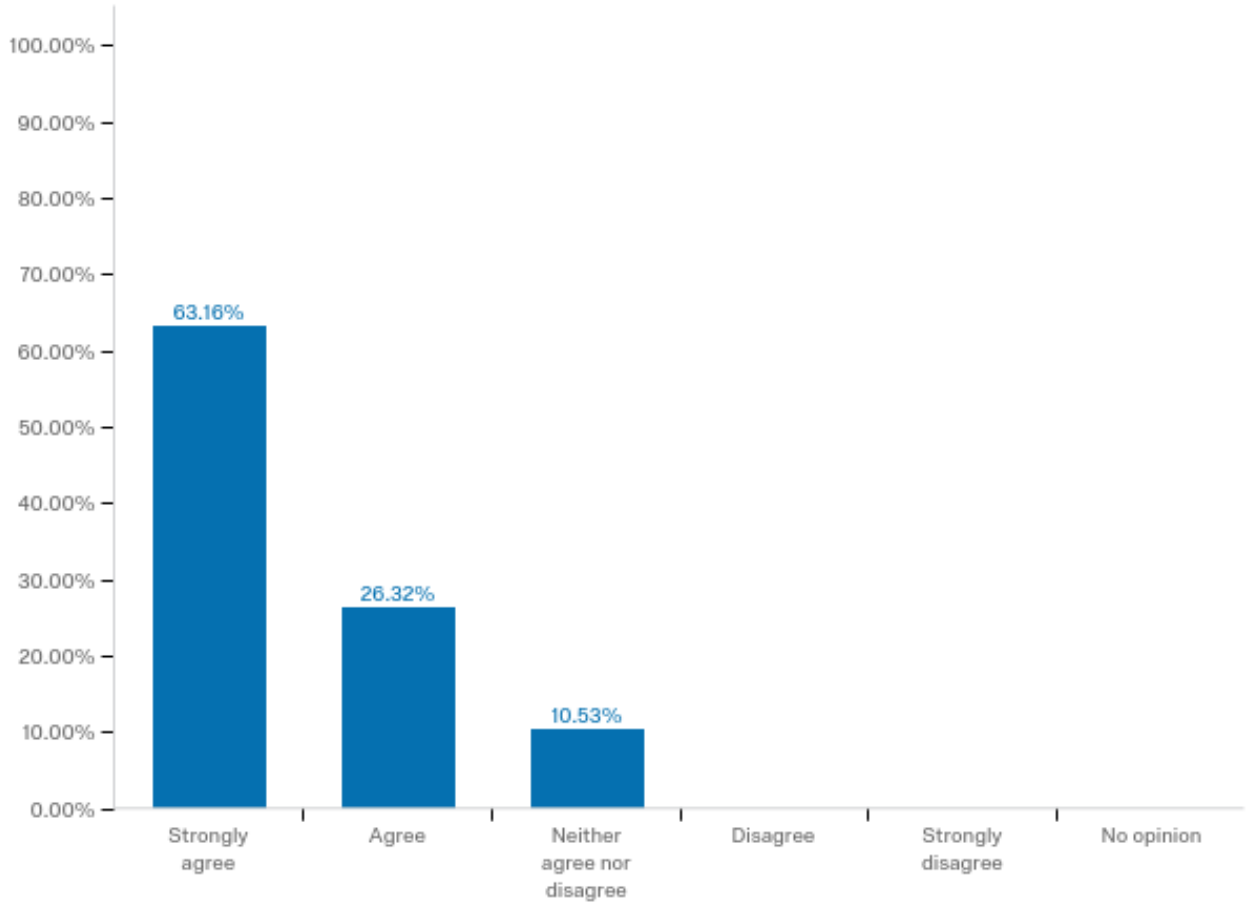
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Drones are effective in reporting and assessing risks from various emergencies including flooding, wildfire, and damage from tornadoes, hurricanes, and chemical spills.	1.00	2.00	1.25	0.43	0.19	20

Q6 - Drones are a safe, reliable, and cost effective means for planning and coordinating responses by delivering video, GPS locations and other data products.



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Drones are a safe, reliable, and cost effective means for planning and coordinating responses by delivering video, GPS locations and other data products.	1.00	3.00	1.53	0.60	0.35	19

Q7 - In reporting and assessing weather or other emergencies the information from drones have acceptable data integrity and quality.



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	In reporting and assessing weather or other emergencies the information from drones have acceptable data integrity and quality.	1.00	3.00	1.47	0.68	0.46	19

Q8 - Please comment on how drone-based damage assessment of emergencies including hurricanes, tornadoes, and wildfires compare to traditional assessment methods without drones.

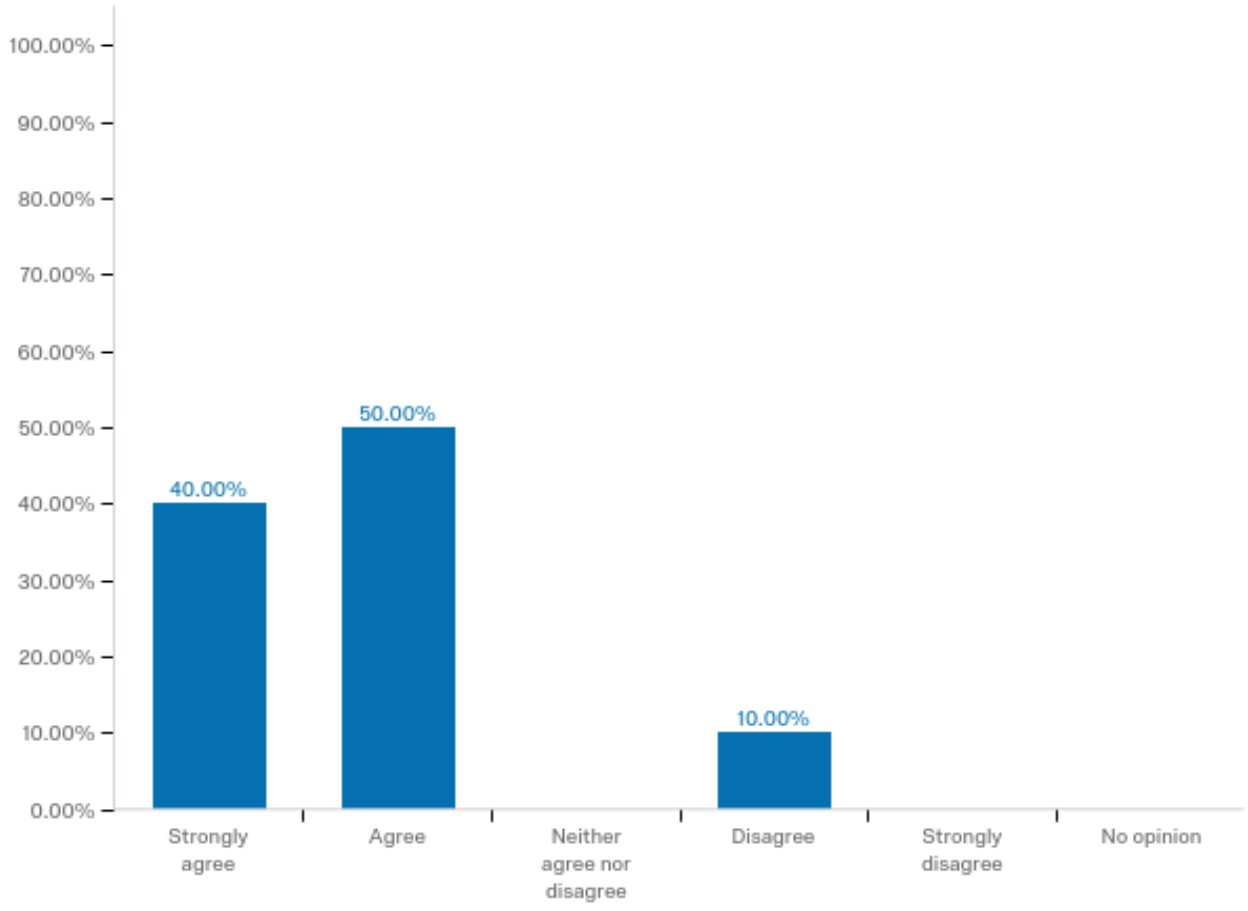
Please comment on how drone-based damage assessment of emergencies including hurricanes, tornadoes, and wildfires compare to traditional assessment methods without drones.
No comparison compared to traditional - area that are inaccessible in order to obtain the necessary data related to an incident that requires a vast amount of immediate information.
Drones have signficant limits on loiter time with sUAS that is most common today. They are also generally a single purpose airframe that aquisition costs along with costs to maintain currency can be quite high. Traditional methods may have a higher hourly costs, but are multimission and can do a larger area faster.
Drones are an efficient and economical way to capture aerial photos for damage assessment. The cost per hour to fly a drone versus a manned aircraft are significantly less. In addition, in the case of fire, being able to pinpoint hotspots to direct crews reduces time in bring events under control.
Drones can quickly access the affected areas that otherwise be cut off the motor vehicles or boats. They can live stream video into the command post to provide real time data for those in command that have to determine how to address the issues of damage and life saving operations.
I would comment that drone-based damage assessments are an additional way to conduct initial damage assessments. I do not believe that initial response and recovery damage assessments would be replaced, but the photos and videos taken from our UAS would allow for additional information in a shorter period following initial response operations. The ability to see the impacts on an entire neighborhood from above, the ability to see damage in the back of homes/properties, and other advantages that an aerial view would provide that a windshield assessment would not. The information would be combined with the information from windshield assessments to give decision makers better information when making response decisions.
3d mapping and bird eye views
The drone permits the assessor to typically see the entire area in question and makes the determination of the extent of damage readily apparent.
We are at the beginning stages of our UAS program. So far, we have used UAVs to conduct the following mission types: a). Photogrammetry of a town flooded by a hurricane; b). Photogrammetry of a dam that was weakened by a hurricane; c). Photogrammetry of a drained lakebed, which will be used to construct a replacement dam; d). Photogrammetry of a major base camp for a large forest fire; e). Photogrammetry of rain caused landslides in the mountains; and f). Assisted with providing a live view of a protest/counter protest at a university
Drones provide a much further reaching capability than do traditional methods from ground level in assessing incidents and seeing the larger picture.
Significantly faster and provides a perspective which we traditionally could not obtain without the use of a helicopter and some perspectives even the helo could not obtain.
Drones are easily deployed, give real-time data, and are often more cost-effective than helicopters. (I was a police helciopter pilot with another agency for seven years.)
Visibility of damage that is inaccessible will be much better and at a much lower cost/risk than with a manned aircraft.
Traditioanlly, the first thing we do in assessment is to obtain an overall picture of the areas affected. This is done via an aerial assessment with either rotary or fixed wing aircraft. Drones provide reposnders the ability to obtain aerial perspective of an area more quickly and with less cost than the tradential method.

I do not do damage assessments. However, I spoke with a co-worker who does do damage assessment and has participated in our UAV training program, but is not yet a remote pilot. He informed me that UAVs could have allowed him to get close-up images of homes that he could not get near due to unsafe conditions from landslides (e.g. debris, deep mud, and knocked over trees) and tornados. After the damage assessment phase ended, a local fire department that has remote pilots offered their UAV services. So, he now knows that he can contact local fire departments if he needs to a UAV to take pictures of an inaccessible damaged home.

Drones enable us to make large scale assessments of natural and man-made disasters. Drones are able to provide real time live video to an Emergency Operations Command Center; where city leaders can make immediate decisions and adjustments to rescue operations.

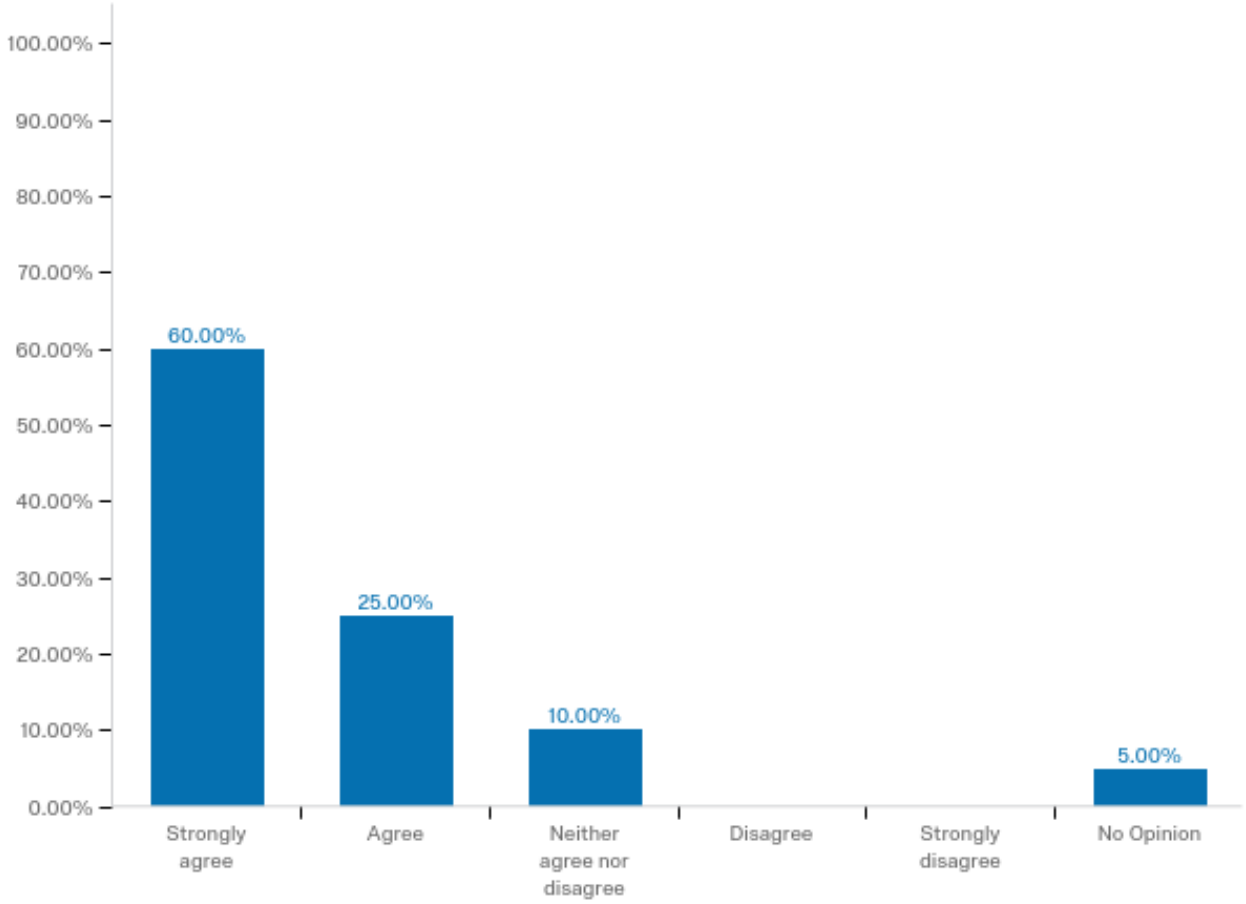
Drones are more cost effective

Q9 - The cost to acquire drones appear to match expectations for performance including flight controls, battery life, data storage and processing speed.



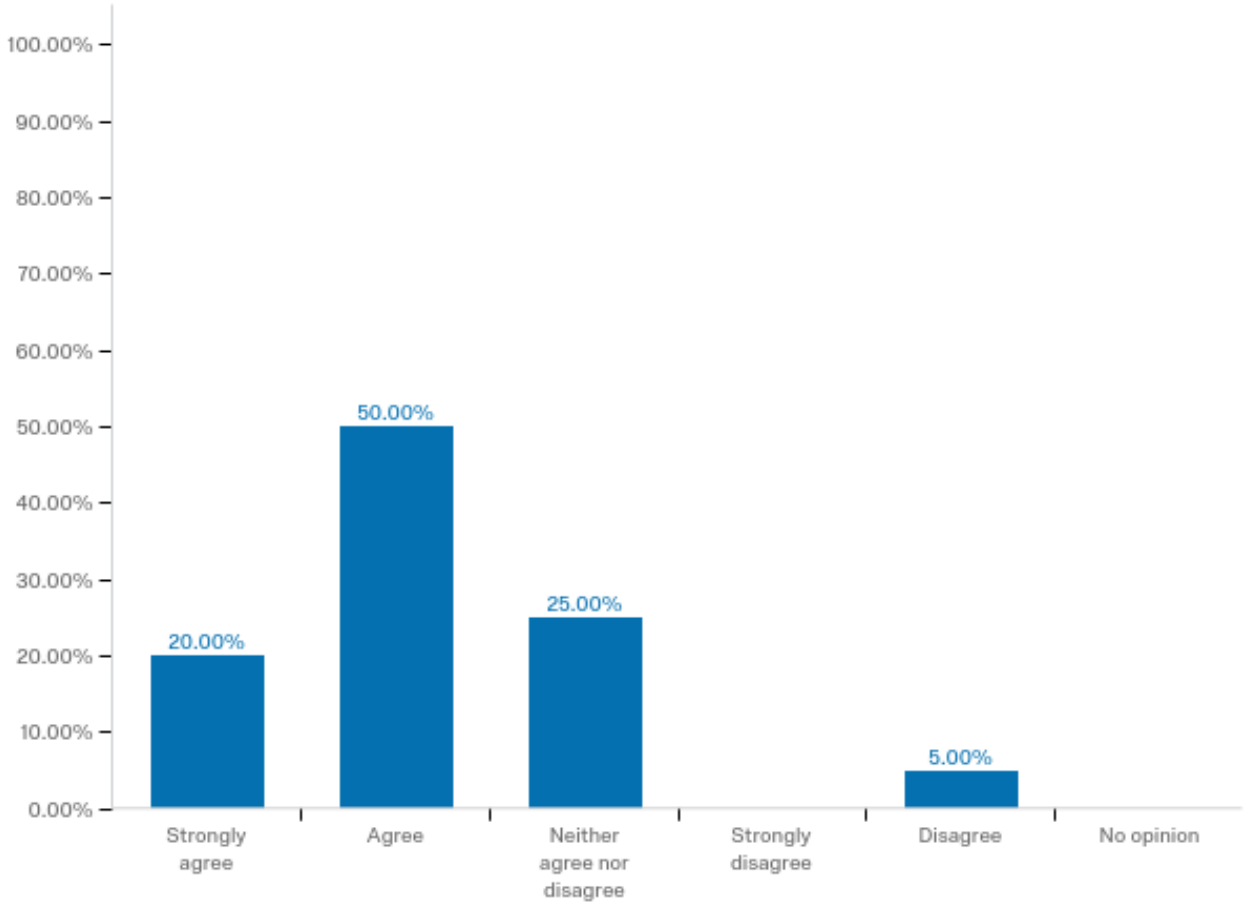
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	The cost to acquire drones appear to match expectations for performance including flight controls, battery life, data storage and processing speed.	1.00	4.00	1.80	0.87	0.76	20

Q10 - Drones appear to have adequate sensor technologies (including heat sensors) to improve and extend search-and-rescue operations especially during night flight.



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Drones appear to have adequate sensor technologies (including heat sensors) to improve and extend search-and-rescue operations especially during night flight.	1.00	6.00	1.70	1.19	1.41	20

Q11 - Effective Emergency Operations involving Drones require flight plans that should be coordinated and carried out with trained Pilots who are also certified Emergency Responders.



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Effective Emergency Operations involving Drones require flight plans that should be coordinated and carried out with trained Pilots who are also certified Emergency Responders.	1.00	5.00	2.20	0.93	0.86	20

Q12 - Please comment on how drones might be improved to better support preparedness, damage assessment, and search-and-rescue operations.

Please comment on how drones might be improved to better support preparedness, damage assessment, and search-and-rescue operations.
Drones assist in the planning of a moderate solution with less the cost. The innovation of aerial drones allow a quick turnaround with the use of batteries. The cost is substantially less than fuels used in modern day helicopters, planes and survey vehicles. although infra-red devices are available for drones the cost far exceeds the cost of a drone. These devices would need to be streamlined with better accessible by cost for a first responder to use.
They must be coordinated with FAA and State/Federal Air Operations Plans. Technology needs to further improve to allow outside line of sight as well as better payload and loiter capabilities.
Improvement in battery technology which will allow for extended flight times. Improved sensor technology (both EOS and Thermal). A better method of relaying multiple low latency live feeds via a secure VPN IP address which would allow incident command and other involved persons to view what the sUAS is capturing in real time.
I don not believe drones need to be improved, I believe a better understanding of drone capabilities for responders will supoorts operations.
The only limitations to current drone operations are the batteries that operate the drones. Technology needs to develop to provide longer lasting battery life so that the flight times of the drones are able to be extended.
I think one of the larger obstacles we find as a City Government is finding pilots that make sense to train and license. We currently have two licensed pilots in the Fire Department. The amount of study and training that it takes to license a pilot that is trusted and able to respond 24/7 is one of our obstacles. The ability to maneuver a drone, and take high quality pictures is at a place where almost any person could do it. For our purposes, I think the cost of high-end products is an issue for government entities who want quality products for their investment.
have drones send gps location to each other to make sure no collisions
Drone technology is very impressive and useful in law enforcement operations. The stability of the aircraft and quality of the cameras available are of tremendous value as it relates to

gathering evidence, public safety, and officer safety. The one concern that I have is the lack of flight time offered by most batteries (15-20 minutes max). Improving uninterrupted flight time is imperative to ensuring the mission at hand can be carried out without interruption and reduce overall downtime for a battery swap.

As for preparedness, we organize UAV training sessions. We took part in preliminary training to use UAVs to monitor radiation plumes from nuclear reactors.

Will need to be included in ICS structure and tasked as any other resource

See previous responses

Weather is a big obstacle for us when it comes to the drones. They are not water resistant and high winds will make it impossible to fly. As technology advances it makes it easier to do both of those thing (see DJI Matrice which is water resistant). The battery life is also limiting, currently we can go for about 22-24 minutes maximum for a flight. Again, technology is advancing this with newer drones being able to stay in the air longer.

The battery life of drones needs to be much, much longer.

longer battery life

Longer flight times between battery changes. More capable cameras at a lower price pint with physical zoom.

Each UAV needs to be equipped with a means to broadcast its positon, make/model, and remote pilot info for Unmanned Aircraft System Traffic Management (UTM) purposes.

It is not the drones that need to be improved, it is the FAA and the system, red tape, that is required to fly in the National Airspace System (NAS). Currently it is very difficult to fly in the NAS around airports because drones do not have any type of radar identification. There needs to be a technology improvement to allow drones to fly in the NAS with out going through all the FAA hurdles.

Commercial EM drones should be less expensive

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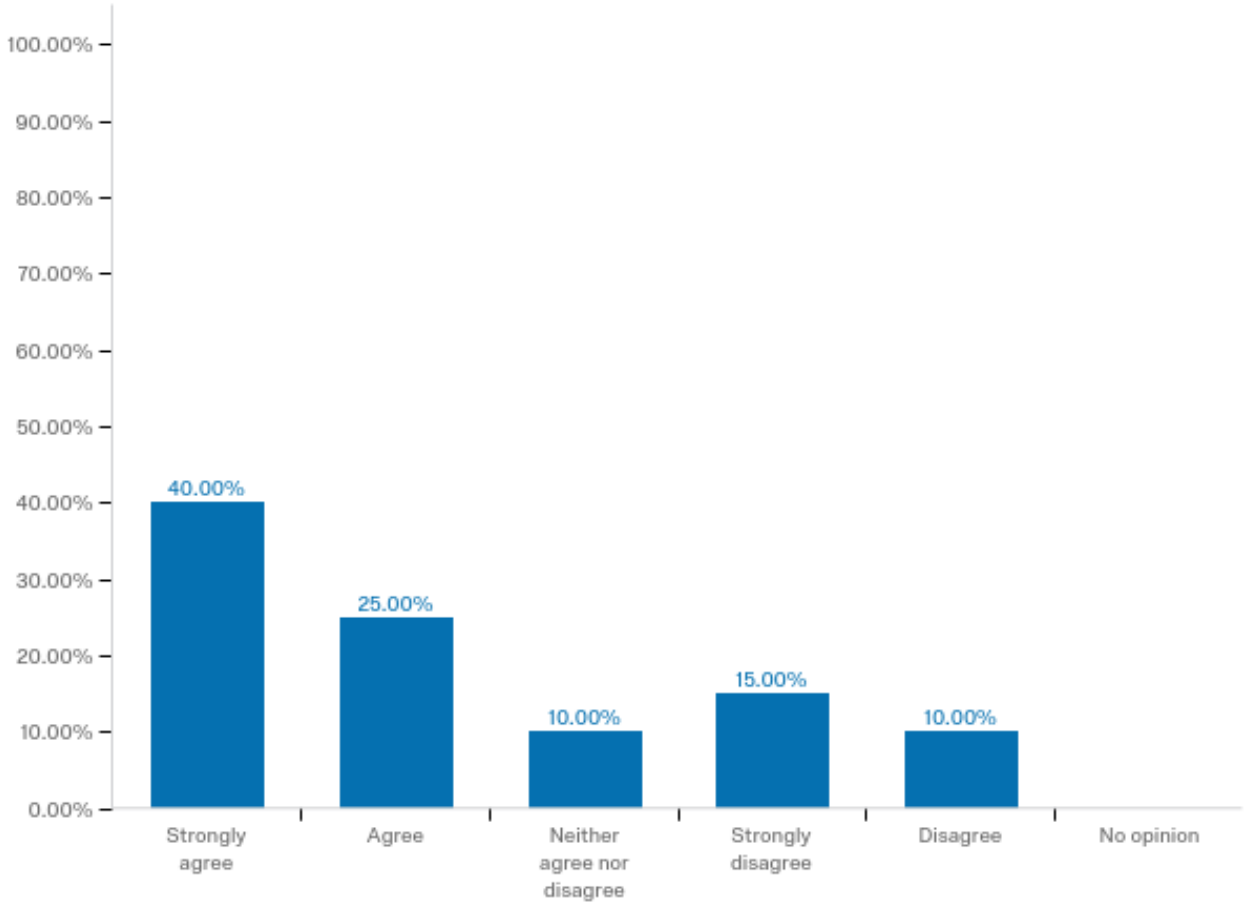
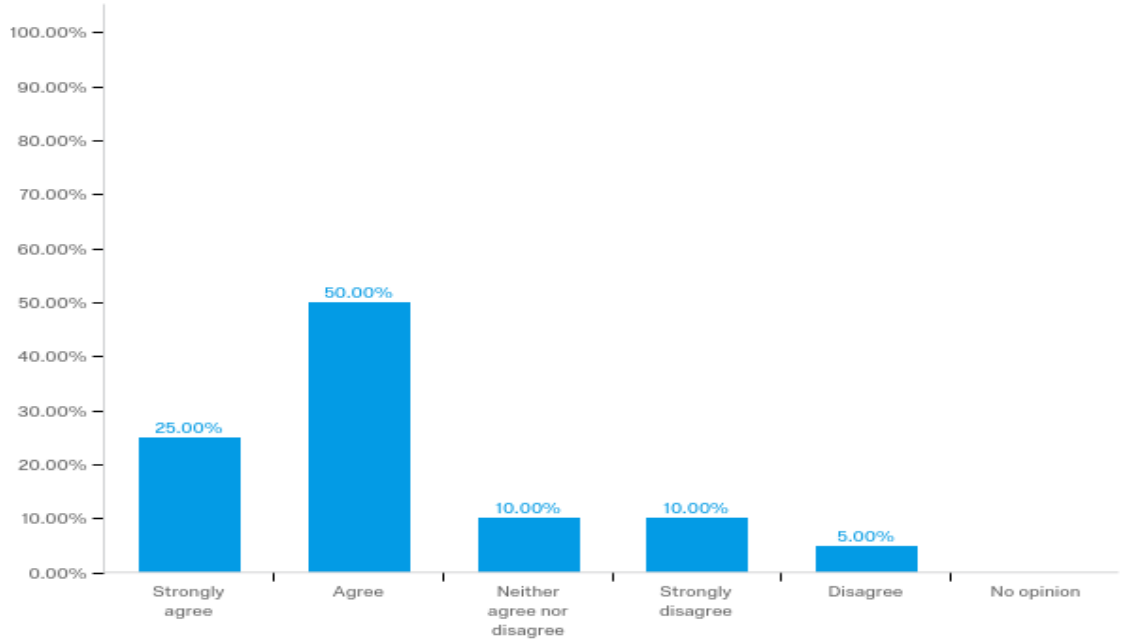
Q13 - Regulatory agencies including the FAA should oversee flight operations involving Drones during emergencies and impose no-fly restrictions if necessary.



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Regulatory agencies including the FAA should oversee flight operations involving Drones during emergencies and impose no-fly restrictions if necessary.	1.00	5.00	2.30	1.38	1.91	20

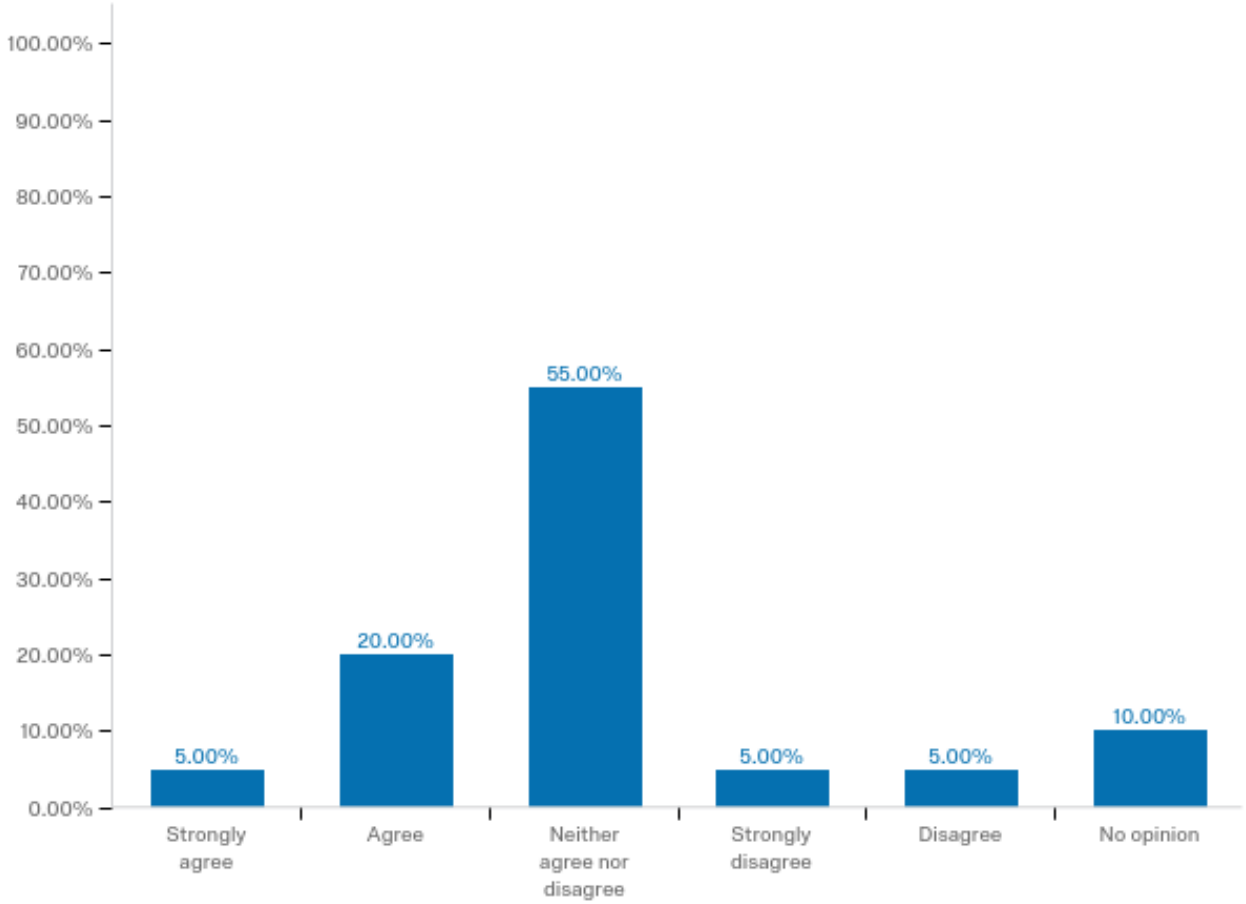
Q14 - Local Emergency Managers should oversee training and certify Drone Pilots for operations involving emergencies including wildfires, flooding, and damage assessment of transportation networks (roads/rail) and utility infrastructure (power, water, gas, drainage).



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Local Emergency Managers should oversee training and certify Drone Pilots for operations involving emergencies including wildfires, flooding, and damage assessment of transportation networks (roads/rail) and utility infrastructure (power,	1.00	5.00	2.20	1.08	1.16	20

water, gas, drainage).						

Q15 - Networked Drones operating in autonomous (pilotless) swarm formations above the 400 foot FAA altitude limit may provide advantages over single-operator line-of-sight drones operating below the 400 foot limit.



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Networked Drones operating in autonomous (pilotless) swarm formations above the 400 foot FAA altitude limit may provide advantages over	1.00	6.00	3.15	1.24	1.53	20

single-operator line-of-sight drones operating below the 400 foot limit.						

Q16 - Please comment on issues and challenges related to FAA regulations and compliance concerning the use of drones for emergency response involving preparedness, damage assessment, and search-and-rescue operations.

Please comment on issues and challenges related to FAA regulations and compliance concerning the use of drones for emergency response involving preparedness, damage assessment, and search-and-rescue operations.
N/A
COA, E-COAs and regulations on interfering with sUAS are slow to change. Public safety needs an ability to enforce FAA regulations on site.
The one challenge we routinely encounter is the "line of sight" restriction.
The process of obtaining a Certificate of Authorization (COA) is ridiculous. You must buy a drone before getting a COA since you need to have a registered drone to apply. If you are not going to receive a COA, you wasted your money. I my agencies situation, we are located within the no fly zone of Washington, DC so we are kind of stuck.
This agency has not encountered any FAA regulations that have hindered these operations.
One of the concerns I already mentioned was the ability to get personnel in the City of Annapolis trained on the FAA Regulations Part 107 to understand what is allowed and not allowed in the airspace. One thing I would say needs to be addressed is the ability for Certified Pilots to notify airports, and other pilots of their flights. I think the ability to report your flight position in an app or website would be advantageous to all parties who fly or manage airspace. I believe that the FAA is understanding of emergency flights, and have established regulations that take emergency flights into consideration.
have manned aircraft above 500 feet when operating with drones in the same area
Current FAA regulations strictly limit the functions that may be carried out by the operator. In order to bypass certain regulations, a certificate of waiver must be applied for and granted. The waiver process is extremely burdensome and slow which reduces the overall availability of the drones in public use.
We developed a document for assisting public agencies on the two different FAA routes (COA vs Part 107) that a public agency can use to implement UAS technology into their operations. In addition, we present and attend UAS conferences/workshops as well as assist other public agencies. We are working on developing live streaming capability to our EOC.
I feel the use of drones during a disaster should be treated like any disaster, at the local level. It can be inconvenient to always have to rely on the FAA for drone usage during a disaster.
I think that many of the regulations should be reassessed and special consideration should be given when it comes to Law Enforcement, Fire/EMS Departments and Emergency

Management. Through proper FAA compliance training, these responders can benefit greatly from the proper and safe use of drones.

The biggest challenge for the FAA will be policing hobbists who have no intention of following regulations regarding the operation of drones.

I think because drone usage in Public Safety is so new and constantly changing, the regulations and compliance can be daunting and confusing to an agency starting a program.

To date, we have not experienced issues with the current FAA Regulations. We operate in concert with a local military testing facility and authorizations have been seamless. We operate in a lot of controlled airspace used for military flight testing and have found the military to be very accomodating in clearing us to fly when needed. As for the FAA regulations, we hired a contractor to assist with the start up of our program. The contractor navigated throught he FAA regulations and assisted us in obtaining the necessary waivers.

The FAA should have a broader definition of what constitutes a COA operation. Consequently, if a remote pilot who thinks that he/she is conducting a COA operation has an accident, the FAA may deem that operation as a non-COA operation, and charge that person with violating Part 107 regulations.

See previous comments on drone and radar identification.
400 foot limit is too high

APPENDIX D: STATISTICAL DATA TABLES

Field	Minimum	Maximum	Mean	Standard Deviation	Variance	Count
Drones are effective in reporting and assessing risks from various emergencies including flooding, wildfire, and damage from tornadoes, hurricanes, and chemical spills.	1.00	2.00	1.25	0.43	0.19	20

Table 4.2 Statistical Data for Question 5

Field	Minimum	Maximum	Mean	Standard Deviation	Variance	Count
Drones are a safe, reliable, and cost effective means for planning and coordinating responses by delivering video, GPS locations and other data products.	1.00	3.00	1.53	0.60	0.35	20

Table 4.3 Statistical Data for Question 6

Field	Minimum	Maximum	Mean	Standard Deviation	Variance	Count
In reporting and assessing weather or other emergencies the information from drones have acceptable data integrity and quality.	1.00	3.00	1.47	0.68	0.46	19

Table 4.4 Statistical Data for Question 7

Field	Minimum	Maximum	Mean	Standard Deviation	Variance	Count
The cost to acquire drones appears to match expectations for performance including flight controls, battery life, data storage and processing speed.	1.00	4.00	1.80	0.87	0.76	20

Table 4.5 Statistical Data for Question 9

Field	Minimum	Maximum	Mean	Standard Deviation	Variance	Count
Drones appear to have adequate sensor technologies (including heat sensors) to improve and extend search-and-rescue operations especially during night flight.	1.00	6.00	1.70	1.19	1.41	20

Table 4.6 Statistical Data for Question 10

Field	Minimum	Maximum	Mean	Standard Deviation	Variance	Count
Effective Emergency Operations involving Drones require flight plans that should be coordinated and carried out with trained Pilots who are also certified Emergency Responders.	1.00	5.00	2.20	0.93	0.86	20

Table 4.7 Statistical Data for Question 11

Field	Minimum	Maximum	Mean	Standard Deviation	Variance	Count
Regulatory agencies including the FAA should oversee flight operations involving Drones during emergencies and impose no-fly restrictions if necessary.	1.00	5.00	2.30	1.38	1.91	20

Table 4.8 Statistical Data for Question 13

Field	Minimum	Maximum	Mean	Standard Deviation	Variance	Count
Local Emergency Managers should oversee training and certify Drone Pilots for operations involving emergencies including wildfires, flooding, and damage assessment of transportation networks (roads/rail) and utility infrastructure (power, water, gas, drainage).	1.00	5.00	2.20	1.08	1.16	20

Table 4.9 Statistical Data for Question 14

Field	Minimum	Maximum	Mean	Standard Deviation	Variance	Count
Networked Drones operating in autonomous (pilotless) swarm formations above the 400 foot FAA altitude limit may provide advantages over single-operator line-of-sight drones operating below the 400 foot limit.	1.00	6.00	3.15	1.24	1.53	20

Table 4.10 Statistical Data for Question 15

APPENDIX E: Survey Respondents' Roles and Location

#	Role	State
1	Emergency Management	North Carolina
2	Emergency Management	North Carolina
3	Emergency Management	North Carolina
4	Emergency Management	Virginia
5	Law Enforcement	Virginia
6	Law Enforcement	Virginia
7	Law Enforcement	Virginia
8	Emergency Management	Virginia
9	Emergency Management	North Carolina
10	Community Revitalization	Maryland
11	Law Enforcement	North Carolina
12	Law Enforcement	Maryland
13	Law Enforcement	Maryland
14	Law Enforcement	Maryland
15	Law Enforcement	Maryland
16	Emergency Management	Maryland
17	Law Enforcement	Virginia
18	Emergency Management	Virginia
19	Public Assistance	Maryland
20	Emergency Management	Maryland

APPENDIX F: IRB APPROVAL LETTER

EAST CAROLINA UNIVERSITY
University & Medical Center Institutional Review Board
4N-64 Brody Medical Sciences Building· Mail Stop 682
600 Moye Boulevard · Greenville, NC 27834
Office 252-744-2914 · Fax 252-744-2284 · www.ecu.edu/ORIC/irb

Notification of Exempt Certification

From: Social/Behavioral IRB
To: Victoria Tanner
CC:
Erol Ozan
Date: 7/16/2018
Re: UMCIRB 18-001414
Disaster Preparedness Integrating Drone Technology in the Southern United States

I am pleased to inform you that your research submission has been certified as exempt on 7/15/2018. This study is eligible for Exempt Certification under category #2.

It is your responsibility to ensure that this research is conducted in the manner reported in your application and/or protocol, as well as being consistent with the ethical principles of the Belmont Report and your profession.

This research study does not require any additional interaction with the UMCIRB unless there are proposed changes to this study. Any change, prior to implementing that change, must be submitted to the UMCIRB for review and approval. The UMCIRB will determine if the change impacts the eligibility of the research for exempt status. If more substantive review is required, you will be notified within five business days.

The Chairperson (or designee) does not have a potential for conflict of interest on this study.