Examining the Use of Unmanned Aerial Vehicles to Conduct Damage Assessment in the City of Norfolk

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Certification Statement

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Signed: 

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Abstract

The problem was Norfolk Fire Rescue had not identified advantages and disadvantages of using unmanned aerial vehicles to conduct damage assessment during a major emergency. The purpose of this research was to identify if the use of unmanned aerial devices for damage assessment would be beneficial to Norfolk Fire Rescue. The ability to conduct an efficient damage assessment process while limiting the exposure of first responders to hazardous areas is essential.

In this descriptive research, the following questions were answered: (a) What must be included in a damage assessment? (b) What standards exist for the use of unmanned aerial vehicles for damage assessments? (c) Are there any fire departments currently using unmanned aerial vehicles for damage assessments? (d) What advantages and disadvantages exist for the use of unmanned aerial vehicles for damage assessments?

Data was collected using an interview and a survey. The interview was conducted with persons responsible for emergency management in the City of Norfolk, and surveys were sent to departments throughout the United States.

Results indicated that the use of unmanned aerial devices for damage assessments is a beneficial technology for fire service organizations. It offers a way to obtain information while keeping first responders out of potential threat areas. Recommendations included purchase of a device and proper training, educating the public on their use, researching further legal considerations, and education of fire service personnel on the damage assessment process.

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Examining the Use of Unmanned Aerial Vehicles to Conduct Damage Assessment in the City of Norfolk

There are several unique challenges that fire service personnel in general, and Norfolk Fire Rescue (NFR) members in particular, are faced with every single day. The vast majority of these incidents are mitigated with the appropriate amount of resources from fire as well as other city departments. There are also potential emergencies that would tax NFR's resources leaving other calls for service delayed, or missed completely. Emergencies such as floods, earthquakes, or hurricanes can quickly consume resources both during and after the event. NFR currently does not have the resources to conduct a good damage assessment that would allow more units to concentrate on calls for service in these high call volume periods. This research on unmanned aerial devices could prove to be beneficial and allow for a thorough and efficient damage assessment process while still being able to conduct normal daily operations during a large scale emergency.

The problem is Norfolk Fire Rescue has not identified advantages and disadvantages of using unmanned aerial vehicles to conduct damage assessment during a major emergency. The descriptive research methodology was used to identify if the use of unmanned aerial devices would prove to be beneficial for the damage assessment process. The research questions addressed were (a) What must be included in a damage assessment? (b) What standards exist for using unmanned aerial vehicles for damage assessment? (c) Are there any fire departments currently using unmanned aerial vehicles for damage assessments? (d) What advantages and disadvantages exist for the use of unmanned aerial vehicles during a damage assessment? This research could serve to benefit NFR in their overall response to large scale emergencies and contribute to a seamless damage assessment process. With a good body of research to help drive

the utilization of this type of technology for a damage assessment, NFR can implement best practices while using these devices during a flood, earthquake, or any other natural or manmade disaster that could occur in the years to come.

Background and Significance

NFR is full of rich tradition and history. The Fire Department has been a fully paid and professional organization since the merger of several volunteer companies in 1871. The department has since evolved and progressed to meet the constant and dynamic demands from the community it serves and its citizens. Norfolk's committed professionals cover an area of 66 square miles of urban city with a population of 246,393 residents (United States Census Bureau, 2015). NFR responds to over 40,000 emergency incidents a year from 14 fire stations that are strategically located throughout the city, with just over 500 dedicated professionals (City of Norfolk, 2014). It also provides a multitude of community and support services from Administrative Services, Fire Marshal's Office, Training, and the Special Operations Divisions. Within its borders Norfolk is home to the largest naval base in the world along with several other military installations, shipyards, and large international shipping terminals. Norfolk Fire Rescue is committed to maintaining a response time of less than four minutes at least 90% of the time.

NFR staffs 12 advanced life support ambulances (ALS), 14 ALS Engine Companies, 7 ALS Ladder Companies, and 2 ALS Rescue Companies. In addition there are two fire boats that are capable of performing water rescue as well as fire suppression. The operations side of the department is separated into three separate battalions, working under three rotating shifts. Services provided include fire suppression, emergency medical services, technical rescue, and waterborne operations. In addition, some stations serve as specialty shops for small tools, turnout gear, breathing apparatuses, and nozzle repairs.

Norfolk lies on the east coast of the United States and is surrounded by large amounts of water. Both water from the Atlantic Ocean as well as other river and tributaries. The likelihood of Norfolk being impacted by a large scale emergency is high due to is location. The city of Norfolk has been ranked number 4 out of the top 5 most vulnerable cities that will be impacted and devastated by hurricanes (Climate Central, 2012). One of the most recent and most devastating hurricanes to hit Norfolk was Hurricane Isabel in 2005. This storm affected many other coastal areas, but dealt a heavy blow to the City of Norfolk and its resources. Winds reached as high as 87 mph sustained and caused not only damage to businesses and homes, but caused major tidal flooding (Ambrose, 2013). In addition to the damage from this hurricane Norfolk also experienced a tornado during this storm which increased the amount of damage and taxed resources even more (National Oceanic and Atmospheric Administration [NOAA], 2005). Hurricane Isabel left the city of Norfolk as well as the State of Virginia with a tremendous need for state and federal resources. Recovery assistance for this hurricane totaled 149 million dollars and 270 million dollars for public assistance (Virginia Department of Emergency Management, n.d.).

Though this is only one of many storms that have impacted the City of Norfolk, the potential for more will always exist. During this storm there was still a need for units to perform their regular duties of fire suppression, emergency medical services and more. The city had a dedicated director of emergency management and has a team responsible for the damage assessment process, planning, and coordination of state and federal agencies (City of Norfolk, 2014). One thing in particular that can be delayed simply because of access to the scene and existing damages immediately after a major event is the damage assessment process. Currently the emergency management division with the help of NFR and other city agencies are

responsible for the initial damage assessment after an event. This is made up of key stakeholders from public works, fire, police, public schools, utilities and more. The challenge arises when these key players are unable to physically go out and conduct damage assessments. Fire Apparatus and other city vehicles may not be able to complete their windshield assessments due to debris or other hazards. An expedient and accurate damage assessment done at the local level is critical to be able to receive assistance during an emergency (Federal Emergency Management Association [FEMA], 2016).

The use of technology such as an unmanned aerial device may prove to be beneficial during the damage assessment process. It could allow NFR and other city agencies to focus resources on other demands that will arise during any type of natural or man-made disaster. The threat of natural disasters will not go away, and the City of Norfolk and all responsible parties must be ready for these types of events. The use of unmanned aerial devices could have a beneficial impact on the damage assessment process.

The problem for this applied research project is NFR has not identified advantages and disadvantages of using unmanned aerial vehicles to conduct damage assessment during a major emergency. The Executive Analysis of Fire Service Operations in Emergency Management course is designed to allow students to be better prepared to assist their communities in the result of a natural disaster. Damage assessment is a large body of this course and with the help of this research could yield positive results for the City of Norfolk and possible many other agencies outside the city border.

The United States Fire Administration developed a strategic plan for the fire service that included five goals to help emergency services improve their delivery of service to the communities and the fire service as a whole (United States Fire Administration [USFA], 2014).

Norfolk Fire Rescue has realized that identifying the pros and cons of unmanned aerial devices for damage assessments is necessary. The third USFA goal was to “improve the fire and emergency services capability for response to and recovery from all hazards” (USFA, 2014, p. 9). The problem with NFR not identifying advantages or disadvantages for using unmanned aerial devices for damage assessments is there will be a continuous tax on resources. NFR has the opportunity to explore technology that will allow for better resource allocation and deployment and ultimately benefit the citizens by allowing for faster cost recovery and state or federal assistance.

Literature Review

The literature discovered for this research examined topics on (a) regulations that exist for the use of unmanned aerial devices, (b) training required for operation, (c) pros and cons of using these devices for damage assessments, and (d) practicality of use by municipal fire departments. The challenge with this literature review was the limited amount of fire departments publishing information on the use of unmanned aerial vehicles (UAV’s) for damage assessments. UAV’s are being used in other areas of the fire service, but appear to have a limited use in emergency management or disaster recovery field.

Efficient damage assessments must use a variety of different methods to obtain as much accurate information as possible. The more accurate and timely information is received from the damage assessment process; the more expedient the disaster declarations can be made (FEMA, 2016). The damage assessment process should be as rapid as possible and will require the evaluation of major areas of concern. These areas of concern would be things such as life safety threats, hazards, area access, property loss, and damage to critical infrastructure such as a water treatment plant (USFA, 2016).

There are several different methods that can be used to evaluate damage in a community. Relying on one way to assess damage in an affected area will not only increase the time it will take to gather information, but it will also put a limit on the quality of information that is being received (FEMA, 2016).

The use of unmanned aerial devices during a major disaster is turning out to be one of the promising and powerful new technologies that exist to aid in the disaster response and relief process (Measure, 2015). Furthermore, Measure (2015) makes the point that the use of an unmanned aerial device supplemented with a traditional means of disaster relief and recovery processes are proving to be very efficient.

Emergency services can quickly become taxed after a large scale emergency such as a hurricane or tornado emergency services leading them to become overwhelmed. After a disaster drones or any other type of unmanned aerial device can help responders gain a more global look at the disaster and locate survivors more quickly (Johnson, 2015). This would be a great benefit and allow the drones to operate while freeing up fire department resources or other entities involved in the damage assessment process.

In Palo Alto California a study was done by the Electric Power Resource Institute to explore the use and benefits of using an unmanned aerial device for damage assessments after a major power outage. They were looking at damage to utility distribution sites in particular during this study. It was noted that the biggest obstacles to restoring power were downed trees or other hazardous conditions that made crew access difficult. They concluded that the use of an unmanned aerial device such as a drone improved restoration times because of rapid deployment and the ability to stream video and quickly gather information (Perry & Kintner, 2012).

Wood (2013) explains that even with concern of public privacy or other regulations stifling the use of drones in public safety, non federal agencies, the benefits will outweigh the concerns. Drones are able to augment operations and help public safety organizations. These devices can be sent into areas where we may not want to risk human life. People may not see the benefit of using a drone during a major emergency until they are a part of that emergency and their privacy concerns take a back seat to the pros of the technology (Wood, 2013).

Researchers in the Netherlands from the University of Twente studied the use of unmanned aerial devices for damage assessments after a major emergency. They concluded that inspection by drones proved to be much faster, cheaper and more efficient than not using them at all. Because the drones have the ability to gather information very quickly, aid and emergency measures can be put into place rapidly, ultimately saving lives (Bekmann, 2014).

Guidelines are set in place for localities to obtain financial support from the government. The Robert T Stafford act requires that requests for declaration have to be completed within thirty days of the event that took place. The request will made will be sent to the Governor of that affected state (Robert T. Stafford Disaster Relief and Emergency Assistance Act, 2013). As with any emergency, a swift response is critical. A through and efficient damage assessment process utilizing various types of technologies can be used to assess high risk areas and quickly develop an operational plan (FEMA, 2016).

One potential roadblock to the use of unmanned aerial vehicles for damage assessments is all of the regulations imposed upon localities by the state and local government. Currently the Commonwealth of Virginia prohibits regulation of these devices by localities, meaning any use of the device will have to be regulated by state and federal laws (Aircraft State Law Landscape, 2016). In the Commonwealth of Virginia protocols exist for the use if unmanned aerial devices

for law enforcement agencies. There are several benefits listed in this document as to why these organizations could use a technology such as this. One of the benefits listed is the use of an unmanned device for disaster management (Department of Criminal Justice Services, 2013). This report goes on to explain several other benefits of using unmanned aerial vehicles for public and community safety. Two of the most significant benefits being the device can be launched from a safe location very quickly, and they offer excellent situational awareness capabilities while limiting exposure of rescuers to hazardous environments (Department of Criminal Justice Services, 2013).

Public Safety organizations wishing to utilize any type of unmanned aerial vehicle must obtain permission from the Federal Aviation Administration (FAA) by obtaining a certificate of waiver or authorization (COA). These permits are issued to organizations and are typically good for up to two years (Federal Aviation Administration, 2016). Before authorization is granted the FAA will ask for a declaration letter from the jurisdiction submitting the request. This letter will have to come from the city or state attorney essentially telling the FAA that the organization making the request is recognized as a government organization or political subdivision under the state (Federal Aviation Administration, 2016).

Several regulations are in place and are expected to be followed by any approved user of an unmanned aerial device. There are ceiling restrictions, weight limits, and operating hours that must be adhered to. The use of drones by public safety agencies must be no more than twenty five pounds, have a ceiling of 400 feet, and not interfere with any other manned aircraft (Federal Aviation Administration, 2016). Also, if needing to use a device within five miles of an airport, it may be done, but only with the permission of the airport or control tower.

With public and state resources being in short supply unmanned aerial vehicles may prove to be cost effective in public safety operations. The drain on resources to conduct an accurate damage assessment could be tremendous. Many law enforcement agencies have started to use drones to help with criminal activity, but are also assisting with natural and manmade disasters. In January 2012 the Mesa Arizona Sheriff's Office praised the use of their drones in assisting the fire department in many operations. It proved to be very cost effective costing $3.36 an hour as opposed to spending upwards of $600 dollars an hour for a manned vehicle ("The Benefits of Unmanned Aircraft Systems," n.d.).

Though many positive benefits can be identified in the use of drones for conducting damage assessments and more, some disadvantages and legal concerns still exist and need to be taken into consideration. One concern is the use of a drone in a populated area and the potential for it to crash. There could be personal injury or further damage to other services such as hitting a power line that was not visible during flight (Werner, 2015). Werner (2015) goes on to identify privacy as being another item for concern by potential users. Some citizens may not feel comfortable with a unmanned aerial device surveying their property without their permission. As with any type of technology that may be put into use fire departments must be willing to understand and follow the legal guidelines set in place and accept a certain amount of liability and responsibility in the event of a potential accident while using a device.

When it comes to the acquisition of an unmanned aerial vehicle to be used by a fire department there are a number of manufacturers that exist. Some of them cater directly to public safety organizations. Though many are being used in the wildfire arena they are offering drones for purchase and training to go along with their use. One company identified with this research was SkyFire Consulting. They advocate the use of drones for the purpose of damage assessments

and coordination with the movement of resources (SkyFire Consulting, n.d.). Additionally they are willing to provide all the necessary training needed to operate the device as well as fill out the appropriate FAA paperwork to ensure you obtain the proper authorization in your state.

In summary, the purpose of this literature review was to examine and summarize the research findings of others on the topic of using unmanned aerial devices for the damage assessment process. The search identified very few organizations that were utilizing this technology for damage assessments. Many organizations were utilizing these devices for other fire department or law enforcement functions. Though there was limited use in the area of damage assessments this literature review provided sufficient information to support the use of unmanned aerial devices by providing a host of benefits. It was identified that there are multiple federal regulations that exist and are constantly changing as well as legal ramifications that could potentially exist for the user of these devices.

Procedures

This applied research project used a survey and an interview with the Director of Emergency Management for the City of Norfolk, Virginia. The purpose of these procedures was to gain as much information from various sources to answer the research questions and help identify if the use of unmanned aerial devices for damage assessments would be a useful technology for the city.

The Internet search included key subjects such as state and federal regulation on the use of UAV's, benefits of their operations, legal concerns, and overall operational use. Websites that were examined were state and local departments such as the Civil Air Patrol and the Federal Aviation Administration and other government agencies. Much of the data gathered through the Internet was from websites that included technical journals, incidents where UAV's were used,

and the research of others on the same topic. Data on the use of UAV's for damage assessment was difficult to obtain. Many agencies are using them for several other operations other than damage assessments, which lead to a lack of focus on one specific use.

A survey (Appendix B) created on the Internet site Survey Monkey was sent out to over 200 firefighters, and it captured 76 respondents from fire departments from around the country. Prior to the dissemination of the survey a search was done to try and identify specific departments that were using UAV's for damage assessments. This was accomplished by performing an Internet search as well as calling multiple departments around the country and contacting departments via email. A total of 60 days was allowed before the survey was closed. The purpose of the survey was to gather data about the current use of UAV's for damage assessments and obtain critical information needed for this research.

A letter was attached to the email link with the survey explaining the purpose of this research and what the survey would entail (see Appendix A). The survey consisted of 13 questions which included check boxes, fill in the blank and short answer responses (see Appendix B). When the survey was sent out, it did not target any particular subject matter expert within a department. The recommendation in the letter was to have a training officer or chief officer complete the survey.

An Interview was conducted with the Director of Emergency Management for the City of Norfolk (J. Redick, personal communication, May 18, 2016). This interview took place in Norfolk, Virginia in the Emergency Operations Center (EOC). In order for the interviewee to be prepared for the questions that were asked, these 10 questions (see Appendix C) were sent to him via email one week prior to the actual interview. This allowed an opportunity for him to prepare for each of the questions he was going to be asked.

Limitations that existed during the data collection included the lack of current information in the United States regarding the use of unmanned aerial devices for damage assessments. There has been little use on the introduction of this equipment for the damage assessment process. Several fire departments are using them to conduct visual observations of large wildland fires or larger structural fires. They are being used by search and rescue teams to help locate people trapped or injured, and law enforcement has started using them as well for many different applications. Though they are being used for many different things, they are limited in their use for the damage assessment process. This led to the inability to gather a large amount of data for this subject matter. The sample size was very limited in this research. The ability to identify departments throughout the country that utilize the use of unmanned aerial devices for damage assessments was challenging. There was no database that existed or a timely way to select multiple agencies that could create a focus group in which to send the survey. Other measures used to collect data could have been used in this research. If conducted again, it may be beneficial for the researcher to conduct interviews with other government agencies that regulate the use of unmanned aerial devices for public safety use. Additionally if time allows participate in a drill where an identified department is using the device for a damage assessment operation. This could lead to an opportunity to gain firsthand knowledge on best practices and lesson learned.

Results

Research question one asked: What must be included in a damage assessment? The information collected during the interview with Norfolk Emergency Management Director (Appendix C) and the literature discovered provided clear expectations on what should be done during a damage assessment. The Emergency Management Director has explained that many city

agencies will be involved in the information gathering process. Any type of damage that will negatively impact the community should be something of concern. The need to target critical infrastructure is paramount. Locations such as schools, hospitals and major roadways need to be assessed as soon as possible. The status of these facilities and infrastructure will have a large impact on our ability to deliver resources in a timely manner. Documentation should be accurate and complete as possible.

The second research question asked: What standards exist for using unmanned aerial vehicles for damage assessment? There are several state and federal regulations that have been placed upon the use of unmanned aerial vehicles for both recreation and public safety use. Using UAV's for damage assessments does not mean regulations fall to the wayside. Any public safety organization wishing to use UAV's for damage assessment must go through an approval process. This process includes an initial certification of authorization issued by the air traffic organization. During this approval process there will be a comprehensive operational and technical review. Depending on how the review process goes and what criteria are being met, provisions or limitations could be imposed as part of the approval. These regulations are set in place by the Federal Aviation Administration (FAA). These regulations provide direction on the size of the device that can be used, ceiling height, operating hour restrictions and more. Any public safety organization that is considering the use of using a UAV for damage assessments must fully comply with these regulations. Many of these rules and regulations are constantly being reviewed and updated as time goes by. It is important for agencies to pay close attention to any changes that will affect their potential operations.

The third research question asked: Are there any fire departments currently using unmanned aerial vehicles for damage assessments? A survey was sent out to that reached 76 fire

departments (See Appendix B). Of those that replied there were only five were currently using UAV's for damage assessments. A large percentage of those surveys though not using UAV's now are considering their use in the future. Of those that are using the devices for damage assessments four of them are using them to assess damage during wildland fires while the fifth one uses the device for assessments during major flooding and tornadoes.

The last research question asked: What advantages and disadvantages exist for the use of unmanned aerial vehicles during a damage assessment? Several advantages were identified during the literature review. The use of this type of technology will ultimately allow for first responders to stay away from areas that would be extremely hazardous. Using UAV's to assess damage will avoid a boots on the ground approach while still being able to collect information. Typically, many city agencies will be responsible for going out into their jurisdictions to gather as much information as possible. With the use of a UAV, it would allow for those agencies to focus their efforts where they may be needed most and still have the damage assessment process continue. One major area of concern is being able to physically assess an area where roads may not allow access from collapse or flooding. UAV's have the benefit of flying into very confined areas when roads, bridges, and tunnel maybe impassable. Though there were many advantages, they have their disadvantages as well. Privacy concerns continue to be a problem with the use of this technology in populated areas. These UAV's are able to get very close to residential homes, and, citizens may sometimes be against an agency gathering information or filming this close to their property. Along with the privacy issues in residential areas, is the worry of potential crash implications. These devices are operated by human beings and there is always room for error. Agencies that want to operate UAV's have to consider and take on the responsibility if one of their devices were to crash into a populated area and cause injury or death to a civilian.

The interview with Norfolk City Emergency Management Director yielded many positive results. One of the biggest things that the use of this technology will offer is a heightened situational awareness for all first responders (J. Redick, personal communication, May 18, 2016). There will be places all over the city where first responders will not be able to make access in the event of an emergency. This technology will allow for a good damage assessment when that happens. The Emergency Management Director feels that the use of a UAV would be very beneficial for the City of Norfolk. Concerns were addressed with the possible legal ramifications that could potentially exist. Most of these legal concerns may be addressed very easily with full transparency of the UAV program with the citizens of Norfolk. “If the public is aware of the use of this technology they will be more inclined to trust the operations.” (J. Redick, personal communication, May 18, 2016). There are many hobbyists who fly UAV’s for recreational purposes. The city of Norfolk also has a Community Emergency Response Team. Norfolk should consider the idea of using these hobbyists as part of the CERT teams to operate the UAV’s when we have a disaster (J. Redick, personal communication, May 18, 2016). It is likely that these operators have already been through the approval process required by the FAA and could be of great assistance when faced with a disaster. Overall the interview concluded that the use of UAV’s for damage assessment would be a tremendous benefit for the City of Norfolk during a large scale disaster.

Collectively, the interview, survey, and literature discovered identified that using UAV’s for damage assessments during a major emergency would be extremely beneficial. Though there are some disadvantages as outlined in this research, the use of this technology will ultimately proved a better way to conduct damage assessments while limiting the number of resources required to do so.

Discussion

Based on the information gathered, Norfolk Fire Rescue can benefit greatly from the use of UAV'S for damage assessments during a major emergency. This study proved to be beneficial in helping Norfolk Fire Rescue identify some steps to take in order to allow for a more timely and thorough assessment process as well as steps it could take to implement best practices that will contribute to a successful outcome should these events arise.

The Commonwealth of Virginia and Norfolk Fire Rescue in particular is no stranger to large scale disasters. The use of unmanned aerial devices during a major disaster is proving to be one of the promising new technologies that exist to aid in the disaster response and relief process (Measure, 2015). Norfolk Fire Rescue can lead the region in the use of this technology to conduct damage assessments and ultimately provide a quicker and more effective disaster response to the community.

The resulting damage that exists after a major emergency such as a flood or hurricane can cause heavy damage all over the city. Being able to access specific areas of concern is critical. These would be things such as life safety threats, hazards, area access, property loss, and damage to critical infrastructure such as a water treatment plant (USFA, 2016). With any response to an emergency, first responders have to be able to reach these target areas. After a disaster an unmanned aerial device can help responders gain a more global look at the disaster and locate survivors more quickly (Johnson, 2015). Even in the event that access to these areas is not possible, the use of a UAV could speed up the assessment process.

This study revealed that not many fire service organizations are currently using UAV's for damage assessments. Still, the use of this technology is proving to be successful in other trades or organizations. An electric company has employed the use of UAV's in their company.

They have found that using these devices drastically improved restoration times due to the rapid deployment and ability to gather information in real time with streaming video (Perry & Kintner, 2012).

The ability to gather information in a timely manner is always a challenge during a damage assessment, especially when participating agencies are unable to get access to do the assessment (J. Redick, personal communication, May 18, 2016). UAV's are piloted by an operator and have the ability to be deployed very quickly, even minutes after an event has swept through the community. Because the drones have the ability to gather information very quickly, aid and emergency measures can be put into place rapidly, ultimately saving lives (Bekmann, 2014).

Several regulations were found for the use of UAV's in public safety agencies. The regulations limit ceiling height, operator qualifications, as well as explain the process to obtain licensure (Federal Aviation Administration, 2016). It is not uncommon for hobbyists to also operate drones for recreational purposes. Using UAV's for recreation still requires the user to follow FAA regulations. Ensuring there are a set number of qualified operators can be challenging for an organization. Using these hobbyists as members of a Community Emergency Response Team may prove valuable during an emergency (J. Redick, personal communication, May 18, 2016). They will likely have gone through the appropriate approval process and can be used on these teams as the sole operators of the device if needed during a damage assessment. This would free up other responders for other tasks (J. Redick, personal communication, May 18, 2016).

UAV's have raised controversy due to privacy concerns, especially in well populated areas where they may be operating. Those agencies considering their use must be aware of these

legal considerations. Werner (2015) explains that some citizens may not feel comfortable with an unmanned aerial device surveying their property without their permission. Full transparency is a must when operating these drones. If the public is educated on their use they are more likely to be accepting of the technology as well as realize the benefits that it can provide to their community (J. Redick, personal communication, May 18, 2016).

These UAV's may prove to be very cost effective. It is not uncommon to find UAV's for purchase in a local department store. They still have the ability to give a detailed assessment much like manned aerial vehicle. The Mesa Arizona Sheriff's Office praised the use of their drones in assisting the fire department in many operations. They concluded that the cost for a UAV operation was $3.36 an hour as opposed to $600.00 an hour for a manned vehicle such as a helicopter ("The Benefits of Unmanned Aircraft Systems," n.d.). The National Guard will assist at times with a fly over, but it comes at a cost. The other problem is we don't get the information back from their survey very quickly, if at all (J. Redick, personal communication, May 18, 2016). With Norfolk Fire Rescue having the ability to survey the damage there is no reliance on a third party to get critical information back to the emergency operations center.

Situational awareness is paramount in any emergency that first responders will face. Norfolk Fire Rescue personnel are constantly reminded of its importance in their daily operations. It was identified that one of the greatest benefits of utilizing UAV's was they offer excellent situational awareness capabilities while limiting exposure of rescuers to hazardous environments (Department of Criminal Justice Services, 2013).

The research and results that were derived from this project will be beneficial in helping NFR identify the benefits and best practices for using UAV's for damage assessments. This body of research will allow NFR to make educated recommendations to its members when responding

to large scale disasters where they may have to put themselves in harm's way. This technology could remove the human element from the damage assessment process while still allowing for the timely collection of information. Other surrounding agencies could benefit from this research as it has shown several benefits of the technology. The study indentified that very few fire service organizations are using UAV's for damage assessments. This body of research could be the catalyst for fire service organizations to explore the benefits of UAV's and provide the best service possible to their communities.

Recommendations

The first recommendation as a result of this research is for NFR to identify critical infrastructure that exists in the community prior to an emergency. This information should be stored where it is accessible to all fire stations that will have these critical areas in their response districts. Even before a large scale emergency hits the city responders would have the ability to identify these areas and pre-plan potential resource requirements.

The second recommendation is to have NFR conduct training for all members on what is required during a damage assessment. Currently a windshield assessment is being used by fire apparatus as they move through their response areas. This training should include how to properly assess damaged building and other infrastructure as well as proper documentation. Timely gathering of information has been identified as critical and this training could potentially help that area.

The third recommendation would be for NFR to identify what laws are currently in place that may restrict the use of UAV's in the Commonwealth of Virginia. Laws and regulations with the use of this technology have proven to be ever changing. Many states have signed petitions

demanding several laws requiring these devices be changed. The City Attorney for the City of Norfolk will be a valuable resource when exploring these laws.

The fourth recommendation would be to educate the public on the use of this technology. Transparency in the operation has been identified as being a factor that could contribute to a successful operation. The citizens of Norfolk can be educated via various mediums such as civic league showings or media releases. Once there is full transparency the community is likely to have buy in to the operations and see the benefits during a disaster.

Another recommendation would be to consider who will operate the UAV. There was no clear direction offered by the research. The city of Norfolk has a Community Emergency Response Team that assists in the damage assessment process. Norfolk also has hobbyists that fly drones for recreational purposes. NFR should reach out to these hobbyists and see if there is an interest in becoming part of the CERT for the sole purpose of using them for damage assessments. the with the Further research should be conducted in the United States on different tunnel firefighting tactics. Limited research has been done to identify various strategies and tactics in the different types of tunnels that exist. There are many different sized tunnels throughout the United States; all having different design features based on their length, age, design, and location. Firefighting efforts could be very problematic in the future if a lack of test fires in roadway tunnels is not given serious consideration.

Lastly, NFR should consider the purchase of a UAV for the damage assessment process. They come at very low cost and have proven to have a very low annual operating cost. It was noted that the Norfolk City Director of Emergency Management sees this technology as a tremendous benefit that will gain support from many city officials. The ability of this technology to offer situational awareness to all first responders is paramount. This body of research has

proven that with the purchase of a UAV the City of Norfolk will now have a more rapid and thorough damage assessment in the areas where first responder or other city agencies are not able to make access. It is in these areas where citizens may be at the greatest risk.

Though large scale natural or man-made disasters are not a common site in the City of Norfolk, proper preparation is critical to a successful outcome. This research proves that the use of an unmanned aerial device for damage assessments will only speed up the disaster recovery process and ensure delivery of resources to citizens in a safe and timely manner. The City of Norfolk and NFR have the ability to lead the region as well as the state in a forward thinking approach to conducting damage assessments.

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Appendix A

Survey Explanation Letter

April 17, 2016

Dear Chief or Training Officer,

On behalf of the National Fire Academy's Executive Fire Officer Program I would like to respectfully request your participation in the following research. The purpose of my research is to identify advantages and disadvantages for using unmanned aerial devices to conduct damage assessments during a major emergency.

The purpose of your participation in this survey would be to provide information on using unmanned aerial devices for your damage assessments. The survey is meant to capture departments that are currently using these in their organizations and identify your successes and room for improvement with these devices. It will ask you about specific challenges that you have faced if currently using them. Lastly, if you have an existing policy or procedure in place to on when and how to use these devices during a large scale emergency it would be greatly appreciated if you could include a copy when sending this survey back to me. If it would be easier, you could also send the policy to my email which is written below.

The information that is obtained will help my research and allow for me to identify if the use of unmanned aerial devices to conduct damage assessments in the City of Norfolk would be beneficial. Thank you very much in advance for your help.

Link to survey: https://www.surveymonkey.com/r/WC5XR7N

Respectfully,

Lt. Jarrod Sergi
Norfolk Fire Rescue
Norfolk, Virginia
7120 Granby Street
Norfolk VA 23505
757-438-2534
Jarrod.Sergi@norfolk.gov

Appendix B

Survey Results

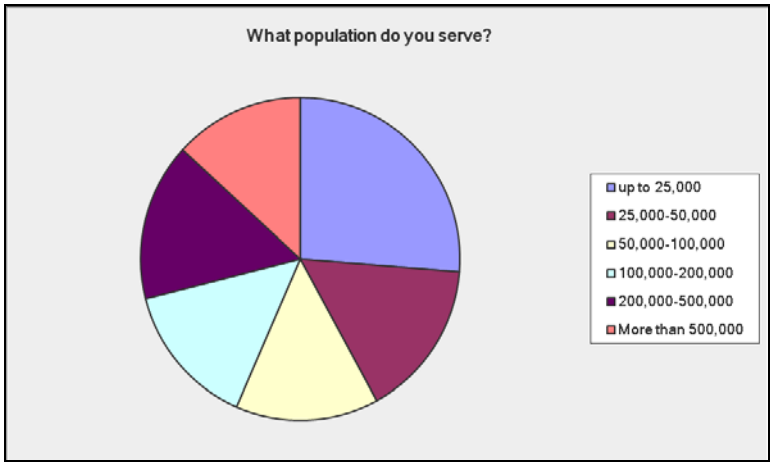
Question 1: What is that name of your organization?

1. Durham Fire, NC
2. City of Athens Fire Department, Ohio
3. North Las Vegas Fire
4. Ridgeland Fire Department
5. Mitchell Fire Department
6. Duxbury Fire Department
7. Burlington Fire
8. Longview Fire Department, Texas
9. Wichita Fire Department, Kansas
10. Gwinnett County Fire and EMS
11. Fort Lauderdale Fire Department
12. North County Fire Protection District
13. Las Vegas Fire Department
14. Clark County Fire Department
15. Bourne Fire and EMS
16. Guam Fire Department
17. Oak Cliff Fire Department
18. Germantown Fire Department
19. Hastings Fire Department
20. Littleton Fire Rescue
21. J.H Ketcham Hose Company
22. Henrico Division of Fire
23. Navy Regional Mid-Atlantic Fire and EMS
24. Castle Rock Fire Department
25. Fairfax County Fire and Rescue
26. Clarksville Fire-Rescue
27. Little Rock Fire Department
28. Hillsborough County Fire-Rescue
29. Gurnee Fire Department
30. Burlington Fire Department
31. Santa Fe Fire Department
32. Warner Robbins Fire Department
33. South Bend Fire Department
34. Durango Fire Protection District
35. Derry Fire and EMS
36. Rockland Fire Department
37. Wallington Fire Department
38. Kansas City Fire Department
39. Cheney Fire Department
40. FDNY

41. Suffolk Fire-Rescue
42. Tiburon Fire District
43. Greensboro Fire Department
44. Norfolk Fire-Rescue
45. Bolingbrook Fire Department
46. Killingworth Volunteer Fire
47. Portsmouth Fire Department
48. Newport New Fire Department
49. Ak-Chin Fire Department
50. LA city Fire Department
51. Baltimore City Fire Department
52. Prince William Fire and EMS
53. Stafford County Fire-Rescue
54. Hampton Fire Rescue
55. Richmond Fire Department
56. Hanover Fire and EMS
57. Palo Alto Fire Department
58. Boston Fire Department
59. Chelsea Fire Department

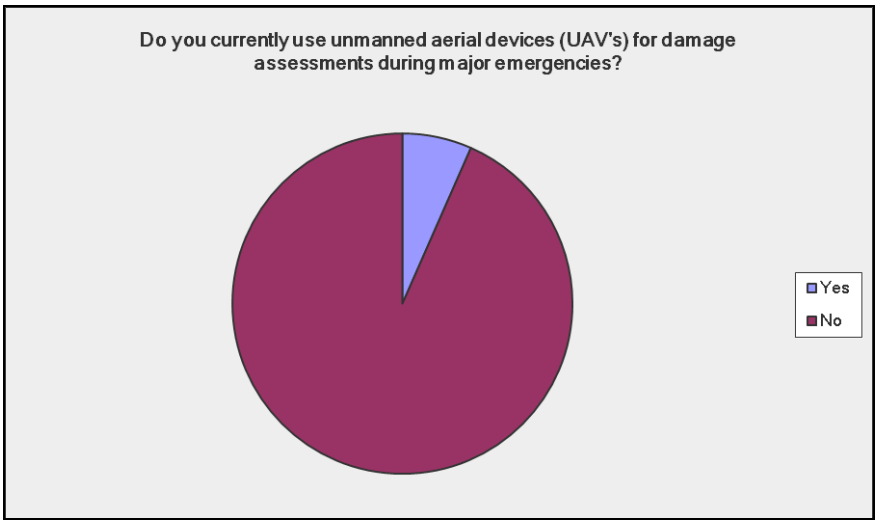
*17 respondents to the survey did not list the name of their organization

Question 2:
What population do you serve?



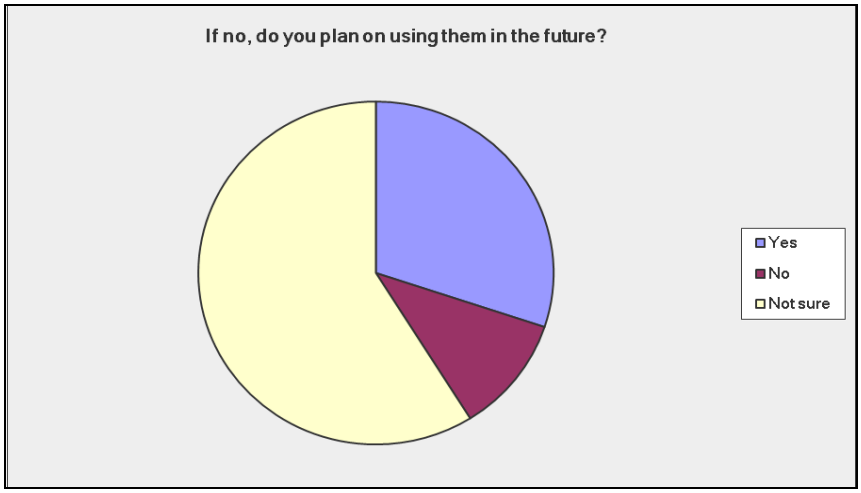
up to 25,000	26.3%	20
25,000-50,000	15.8%	12
50,000-100,000	14.5%	11
100,000-200,000	14.5%	11
200,000-500,000	15.8%	12
More than 500,000	13.2%	10

Question 3:
Do you currently use unmanned aerial devices for damage assessments during a major emergency?



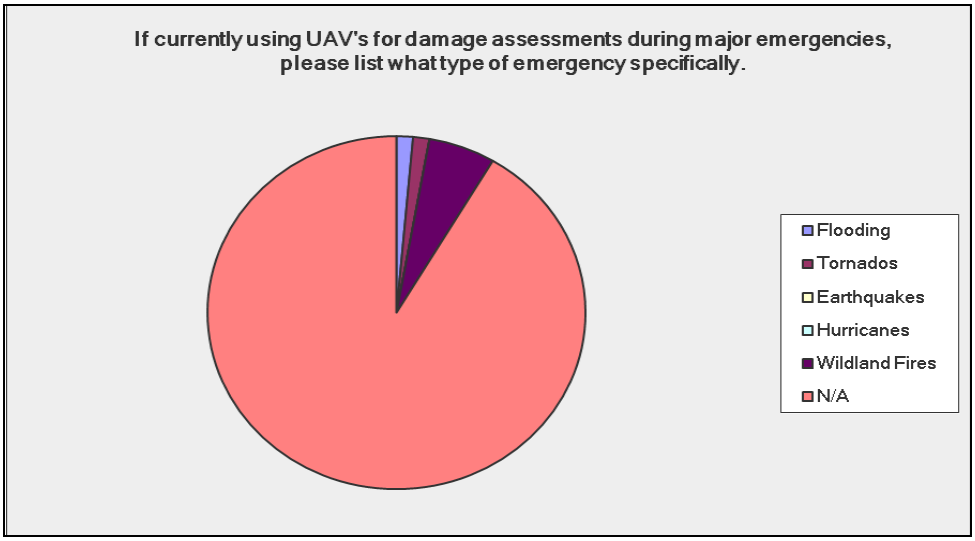
Yes	6.6%	5
No	93.4%	71

Question 4:
If no, do you plan on using them in the future?



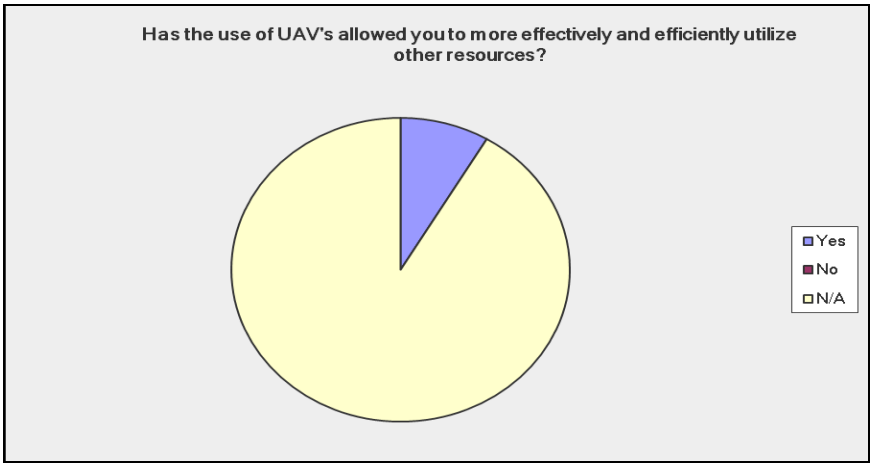
Yes	30.1%	22
No	11.0%	8
Not sure	58.9%	43

Question 5:
If currently using UAV's for damage assessments, please list what specific types of emergencies.



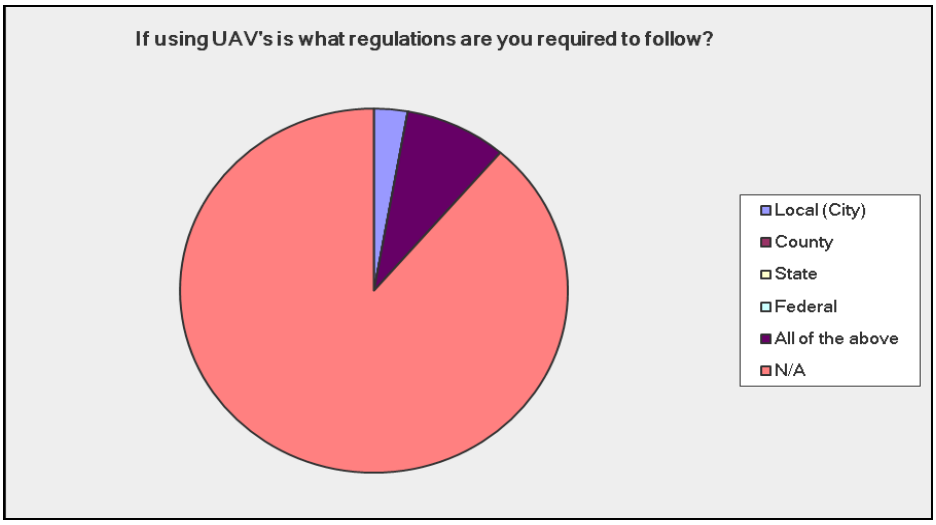
Flooding	1.4%	1
Tornados	1.4%	1
Earthquakes	0.0%	0
Hurricanes	0.0%	0
Wildland Fires	5.7%	4
N/A	91.4%	64

Question 6:
Has the use of UAV's allowed you to use other resources more effectively?



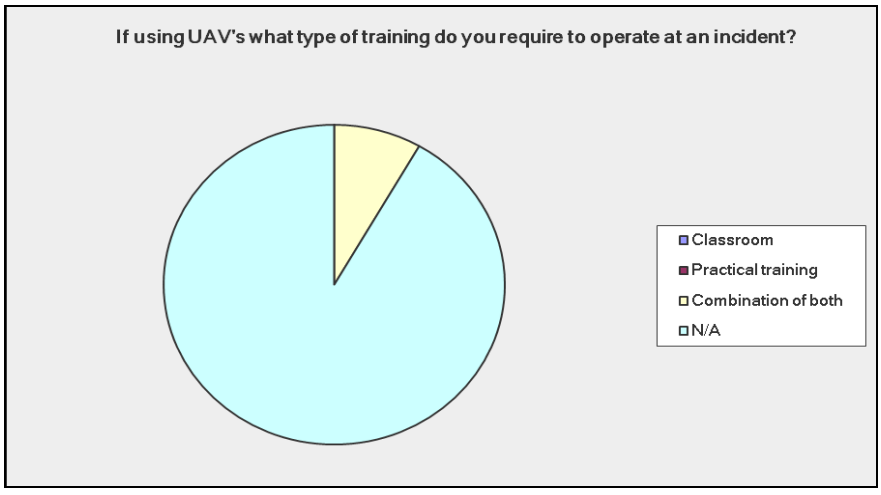
Yes	8.5%	6
No	0.0%	0
N/A	91.5%	65

Question 7:
If using UAV's what regulations are you required to follow?



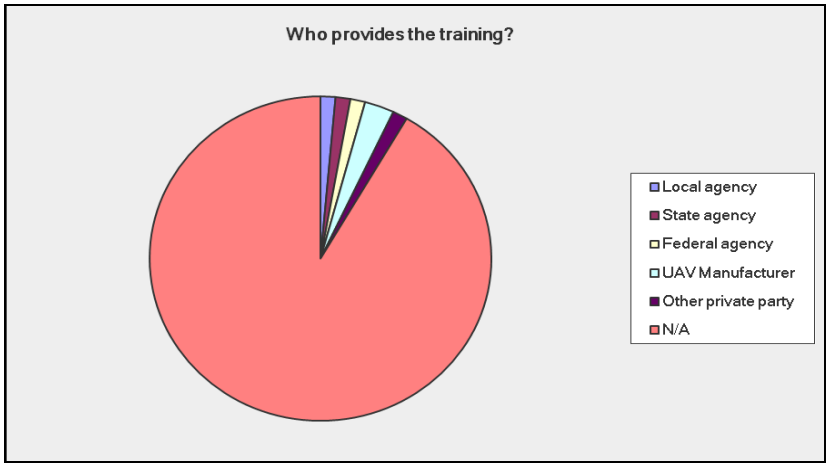
Local (City)	2.8%	2
County	0.0%	0
State	0.0%	0
Federal	0.0%	0
All of the above	8.5%	6
N/A	88.7%	63

Question 8:
If using UAV's what type of training do you require for operation at an incident?



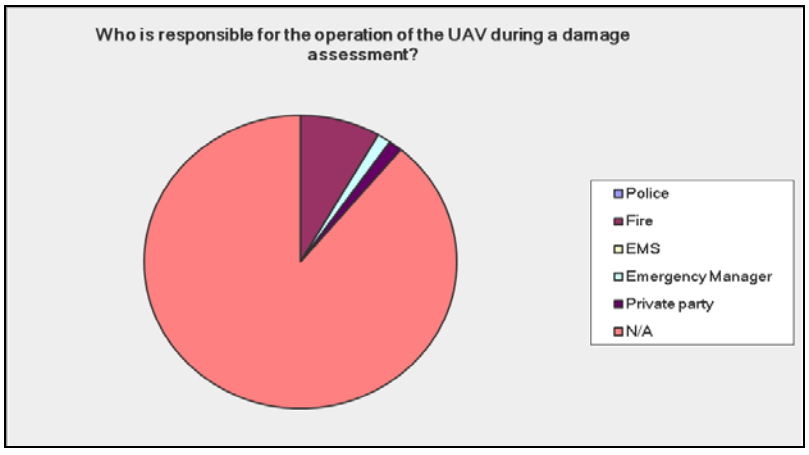
Classroom	0.0%	0
Practical training	0.0%	0
Combination of both	8.3%	6
N/A	91.7%	66

Question 9:
Who provides the training?



Local agency	1.4%	1
State agency	1.4%	1
Federal agency	1.4%	1
UAV Manufacturer	2.8%	2
Other private party	1.4%	1
N/A	91.7%	66

Question 10:
Who is responsible for the operation of the UAV?



Police	0.0%	0
Fire	8.3%	6
EMS	0.0%	0
Emergency Manager	1.4%	1
Private party	1.4%	1
N/A	88.9%	64

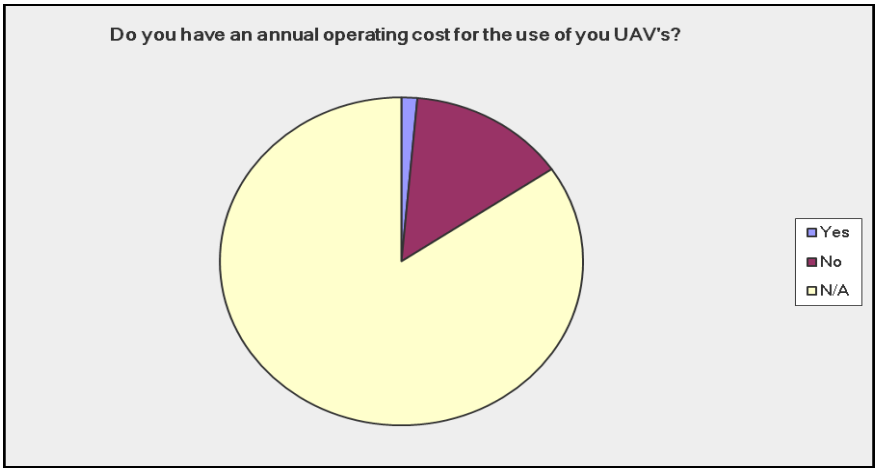
Question 11:
What have you found to be the advantages of using UAV's for damage assessments?

1. Great visual assessment
2. Aerial view with video
3. Videos are effective public education tools
4. We are discussing using them for wildfires and floods
5. We do not use UAV's, the police does.
6. A better visual
7. We are able to get a 360 of different terrain that may not be accessible
8. Only using them for the regional tech team
9. Have not explored UAV use because it is too new.
10. Cheaper than a helicopter or other fixed wing aircraft.

Question 12:
What have you found to be the disadvantages of using UAV's for damage assessments?

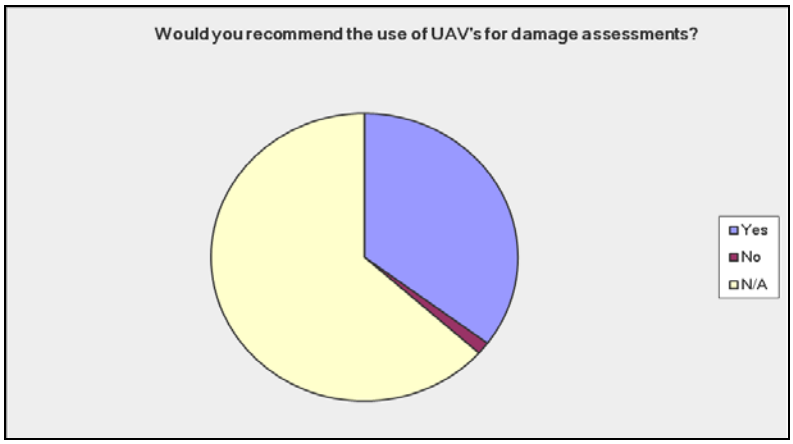
1. Getting the operators licensed
2. People are hesitant to use it in fear of crashing or damaging it.
3. The risk of radio interference
4. Noise, regulations and lack of funding.
5. The cost of training and maintaining pilots up to the FAA standards.

Question 13:
Do you have an annual operating cost associated with the operation of a UAV?



Yes	1.4%	1
No	14.1%	10
N/A	84.5%	60

Question 14:
Would you recommend the use of UAV's for damage assessments?



Yes	35.2%	25
No	1.4%	1
N/A	63.4%	45

Appendix C

UAV'S for damage assessments interview
Emergency Management Director
Jim Redick, City of Norfolk

1. How are damage assessments currently being done?

   They are currently being done through the neighborhood development office. Its an all boots on the ground operation. Augmentation is done through the windshield assessments with fire, police, CERT, and Red Cross. The National Guard will assist with fly over's, but info from them rarely makes it back to Norfolk. We also use what is called GIS Storm. The citizens are able to call in and it can be entered into the GIS system. GIS Mobile can also input from peoples smartphones. We have to be able to capture as much as possible in many different ways.

2. What must be included in the damage assessment process?

   What we are looking for is all agencies involved to take a close look at a number of different things. We have to know the condition of the homes in the city and if there are any structural concerns. If there are any life safety issues we need to know those immediately. If there are any types of critical infrastructure that have been damaged that is also important to us. Access is a big one. There may be wires or trees down on up to flooding or missing roadways. Ife we can't get to it, we may not be able to assist. Really anything out there in the community that would affect the people living here should be documented.

3. What is the most difficult part of the damage assessment process?

   Getting the information in on time is a big one. The next thing would be all departments properly documenting their findings correctly as well as tracking the hours needed to mitigate the hazard.

4. Do you know of any other cities/organizations that are using unmanned aerial vehicles for damage assessments during major emergencies?

   No, I am not aware of anyone that is using this type of technology for this use.

5. What do you feel would be the biggest advantage of using UAV's for damage assessments?

   Situational awareness of the incident would be huge. There will be areas we won't be able to reach and get resources to. UAV's would be able to identify areas that need attention that we can't get to. Long term data entry is a bonus for mapping purposes. Another thing that these things would be great for are delivering medications to areas where vehicles can't get to.

6. What do you see as the disadvantages?

   Some disadvantages would be some legal concerns or limits set forth by the FAA. While there are hurdles they can be easily overcome. Full transparency is critical with something like this. If the public is aware of the use of this technology they will be more inclined to trust the operations.

7. Do you feel the city of Norfolk would benefit from this type of technology?

   Absolutely we would benefit from it.

8. As the Emergency Management Director who do you feel would best be responsible for the operation of UAV's if we were to use them?

   A team may have to be put together to operate the drones. There are several hobbyists in this area that fly them on a regular basis. They may be interested in becoming part of a CERT team for the sole purpose to assist us in the damage assessment process.

9. Do you feel that this type of technology would gain support from other key city officials and stakeholders?

   Yes, I feel that the key players would see this a tremendous benefit for our emergency management operations.

10. Is there any further information that you feel would be valuable to the research?

    Possibly reach out to the hobbyists that fly these drones and see if there would be an interest in assisting us in a major emergency. Once again, we can get them training to be CERT team members and use them to conduct damage assessments with their drones