The Practicality of Utilizing Unmanned Aerial Vehicles for Damage Assessments

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Austin, Texas

2013

Certification Statement

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Abstract

The dilemma for Austin's disaster response teams is generating timely reports that accurately depict the extent of damage during the early stages of a disaster. The purpose of this research is to investigate the practicality of utilizing unmanned vehicles for damage assessments. The descriptive method is utilized for evaluating this technology from a qualitative perspective. This researcher highlights the capabilities and advances made in drone technology. The exploration into this topic answered the following questions: (1) What are the available types of unmanned aerial vehicles (UAV) being utilized for emergency response? (2) What are the pros and cons for utilizing this equipment during damage assessments? (3) Where are unmanned aerial vehicles currently being employed? (4) What are the legal issues related to this technology? (5) How can Austin's disaster response teams incorporate unmanned aerial vehicles into their damage assessment process?

Damage assessments can be communicated utilizing a video process that captures incident demands. The benefits of unmanned aerial vehicles during a disaster allows for immediate feedback. UAV are expected to enhance the way emergency response teams operate during disastrous situations. The visual capabilities lend support to bolstering the case for federal assistance. The concept and functionality of UAV during damage assessments seems promising. Reducing the exposure of assessment team members to hazardous environments boosts this technology's relevance. There is an abundance of UAV available in the United States. Drones should be an integral part of any disaster response protocol. This technology seems to expand the scope of disaster assessments by enabling emergency response teams to collect and disseminate information at a faster rate.

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Introduction

"Austin is located at the intersection of four major ecological regions, and is consequently a temperate of hot-green oasis with a highly variable climate having some characteristics of the desert, the tropics, and a wetter climate," ("Austin, Texas," 2013, para. 14). The city's population is nearing 900,000 with an infrastructure similar to most municipalities. The boundaries of the city continue to expand through annexation. The Colorado River is encompassed in the area along with numerous manufactured lakes that are scattered throughout the region. Experts say the rocky soil and steep terrain make for perfect flooding conditions. In Austin, 16 low-water crossings can flood with just an inch of rain over an hour's time (Lewis, 2013). Austin's response teams provide emergency services within the city's 318 square miles. In addition, the Austin Fire Department (AFD) participates in regional dispatching, which includes 307 square miles of extra-territorial jurisdictions. The City of Austin operates under a basic emergency plan that outlines the framework for coordinated response. This plan provides conceptual guidance for multi-agencies in areas related to legal issues, emergency organizations, incident command authority, and departmental responsibilities. The dilemma for Austin's disaster response teams is generating timely reports that accurately depict the extent of damage during the early stages of a disaster. This is especially true during flood conditions. Through visual communication, agencies can properly assess the resources needed to assist toward a recovery. Damage assessments can be communicated utilizing a video process that captures incident demands. This research suggests that prevailing technology is available for utilization in the disaster response process. Furthermore, this application could generate opportunities for enhancing multi-agency coordination, which includes mitigation, preparedness, response, and recovery.

Descriptive research will be used to exhibit the capabilities of trending technology that is available for disaster response teams. This research will emphasize the usability of unmanned aircraft vehicles during damage assessments. The following questions will be addressed: (a) What are the available types of unmanned aerial vehicles being utilized for emergency response? (b) What are the pros and cons for utilizing this equipment during damage assessments? (c) Where are unmanned aerial vehicles currently being employed? (d) What are the legal issues related to this technology? (e) How can Austin's disaster response teams incorporate unmanned aerial vehicles into their damage assessment process?

Background and Significance

“Federal Emergency” (2013) describes the National Incident Management System (NIMS) as a comprehensive, national approach to incident management that is applicable at all jurisdictional levels across functional disciplines. Homeland Security Presidential Directive 5 requires all federal, state, and local agencies to adopt NIMS, a condition for federal preparedness assistance. The NIMS system creates a unified foundation for disaster management. This structure provides direction for all government and non-governmental agencies to work together during domestic incidents. The basic premise of this system is derived from the utilization of common terminology, operational procedures, communications, and resource identification. The groundwork for NIMS application lies in the efficient and effective responses from a fire agency response to a multi-jurisdictional natural disaster or terrorism response ("Federal Emergency," 2013).

The Office of Homeland Security and Emergency Management (HSEM) maintain the Austin/Travis County Emergency Operations Center (EOC). During area-wide emergencies, the EOC serves as the command center for the City of Austin and Travis County response and recovery operations (“City of Austin,” 2011). The EOC is central to the mission for mitigating disastrous events. The implementation of this management system assists in the establishment of a common operational structure. This provides a conceptual framework for a coordinated multi-agency response. Austin’s emergency operations plans are guided by the operational procedures and concepts set forth by various authorities (see Appendix A). The EOC is a multi-agency coordination point within the NIMS system that supports emergency response activities. “When a disaster occurs, it is necessary to collect and analyze information concerning the nature, severity, and extent of the situation, and to report the information through established channels,” (“Emergency Operations,” 2012, p. 74). The organizational and operational concepts contained within NIMS for disaster management are made tenable through a network of cooperating agencies that work in tandem to mitigate specific events. Having a clear picture that assists in recognizing the needs of an area devastated by disasters is important for providing timely resources. This sequentially supports the efforts of returning a community to its pre-incident state.

According to the Federal Emergency Management Agency (FEMA) website, Texas had four additional disasters declared. This brings the total of major disaster declarations to 87. The majority of the declarations were considered hydrologic hazards. These are events related to severe weather such as tornados and flooding. “Hydrologic hazards are events or incidents associated with water-related damage and account for over 75 percent of federal disaster declarations in the United States,” (“Hazard Mitigation,” 2010, p. 4). Additionally, there are two other categories of declarations listed on FEMA’s website. These are emergency and fire management-assistant declarations. The Texas numbers in each of these categories were 13 and 234, respectively. In comparison to other states, Texas had the most declarations totaling 334 disasters. These are the most declarations affirmed to date followed by California. Whiteman (2013) reiterates that Texas has dealt with tornadoes, floods, wildfires, and regular coastal hurricanes within the Lone Star State’s nearly 267,000 square miles. There has been at least one major disaster declared nearly every calendar year.

“Texas has the most flash floods-related deaths in the nation, earning it the nickname, ‘flash flood alley,’” (Lewis, 2013, para. 1). Flooding is considered to be the most serious type of natural disaster in the Austin area. The hazardous conditions associated with floods include numerous low-water crossings and large volumes of water moving at high rates. “Being in flash flood alley, the creeks can erode very quickly during a large flood event, the drone would allow us to take aerial photos right away and find places where things are being severely affected," (A. Rudin, personal communication, August 7, 2013). Central Texas' weather patterns bring a unique mix of threats that require varied levels of preparedness. The city of Austin's emergency teams provides a variety of support to all hazardous scenarios. This includes monitoring and maintaining critical and key resources within the city (see Appendix B). Many different types of weather patterns, which can change in a moment's notice, affect Texas. According to Elsberry (2013), the following dates highlight two of the most recent destructive and deadliest floods in Austin's history:

> In October 1998, twin hurricanes Madeline and Lester caused inland flooding across the lower portion of Texas. Thirty-one people across the state died, 20 counties were considered disaster areas, and 454 homes were destroyed. Property damage losses reached almost $1 billion. In November 2001, 15 inches of rain produced flash flooding. Onion and Shoal Creeks swelled, causing businesses to flood and countless cars to be caught in the rising water. Ten people in Central Texas died; eight deaths were vehicle related. Damage was estimated in the millions. (p. 3)

These catastrophes provide research and assessment opportunities for improving disaster response protocols. The goal is to identify community vulnerabilities, and understand the correlation between emergency response and community demands. The assessment of historical disasters can identify universal issues, resulting in the development of appropriate methods for evaluating and managing future incidents.

The City of Austin's emergency management team provides a number of services and support during the preparation, response, and recovery phases of a disaster. This includes the establishment of an Emergency Operations Center (EOC). The EOC is the hub for the disbursement of information and coordination, which assists in managing and organizing area response. This centralized system facilitates the prioritization of city resources and the prevention of further property and economic losses. Some examples of priority response include search and rescue operations, caring for the injured, and re-establishing vital public services. An activated EOC brings together decision-makers for strategy development and coordinating the flow of information. Some examples of representation at Austin's EOC include the American Red Cross, Austin Energy, Austin Independent School District, Austin/Travis County Amateur Radio Emergency Service, Capital Metro, Austin's public safety agencies (Fire, Police, and EMS), Federal Bureau of Investigations, Federal Emergency Management Agency, Lower Colorado River Authority, Salvation Army, Travis County, Texas Department of Transportation, and the University of Texas.

The function of the Austin Fire Department (AFD) during a disastrous event is to work within the scope of an EOC's contingency plan. AFD's main responsibility during disastrous episodes is firefighting, hazardous materials mitigation, radiological protection, evacuation, search, and rescue. These tasks are associated with the capabilities of the organization as they relate to training and equipping personnel. A risk assessment has identified 14 possible hazards in the Austin area. These vulnerabilities include dam failure, drought, extreme heat, flood, hail, hurricane wind, thunderstorms, tornado, winter storm, wildfire, infectious disease, hazardous materials release, pipeline failure, and terrorism. As part of the Austin area's emergency response teams, the Fire Department utilizes an advisory system that is similar to the national defense condition system. AFD utilizes a resource condition (Recon) for monitoring its resource levels. These levels are characterized as: one=routine-, two=alert, three=emergency, four=severe, and five=extreme. This system is established to monitor AFD active resources. In addition, the trigger mechanisms associated with the activities dictate movement from one level to the next. Some of the common triggering mechanisms for EOC activation include severe widespread damage, evacuation requiring long-term sheltering of citizens, and/or a significant number of casualties. Figure 1 illustrates the probable scenarios that would trigger EOC activation in the Austin area. According to the city's hazardous mitigation plan, this chart shows wildfires and floods as the highest risks. The codes are H=high risk, M=medium risk, and L= low risk.

Figure 1

Hazardous Risk Ranking

HAZARD	RANKING
Inland Flooding	H
Wildfire	H
Hail	H
Infectious Disease (Pandemic)	M
Tornado	M
HAZMAT	M
Pipeline	M
Hurricane Wind	M
Winter Storm	M
Terrorism	M
Drought	L
Thunderstorm	L
Extreme Heat	L
Dam Failure	L

> Texas Task Force 1 (TX-TF1) is the most deployed urban search and rescue (US&R) team in the country. Teams have expertise in responding to both man-made and natural disasters. TX-TF1 functions as a federal team under FEMA's national US&R program and as Texas' only statewide US&R team under the direction of the Texas Division of Emergency Management. (“Texas Task Force 1,” n.d., para. 1)

The Austin Fire Department has approximately 40 members on the TX-TF1 team. These individuals are divided up into three groups that encompass a structural team, boat squads, and Helo rescue swimmers. These members are prepared to respond to state and national disasters, and can be ready for deployment within hours of activation. According to D. Clopton, "Recon and getting that initial information is always the toughest part," (personal communication, August 10, 2013). These disaster response teams are tasked with assisting communities across the United States. In many cases, there are high levels of risks associated with these deployments. An exploration into technological advances could minimize and/or offset these hazards.

For the purpose of this research, the terms "Unmanned Aerial Systems (UAS)," "Unmanned Aerial Vehicle (UAV)," and "drone" will be utilized interchangeably.

> Drone proponents would prefer that everyone use the term "UAV," for Unmanned Aerial Vehicles, or "UAS," for Unmanned Aerial System ("system" in order to encompass the entirety of the vehicle that flies, the ground-based controller, and the communications connection that connects the two. (American Civil Liberties Union, 2013, para. 2)

Many of the resources have variations in terminology when referencing the depiction of this technology but essentially, the meaning is the same. Drones have the potential for speeding up the recovery process. This is accomplishable through visual images sent back from the UAV to the EOC. Timely and accurate communication is essential for getting the right resources in place to effectively mitigate an incident. Having the capability of observation enhances situational awareness. It gives various agencies a collective viewpoint of the disastrous event and strengthens the assessment process by capturing community vulnerabilities. "First responders and emergency management officials see potential in monitoring and fighting wildfires or assessing damage from natural disasters in real time," (Oot, 2013, para. 7). Visual communication narrows the interpretation on what is reported at the incident. It gives agencies visual perspective as to the extent of damage.

The basic premise of this research is to explore potential efficiencies during the damage assessment process. It is this researcher's opinion that the availability of technological advances could improve the damage assessment process during the response phase of a catastrophe. Damage assessments frequently become choke points due largely to obstacles, such as downed trees blocking roads or icy conditions that make it extremely difficult for crews to get access and report damage, (Electric Power Research Institute, 2012). The reluctance to explore availability of advancements in technology hinders potential for improvements. Public safety must constantly investigate opportunities for process enhancements. Having a systematic approach in every facet of the recovery process enhances our capabilities of returning communities to pre-disaster state.

This research is correlated to the Executive Fire Officers Program Executive Analysis of Fire Service Operations in Emergency Management. This curriculum focuses on administrative functions necessary to reinforcing command and control concepts for community-wide response activities in support of emergency and/or disastrous events. The utilization of drone technology could enhance the effectiveness of decision making in relation to formulating the correct strategy, goals, and objectives. Having the capability of visually communicating damage assessment reports to the EOC via drones is intriguing. The motivation for this study is to provide an efficient and effective systematic procedure for communicating resource needs. The progression of this technology could enhance multi-agency coordination in the areas of mitigation, preparedness, response, and recovery. It could enable agencies to make sound decisions on how to manage the incident and allocate resources. These concepts are aligned with the United States Fire Administration's (USFA) operational goals of improving the fire and emergency services capability for response and recovery from all hazards.

Literature Review

The International Federation of Red Cross and Red Crescent Societies (n.d.) recognizes a disaster as a catastrophic event that seriously disrupts the functioning of a community and causes human, material, and economic or environmental losses that exceed the community's ability to cope utilizing available resources. The incorporation of unmanned aerial vehicle technology could offer better insight into understanding the nature and scope of a disastrous event. Overcoming a catastrophic disruption is dependent upon the efficient and effective assessment processes utilized by emergency management teams. The current protocol used for the Austin/Travis County Emergency Operations Center is to assign members of the American Red Cross to assess damage. The assumption is that public safety personnel will be too busy to participate. These assessment teams will be deployed into hazardous zones to determine the community's degree of functionality and damaged infrastructure. This measurement is important for understanding the extent of an area impacted by a hazardous event. Interpretation, timeliness, and translation of the gathered information are significant when it comes to identifying the extenuating circumstances. The purpose of this literature review is to evaluate the practicality of utilizing unmanned aerial vehicles for damage assessments.

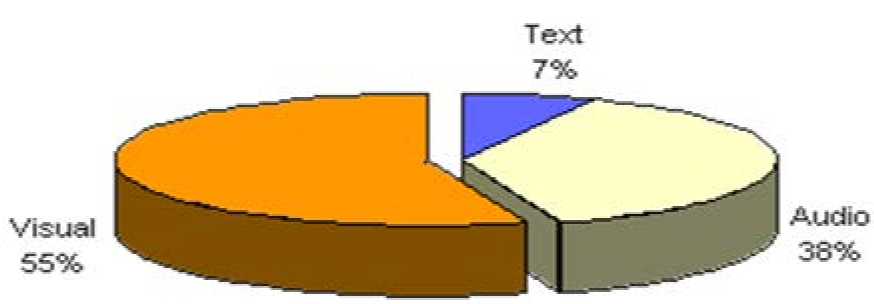
It is incumbent upon emergency management teams to look for efficient and effective ways for speeding up the recovery process. The timeliness of assessments could enhance multi-agency coordination for ordering and allocating resources. Process improvements are essential for reducing the physical, financial, and emotional losses that occur during disasters. Speeding up recovery and maintaining services is vital for the sustainment of the community. Unmanned vehicles could be utilized in every aspect of the recovery process. This technology would allow members in the EOC to get a continued bird's eye view of the devastation. The benefits of unmanned aerial vehicles during a disaster allows for immediate feedback. In order to appreciate the capabilities of unmanned aerial vehicles, this review will link five subject areas. These include the Federal Aviation Administration (FAA), legal issues, Unmanned Aerial Vehicles (UAV), visual communication, and damage assessment. Collectively, these categories were researched by conducting interviews, and reviewing evaluation books, journals, websites, and reports as they relate to unmanned aerial vehicles and other areas associated with damage assessments.

Visual Communication

Some say that a picture is worth a thousand words. It seems easier to describe a situation with images as opposed to descriptive text. It is recognized that visual images have the most impact when compared to other forms of communication. The following illustration (Figure 2) compares the top three forms of communication. It shows that visual images have a 55 percent impact when compared to other forms of messaging.

Figure 2

Impact of Communications



Why is this important to disaster management? Having visual capabilities into the disaster areas allows for a shared awareness. In addition, it minimizes the possibility of area details being misinterpreted. Expanding the opportunity for visual communication technology should be explored for improving current processes. A case in point: the Austin Police Department utilizes High Activity Location Observation (HALO) cameras in downtown Austin and high crime areas. There are approximately 40 fixed cameras deployed in these locations. The visual images from these cameras have effectively increased the arrest rate and minimized unlawful activity for the police department. It would seem that these visual images provide an edge to the operational process. This realization contributes to the concept of the importance of visual communication.

> Visual communication is described as the conveyance of ideas and information in forms that can be read or looked upon. Visual communication, in part or completely, relies on vision and is primarily presented or expressed with two-dimensional images, which include signs, typography, drawing, graphic design, illustration, color, and electronic resources. (“Visual Communication,” 2013, para. 1)

Correlating these concepts into the discipline of disaster management could elevate its informational reporting process. The utilization of visual formats could increase efficiencies in communications and enhance the damage assessment process by highlighting community necessities. In addition, this method could illustrate the degree of devastation associated with each event. Having an effective communication process in place provides the opportunity to coordinate and properly deploy allocated resources. Keep in mind that, “Visualization is intended to communicate the complex in a quick and apparent manner. Capturing the elements and essence of complex plans is key to widespread strategic implementation, as well as ensuring your stakeholders can clearly see the ‘big picture,’” (Lore, 2011, para. 6).

The Incident Command System (ICS) is a standardized managerial tool utilized for all hazardous events. This system allows for the expansion or consolidation of management functions. There are five general staff positions within the ICS structure, along with reporting elements. These include the Incident Commander (IC), operations, planning, logistics, and finance/administration. The planning section is where the linkage for the visual communication should be implemented. This division already has the responsibility for collecting and disseminating information throughout an incident. It seems logical to continue working within this format. The Department of Labor (2013) describes the planning section as being responsible for the collection, evaluation, dissemination, and use of information concerning developments in the incident and status of resources. Most of this information-gathering process is accomplished by observers in the field that report up through the chain of command by way of the situational unit leaders. Having visual capabilities would only enhance the information-gathering process and provide real-time feedback concerning situational status. Furthermore, it would enable managers to get a better understanding of the complexities associated with an incident. Collectively, this would improve the decision-making process for both the strategic and tactical objectives.

The benefits of adding visual capabilities to the information-gathering process cannot be overstated. Most of the contingency plans relied upon during the onset of a disaster come in the preparation phase. Sometimes there is a need for revisions due to information and/or status changes.

> Physical maps of the incident area are typically used to plan the routing and positioning of resources relative to the area of interest. However, because they depict conditions prior to the incident, local operators must often adapt or even discard their initial plans due to

> unforeseen circumstances, such as restricted access or other unexpected hazards. (Jennex, 2011 p. 66)

Having outdated information is worse than no information. Command and control visual enhancements can be expanded through observers in the field. Outfitting these individuals with the appropriate technology would not only enhance situational awareness but also assist with updating the incident action plan. Visual images can assist with making it immediately known as to the purposes for the change in direction. Having real-time intelligence should serve as an upgrade for monitoring and illustrating devastation. These capabilities can lessen the impact of misaligned information and offer a continuous link to actions in the field. Jennex (2011) declares that ICs are often in an environment where information arrives slowly and are dependent on interpretations from other individuals.

Federal Aviation Administration

> The Federal Aviation Administration (FAA) is the agency of the United States Department of Transportation responsible for the regulation and oversight of civil aviation within the U.S., as well as operation and development of the National Airspace System. Its primary mission is to ensure safety of civil aviation. ("Federal Aviation," 2013, para. 1)

The emergence and demand for UAV has increased through the years. The technical applications associated with UAV deployment are appealing. This has prompted many public safety agencies to seek avenues for incorporating these innovative tools into their response protocols. The dilemma is the lack of universal procedures needed to govern the operation of this technology in the national airspace. This vagueness has contributed to the confusion associated with UAV deployments and FAA guidelines. Question and answer information retrieved from the

Homeland Surveillance and Electronics website offers some insight on the subject (see Appendix C).

> In February 2012, President Obama signed the FAA Modernization and Reform Act of 2012 (FMRA) into law. FMRA provides, among other things, a set of overlapping deadlines for the integration of UAS into the national airspace over the next three years. (Villasenor, 2012, p. 470)

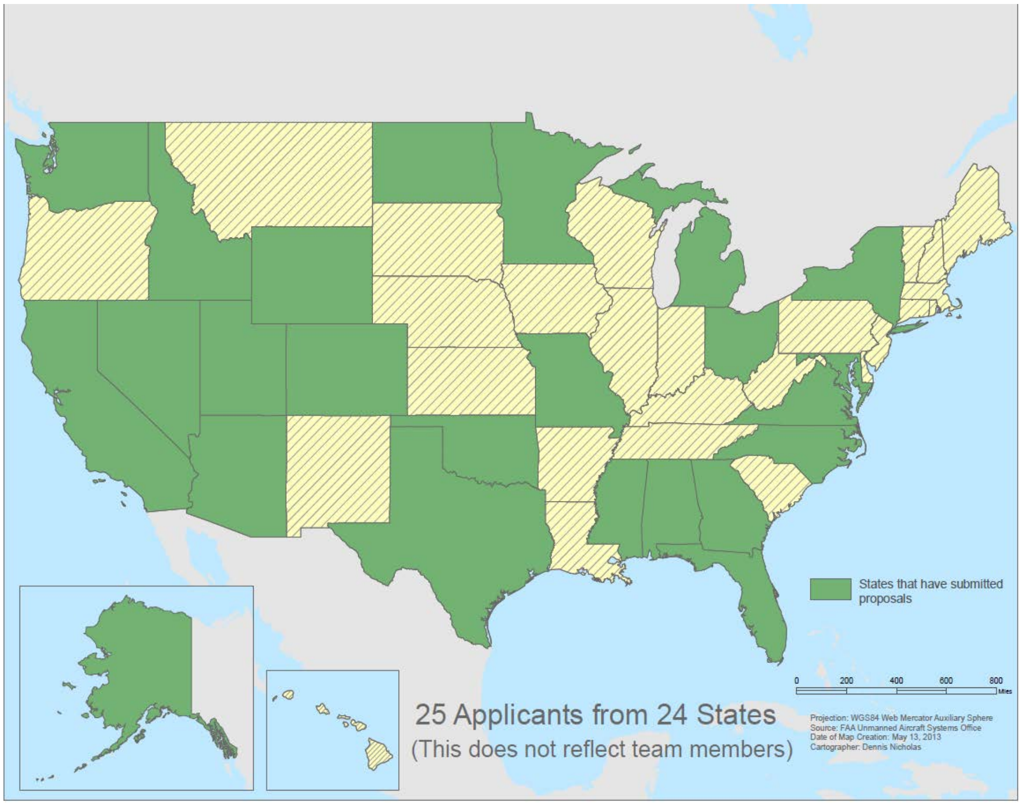
The FAA classifies aircrafts, without regard to whether they are manned or unmanned, as public or civil (Villasenor, 2012). These classifications assist with understanding the metrics associated with each flight class. In addition, it outlines the scope of responsibilities specific to each apparatus. Villasenor also noted that public aircraft are those operated by local, state, and federal public entities, while private companies (including individuals) and other non-government entities typically operate civil aircraft. These distinctions are necessitated by various perquisites related to certification and authorization. Both civil and public UAV operations require different approvals for operating in the national airspace. These initiatives assist with the regulation and tracking of the type of UAV put into operation. There are two types of requests for UAV deployment. The first type is for “civil operation (private industry): applicants may obtain a Special Airworthiness Certificate, experimental category by demonstrating that their unmanned aircraft system can operate safely within an assigned flight test area and cause no harm to the public,” (Federal Aviation Administration, 2013, para. 1). An example of a U.S. air-worthiness application can be found at the following website: http://www.faa.gov/documentLibrary/media/Form/FAA%208130-6%20OMB%20rev%208-11.pdf. This process is normally accomplished through the local FAA office.

The second type is for “public operation (U.S. Government Organizations): for public operation, the FAA issues a Certificate of Authorization or Waiver (COA) that permits public agencies and organizations to operate a particular UA, for a particular purpose, in a particular area,” (Federal Aviation Administration, 2013, para. 2). An example of this application can be found at the following website: http://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/systemops/aaim/organizations/uas/media/COA%20Sample%20Application%20v%201-1.pdf. This category of authorization requires an operational and technical review by FAA.

Another requirement of the FAA Modernization and Reform Act of 2012 (FMRA) is to establish a UAV research and testing site. The FAA is currently seeking proposals for six UAV testing sites, which will be located across the nation. The basic motive for these locations is to collect supplementary information on how to regulate drones. The test site selection process started earlier in 2013. It is projected that, by years end, the selected test locations will be announced. Many states are competing heavily for the opportunity to become one of these designated testing areas. A substantial government investment into the community is expected. Residents could see an abundance of jobs and dollars pumped into the local economy. In 2016, it is forecasted that Texas could see a total economic benefit of more than $362 million (see Appendix D) if the UAV industry expands in the state. This will prove to be a substantial investment by the government. In addition to the economic boost, it would allow communities to build political capital toward recognizing the relevancy of this technology. The following illustration (see Figure 3) from the FAA website currently depicts 25 applications from across the nation submitted by various organizations from 24 states displayed in green on the map.

Figure 3

FAA Site Testing Applications



Legal Issues

“The potential privacy challenges raised by unmanned aircraft are direct consequences of their capabilities and of the rules governing the manner in which they can be flown,” (Villasenor, 2012, p. 460). The legal issues associated with drone technology are complex. It is difficult to pinpoint the parameters associated with this advancing industry. UAV are expected to enhance the way emergency response teams operate during disastrous situations. Trying to define the legal boundaries without suppressing operational capabilities related to UAV technology has been difficult. Villasenor mentions that much of the attention regarding UAS privacy laws has been focused on government use and the Fourth Amendment. The non-government use will likely raise some of the most significant privacy challenges. Many states have been enacting legislation to offset the ambiguous climate associated with UAV. As of October 9, 2013, there has been legislation proposed in 42 states (see Appendix E). So far, eight laws have been enacted and six are still alive in committees. It seems that some state laws are based on emotion and/or resistance to government without really understanding the value of this emerging industry. Goodwin (2013) points out that it is unclear whether the FAA will delve into any of the privacy issues when it issues regulations on unmanned aircrafts.

"Texas, like the rest of the country, is conflicted when it comes to drones: on the one hand, enthusiastically courting their potential uses and economic benefits, and on the other, deeply apprehensive about their proliferation, even when unarmed," (Bell, 2013, para. 2). On June 14, 2013, Texas Governor Rick Perry signed House Bill 912, known as the Texas Privacy Act. When this bill was first introduced, the media reported that Texas had the most stringent restrictions concerning unmanned drones in the United States. This researcher found several articles online supporting this rigorous claim. When the bill was signed, it turns out this was not the case. The Texas Privacy Act comes with at least 40 exemptions, which allow for the use and deployment of UAV. For example, there is verbiage in the bill which allows agencies to deploy UAV for surveying disaster areas.

> House Bill 912 may bolster a sense of personal security and privacy for Texans statewide. However, exempting natural resource businesses, media agents, first responders, and the entire Texas-Mexico border reveals the more likely consequences of future drone bans: the individual right to privacy exists, up until the point where privacy becomes political. (Heindel, 2013, para. 5)

"The U.S. Supreme Court declared years ago that individuals have no "expectation of privacy" in public places, making people on city streets or open fields fair game for aerial surveillance," (Geiger, 2011, para. 5). The paranoia of surveillance is counteracting viable uses for this technology. This has prompted many communities to discard UAV potential and focus on corrupt scenarios. The fear of governmental surveillance has become a reoccurring theme. "One of the things we have run into on federal deployments is the resentment of or resistance to FEMA. We have been in circumstances where they told us to take the stickers or labels off the trucks because we are going into an area where government agencies are not well received," (M. Frick, personal communication, August 14, 2013). It is interesting to observe the attention exhibited on these aerial apparatuses, while little attention is applied to fixed cameras and orbiting satellites. It is assumed that if these technologies were in the news conducting military-type missions, then they would also probably garner the same type of scrutiny. This researcher concedes that there are avenues where this technology could be utilized nefariously. There is hope that communities will eventually see the positives.

> While such technology can indeed be abused, it also has many valuable uses: search and rescue, disaster management (searching for survivors or trouble spots), agriculture, legitimate security (say, oil pipeline or utility surveillance), and following of criminal suspects without risky road pursuit, are just a few possibilities. (Daily KOS, 2012, para. 10)

Damage Assessments

The process of damage assessment is considered to be a prerequisite for all disaster management practices (Bhati, 2012). The collection of the community's situational status assists with gauging operational capabilities, community needs, and infrastructure impairment.

> The Rapid Needs Assessment (RNA) determines the scope of the disaster, assesses what resources are necessary to conduct life-saving and life-sustaining operations during the

> emergency response phase of a disaster, and provides State officials with quick and accurate information to enable them to determine whether State and/or Federal assistance is warranted. (State Disaster, 2011, p. 2)

The terminology for damage assessments is used interchangeably depending upon jurisdiction. Similar terms include rapid needs, rapid damage, and immediate assessments. All of these terms have been linked to some type of initial response activities. The City of Austin uses the terminology Rapid Damage Assessment (RDA) for its evaluation of community infrastructure.

Preliminary damage assessments are joint evaluations used to determine the magnitude and impact of an event's damage (City, & County San, 2013). This review allows the emergency management team to track and survey the devastation associated with an event. This summary of information is utilized to determine if a disaster declaration is warranted. In order to obtain outside assistance, senior officials should follow a checklist when response capabilities exceed local resources (see Appendix F). The information in the documentation influences whether or not supplemental resources from the federal government will be approved.

> A FEMA/State team will usually visit local applicants and view their damage first-hand to assess the scope of damage and estimate repair costs. The State uses the results of the Preliminary Damage Assessment (PDA) to determine if the situation is beyond the combined capabilities of the State and local resources, and to verify the need for supplemental Federal assistance. The PDA also identifies any unmet needs that may require immediate attention. (City, & County San, 2013, p. 12)

Damage assessments assist in providing the necessary information to begin making decisions on how to provide, restore, and repair infrastructure in the aftermath of a catastrophic event.

In the City of Austin, the American Red Cross Damage Assessment Teams conduct ground surveys, which require observation and reporting of damage, casualties, and status of affected areas. This survey includes the inspection of facilities essential to public welfare, safety, and sheltering (“Emergency Operations,” 2012). The difficulty of conducting an effective damage assessment will vary with the size and complexity of the incident. There are various types of assessments conducted during the course of an event. These assessments happen at different intervals within the evaluation process. Depending upon jurisdictions, these surveys could have different meanings. Emergency operations (2012) highlight that damage assessments are generally performed in three phases:

- Windshield survey, a brief survey of all areas;
- Rapid damage assessment of public buildings and other city structures; and
- Detailed engineering evaluation of certain buildings and structures.

There are slight variations from municipality to municipality when it comes to deploying damage assessment teams. Regardless of location, the basic principle for these assessment groups is to survey areas and collect information for evaluation.

> There are various departments with field personnel that conduct windshield surveys of the immediate area around their facilities as well as conduct a quick “drive-through” of the city to document and report from vehicles the status of streets, utilities, major external building damage, damaged or blocked roads, unattended fires, and medical emergencies. (2013, February, p. 5)

This researcher proposes the utilization of drone technology during damage assessment. It is incumbent upon disaster management teams to look for efficient and effective ways to accelerate evaluation processes. Having access to a broader vantage point allows for logical connections to be made into other areas of devastation. The UAV visual capabilities lend support to bolstering the case for federal assistance. The concept and functionality of UAV during damage assessments seems promising. "The unmanned aircraft, which can be small and light enough to be cradled in a technician's hands, can quickly survey devastated areas that are difficult to reach by truck because of poor road conditions and obstacles, such as downed trees," (Olearczyk, 2012, para. 2).

Unmanned Aerial Vehicles

> An unmanned aerial vehicle (UAV), colloquially known as a drone, is an aircraft without a human pilot on board. Its flight is controlled either autonomously by computers in the vehicle or under the remote control of a pilot on the ground or in another vehicle. (2013, October 14, para. 1)

Access impediments would be reduced and/or eliminated with the deployment of drones. Essentially, this technology would allow an operator unlimited access to hazardous zones. Reducing the exposure of assessment team members to hazardous environments boosts this technology's relevance. The accuracy of assessments would increase due to the live feeds presented by this equipment. Disaster team members would be able to produce true pictures of the devastation. If employed, this technology appears to offer a quick method for capturing data. The planning section within the incident command structure could benefit from these intelligence-gathering apparatuses. The GPS and mapping features associated with most UAV would be an added benefit for tracking and deploying resources in impacted areas.

It is difficult to identify the origination of UAV due to sporadic use and variations in conceptual design, and to compare the categories in which these inventions were placed.

> The forerunner of today's UAV is reported to be the American Navy Curtiss/Sperry "flying bomb." This primitive cruise missile first flew on March 6, 1918. The Charles Kettering Aerial Torpedo, also known as the Kettering Bug, was a parallel effort backed by the American Army. (Dragan Fly Innovation, 2013, para. 3)

Though the concept of unmanned aerial vehicles has been around for decades, it appears that the common origin of their intent was to reduce exposure to human life. Currently, military-type drones are dominating publications with reports of their enhanced flight, surveillance, and weapons systems, and destruction capabilities. This ominous perception has been difficult to erase. It would seem that military technology is at a higher threshold of sophistication than what is needed for assessing disaster areas. Then again, the complexity needed to navigate, operate, and collect information and report it back to the EOC could require the same level of sophistication. Throughout history, the recognition of a universal definition has been difficult to ascertain. This researcher discovered that UAV could be categorized in a number of formats that include balloons, planes, bombs, missiles, and/or helicopters.

In order to maintain situational awareness when operating these vehicles, operators must utilize their own senses to avoid collisions. Applications for certificate of authorization require drones to have the same level of operational safety as manned aircrafts. This stipulation is set forth by the FAA "right of way" rules.

> The sense-and-avoid system must detect the traffic in time to process the sensor information, determine if a conflict exists, and execute a maneuver according to the right-of-way rules. If pilot interaction with the system is required, the transmission and decision time must also be included in the total time between the initial detection and the point of minimum separation. (Murraru, 2010, p. 136)

Currently, there is no suitable technology available that provides the capabilities of sense and avoid. Some of the future promise for UAV aircrafts includes collision avoidance, autonomous flight control, vision-based aircraft detection, and path planning. While larger platforms have the sophistication to operate at an altitude above 400 feet, smaller UAV operators must maintain a line of site for their aircraft, and stay at or below this threshold. An illustration from a Government Accounting Office (GAO) report shows the operational platforms utilized at the various altitudes (see Appendix G). The smaller drones can be deployed at lower levels and are utilized for wildfire tracking, crime scene surveillance, and search/rescue. The larger UAV are deployed above the 400 feet threshold, and are utilized for research projects, military training, and border surveillance.

> The term unmanned aircraft system (UAS) emphasizes the importance of other elements beyond an aircraft itself. A typical UAS consists of the unmanned aircraft (UA); control system, such as Ground Control Station (GCS); control link, a specialized data link; and other related support equipment. (2013, October 14, para. 23)

While most of the system components are self-explanatory, this researcher believes that the term “data link and ground control station” needs further exploration. “A ground control station (GCS) is a land- or sea-based control center that provides the facilities for human control of unmanned vehicles in the air or in space,” (“Ground Control,” 2013, para. 1). This component of the UAS allows for the activation, control, and monitoring of the vehicle. This is the lifeline for deploying the technology. During a damage assessment, the CSG could be a portable case, vehicle, or trailer deployed near disaster areas (see Appendix H). Some of the larger aerial apparatus can be operated from locations miles away. This is all predicated upon the technology and capabilities of the system deployed. The Defense Industry Daily (2011) maintains that the ground station controls where the UAV goes and what it sees. It receives and processes information collected by a UAV and reroutes it via data link to the appropriate end user.

> A data link is the means of connecting one location to another for the purpose of transmitting and receiving digital information. There are at least three types of basic data-link configurations that can be conceived of and used: Simplex communications, most commonly meaning all communications in one direction only. Half-duplex communications, meaning communications are in both directions, but not both ways simultaneously. Duplex communications are communications in both directions simultaneously. (“Data Link,” 2013, para.1)

This connection of information provides visual images back to a receiving station where the collected information could be analyzed. UAS have utilized two of the three types of data link signals for two-way transmission of communication. These include the half-duplex and duplex configurations. Additional categories associated with UAV classifications can be found in Appendix I. This addendum highlights the variances in capabilities that include takeoff weight, flight altitude, endurance, data link distance, and the mission of some apparatuses. Newer and more powerful UAV continue to be updated dependent upon future needs and capabilities of the systems deployed.

This researcher discovered numerous vendors, conferences, and associations that are in alliance with UAV technology. Some of the products that were evaluated are as follows: Leptron, Micro-Drones, Lehmann Aviation, Marcus UAV, AeroVironment, Inc., Pulse Aero, UAV Factory, Aibotix, Draganfly, and Aeryon. All of these systems provide the monitoring and reporting ability needed during damage assessment. Each of these systems has their own variances when it comes to flight time and payload. Some of these apparatuses offer hovering capabilities while others are of the fixed wing variety. The websites for these technologies can be found at the following locations:

- http://www.leptron.com/corporate/
- http://www.microdrones.com/index.php
- http://www.lehmannaviation.com/la/la100.php
- http://www.marcusuav.com/zephyruav/
- http://www.avinc.com/uas/
- http://pulseaero.com/index.php?gclid=CLiF5cr2m7kCFY3m7AodtgMAQQ
- http://www.uavfactory.com/
- http://www.aibotix.com/aibot-x6.html
- http://www.draganfly.com/uav-helicopter/draganflyer-x6a/
- http://www.aeryon.com/

There is an abundance of UAV technology available in the United States. It is expected that this industry will progress significantly by the year 2015. The implementation of this equipment into damage assessment protocols could have enormous potential for improving the information-gathering process. Drones continue to be beta tested in various formats. Drones were used during Hurricane Katrina, which struck Louisiana and Texas in 2008. The Aeryon Scout drone has been used to perform search and rescue activities on a smaller scale, such as searching for missing persons (October 14, 2013). This technology allows rescue workers entry into areas that would otherwise be impeded by debris. Incomplete and/or inaccurate assessment reports could be a thing of the past. UAV could enhance situational awareness and provide structured details for navigating through the recovery process.

The perceived negatives that go against UAV are incredulous. The consistent argument raised against drones is the discernment over government surveillance. It seems that this assumption alone has delayed and/or held the industry back.

> Most people think of drones as spy devices. While this is true of many military and police applications, it is certainly not the whole story of how and why drones are being developed. Once upon a time, people thought of smart phones as spy technology. (Hub Pages, 2013, para. 2)

This researcher surmises that the stealth capabilities of drones are what give the public trepidation. There are numerous challenges that lie ahead for this technology. Even with the obvious benefits associated with this equipment, there seems to be a rise in legislation proposals to limit and/or ban UAV applications. It is interesting that so many municipalities are already enacting policies that go against an industry that has yet to reach its full potential.

In summary, this literature review surpassed this researcher's interest when it comes to the utilization of UAV during the damage assessment process. Drone deployment seems to revive the logical connections associated with rapid operation, ground coverage, and data collection. The relationship among visual communication, damage assessment, Federal Aviation Administration, legal issues and UAV were substantiated. These topics correlate the viability of the technology. UAV should be an integral part of any disaster response protocol. These apparatus enhance mission capability and give their operators distance from hazardous environments. In addition, the technology's live feeds offer opportunities for enhanced evaluations of community infrastructure as opposed to unreliable interpretations. Overall, drones offer emergency management teams a clearer picture of what needs to be addressed in an efficient manner. It is all-encompassing technology that allows for improved situational awareness. This equipment should continue to be explored as a valuable asset for improving the capabilities of emergency management teams.

Procedures

The procedures outlined in this Applied Research Project (ARP) consist of developing a research problem, purpose, and questions. A Literature review was conducted to explore the prospect and practicality of utilizing drones for damage assessments. This researcher wanted to understand the viability of UAV technology. Can process improvements be achieved with implementation of these vehicles? The terminologies associated with these vehicles have been used interchangeably with terms like drones, vehicles, apparatus and UAV. In addition, there have been other deployment formats associated with this technology such as ocean, agriculture, pipeline, and environmental monitoring. Robotics in various formats has allowed society to explore new boundaries. Many obstacles can easily be challenged with the use of this technology. Unmanned vehicles provide a safe vantage point for individuals deployed in dangerous environments. It reduces risk and provides an avenue for collecting environmental information.

The descriptive methodology was used to evaluate research materials for the five questions proposed. An investigation into the practicality of utilizing UAV during disaster assessments was reviewed. It was discovered that drones have been utilized in a number of other scenarios aside from search and rescue. Some of these situations include atmospheric monitoring, highway monitoring, photography, border patrol, tracking criminals, and lost and found. Other subject areas that correlate to the deployment of this technology were also evaluated. This includes capabilities associated with UAV systems, hardware, and software. Current and futuristic aerial apparatus were also examined both in the fixed-wing and hovering formats. All of these activities assisted with giving this researcher an overall perspective on the viability of this technology being utilized for information collecting and reporting. This study assisted in honing this researcher's understanding on where process improvements could be made in relation to damage assessments. Communications with the various vendors that market UAV brought forth better insight into the industry and how beneficial the technology could be in the future.

The Internet was a major factor in this research. It was instrumental for exploring the various UAV formats and programs available in the United States and abroad. Numerous articles, reports, brochures, presentations, specifications, schematics, and flight plans were retrieved to assist with identifying the capabilities of this technology. In addition, there were a number of interviews conducted. All of this information assisted with clarifying any outstanding queries associated with the technology. In addition, current deployments of UAV during major wildfires were monitored for best practices and situational awareness. "The 4,000 firefighters battling the giant 12-day-old Rim Fire in the Sierra Nevada that has now burned more than 192,000 acres added a California National Guard Predator drone to their arsenal," (Aljazeera America, 2013, para. 1). These instances highlight the technology's value during extreme circumstances and where the capabilities of these unmanned vehicles are being showcased. "While unmanned aircraft have mapped past fires, use of the Predator will be the longest sustained mission by drone in California to broadcast information to firefighters in real time," (Aljazeera America, 2013, para. 7).

For this researcher, the exploration into UAV technology began in January 2011. The original concept was to explore the possibilities of utilizing these devices for wildfire tracking. It is obvious that the capabilities of these devices can be expanded to other areas of the incident command system. In order to get some operational perspective associated with UAV technology, this researcher invited a representative from Leptron, a UAV manufacturer, to do a flight demonstration in Austin, Texas (see Appendix J). “The Avenger helicopter is a revolutionary platform that creates a mobile high-performance platform for high or low altitude surveillance, photography, and sensor management,” (Leptron, n.d, para.1). This flight exhibition allowed this researcher to get some hands-on flight time and observe the vehicle’s capabilities. Live video feeds were generated back to the command post on the ground during flight. Immediately, everyone could conceptualize the benefits of the technology. Most of the members in the demonstration group were from public safety agencies. A second invitation was extended to Leptron in Spring 2012 for additional demonstrations. Again, this researcher was able to engage and ask additional questions pertaining to new features and advancements in the product line.

The second step consisted of creating interview questions (see Appendix K). The basic premise of these questions was to validate the usefulness of drone technology during damage assessments. The collection of auxiliary information was accomplished through questions that gauged perceptions about the technology. The individuals were chosen based on their experience in the fire service and disaster response. Collectively, this group has been involved with more than 70 disaster deployments. This researcher wanted candidates who understood the scope and degree of operations needed to overcome a tumultuous event. This was important for the discussions when ascertaining past experience and involvement in major disasters. Furthermore, these individuals were selected because of their knowledge and experience in disaster deployment. This was important for correlating UAV technology into the Incident Command System (ICS). There were 10 questions asked during the interview, with opportunities for follow- up questions. Once permission was granted to conduct the interview, the session was taped. These interviews were conducted in an unstructured format. Each interview took approximately 10 minutes to complete.

The third step in this process was to review websites from the Electronic Frontier Foundation (EFF), Do It Yourself (DIY) Drones, and the Association for Unmanned Vehicle Systems International (AUVSI). The DIY drone site offered insight into the personal UAV community. The EFF website is a non-profit organization that works to protect fundamental rights in the technological world. The AUVSI website featured technological advances and conference information. All of these sites offered this researcher better insight into the legalities and technology advances associated with drones. In addition, it assisted with understanding both sides of the UAV debate. The benefit of these web sites was the attainment of significant information associated with UAV. The websites can be found via the following links:

https://www.eff.org/search/site/Drones

http://diydrones.com/

http://www.auvsi.org/Home/

Several opportunities were made available to attend informational presentations. The first was presented by webinar on June 26, 2013 from 1200 to 1300. The subject heading of this presentation was Disaster Recovery and COOP: The Latest Techniques and Tactics for Success. The 360 Government hosted this class. This researcher gained perspective on the challenges associated with Continuity of Operation Plans (COOP). This class expounded upon key technological and implementation factors associated with disaster and recovery. The second opportunity was presented in Austin, Texas on August 20-21 from 0830 to 1730. The subject heading for this course was Texas Disaster Recovery. The Texas Department of Public Safety hosted this two-day course. The basic premise was to give an overview of the disaster recovery process. This class highlighted the basic policies, concepts, and procedures for disaster recovery. Damage assessment, document preparation, and recovery procedures were some of the featured topics, which included discussion on federal and state assistance opportunities. Both presentations assisted in elevating assumptions concerning UAV deployment during the aftermath of a disaster.

Some of the limitations associated with this research revolved around the subject matter itself. The current stigma attached to drones made it difficult to expand topic exploration. It almost seemed like this subject was taboo. Most of the news stories referencing drones had a negative connotation. This contributed to some evasiveness when seeking collaboration with other city departments and the possibility of implementing a drone program. If departmental drone programs are being explored, it is suspected that most agencies are waiting for the right time. Furthermore, the understanding of disaster assessments and how this technology could coincide with EOC operations confined the interview candidate pool. The group selected for discussions needed to have some connection to the fire service, unmanned vehicles, and/or disaster management. The interviews were carried out in an unstructured format. This made it difficult to compare and/or generalize results. The initial goal was to interview 15 individuals but due to time constraints and the amount of information collected, only 10 interviews were conducted.

It appears the concept of UAV deployment is seen as corruptible. Abstract views of this technology fall on both sides of the proverbial debates. Most of the individuals interviewed offered their opinions with regard to the technology while others had in-depth knowledge of UAV platforms. There were variations of technical expertise when it came to discussing the possibilities of deploying this technology for disaster assessments. In addition, some of the individuals interviewed did not have a complete understanding of the emergency operations center and response protocols at the senior management level. An understanding of the importance of accurate reporting could have been missed. UAV applicability had to be bridged in the discussions to recognize how accurate reporting is advantageous when seeking disaster declarations. Furthermore, it would have served this research well if an actual drone was available full time for testing.

Results

Damage Assessment measures the degree of damage and defines present infrastructure conditions. Though the responsibility of gathering information varies from jurisdiction to jurisdiction, this researcher wanted to focus on the utilization of UAV deployment for ascertaining post-disaster data. The main measure of this technology is related to the timeliness of gathering and reporting accurate damage assessment reports back to the EOC. This in turn would equate to getting a clearer understanding of an event which assists in getting the proper number and kind of resources. The results for this study were acquired from a combination of interviews, inquiries, and reviews of various resources. All questions proposed were answered from the numerous materials reviewed.

1. *What are the classifications for unmanned aerial vehicles?*

There are various types of platforms and definitions associated with UAV. Aside from depicting this technology as either fixed-wing or rotary, there are a number of parameters that assist in categorizing the various aerial formats. Some of these include maximum takeoff weight, maximum flight altitude, endurance, and data link range. The European Association of Unmanned Vehicle Systems (EUROUVS) delineates UAV into four main classifications: micro/mini, tactical, strategic, and special task. These classifications are broken down into subcategories describing mission capabilities and system requirements associated with the various aerial technologies. These systems are capable of sustained flight without the need of a human element onboard. Collectively, these systems are unmanned and recoverable with automatic controls that assist with takeoff and landing.

Bento (2008) acknowledges the categories of micro and mini UAV, which comprise the smallest platforms that fly at altitudes fewer than 300 meters. This class of UAV would be the easiest to deploy in areas impacted by a disastrous event. These vehicles are the smallest and most maneuverable of all applications. Most of these systems have vertical takeoff and landing capabilities that aide in the sustainment of monitoring specific areas through hovering. This continued assessment is advantageous for timely reporting and uninterrupted evaluation of disaster areas. Some of the current mission applications utilized for these mico/mini vehicles include scouting, pollution measurements, surveillance, communication relay, and nuclear, biological, and chemical sampling. One could only assume that the potential applications for the micro/mini UAV will only expand. These current operating schemes should give disaster management teams insight into the technological potential of these systems.

“The category for tactical UAV includes heaver platforms that fly at higher altitudes from 3,000 to 8,000 meters. Unlike micro and mini UAV, which are mostly used for civil/commercial applications, tactical UAV primarily support military applications,” (Bento, 2008, p.56). These are the types of drones that most Americans fear. They are the military type with enhanced capabilities of surveillance and missile strikes. “There are six subcategories in which tactical UAV can be divided: Close range (CR), Short Range (SR), Medium Range (MR), Long Range (LR), Endurance (EN), and finally, Medium Altitude Long Range (MALE) UAV,” (Bento, 2008, p. 56). This is the category where all other types of drones get classified. It is difficult to separate due to the lack of education and government paranoia. Most Americans know about UAV but do not have a clear picture of the benefits associated with the technology. This unawareness has caused some community activists to down play the benefits and challenge their viability.

The characteristics associated with UAV in the strategic category include the ability to fly at high altitudes that can cover large areas with longer endurance. An example of a strategic type UAV is Global Hawk. This apparatus is a high-altitude, endurance, unmanned aerial reconnaissance system. It has the capability to remain airborne for days.

> The Global Hawk is operated by the United States Air Force and U.S. Navy. It is used as a high-altitude platform for surveillance and security. Missions for the Global Hawk cover the spectrum of intelligence collection capability to support forces in worldwide military operations. According to the United States Air Force, the superior surveillance capabilities of the aircraft allow more precise weapons targeting and better protection of friendly forces. (“Northrop Grumman RQ,” 2013, para. 2)

This vehicle highlights the capabilities of UAV technology and how it can be utilized in various formats.

Other UAV references have classified drones according to their functional capabilities. These categories separate these apparatus according to purpose rather than size. Depending upon the reference, UAV could be in a number of different categories. Some operate on fuel cells, while others function by electric motor. The U.S. Navy has a drone that operates on liquid hydrogen. This apparatus recently set a record by staying airborne for 48 hours without the need to refuel. It seems that functional categories will fluctuate do to a rapidly evolving field.

For now, UAV typically fall into one of six functional categories:

> Target and decoy – providing ground and aerial gunnery a target that simulates an enemy aircraft or missile; Reconnaissance – providing battlefield intelligence; Combat – providing attack capability for high-risk missions; Logistics – UAV specifically designed for cargo and logistics operation; Research and development – used to further develop UAV technologies to be integrated into field-deployed UAV aircraft; Civil and Commercial UAV – UAV specifically designed for civil and commercial applications. (October 14, 2013, para. 12)

2. What are the pros and cons for utilizing this technology?

The main benefit to this technology would be its capability to reach into areas that could otherwise be impeded by debris. It appears that drones allow for a quick response without putting team members in unsafe environments.

> The benefits of drones in an emergency are reach, speed, safety, and cost. When there is no power, a UAV can fly through the dark and live-stream night-vision footage to people on the ground, its paths automatically programmed so it doesn't miss a spot. A mounted infrared camera can pick up on heat signatures of bodies, pinpointing the locations of survivors so rescuers know where to go. (Kelly, 2013, para. 7)

This provides a clear understanding of what needs to be accomplished. The enhancement of situational awareness provides structure and details for mitigation during the recovery process. These details can be funneled through the planning section of the incident command system. Sometimes damage assessment can be delayed due to the inability to access certain areas. Frick (2013) describes that one of the issues that they sometimes run into is the inability to get teams across obstacles or barriers to continue their assessment. This prevents responding agencies from understanding and getting a true picture of an actual event. UAV allows for a clearer understanding of an event and assists in getting the right resources in place.

Another benefit related to this technology would be the cost when compared to manned helicopters. The price for a typical helicopter can range between $30,000 and $6,000,000. This cost is dependent upon the model and capabilities of the aircraft. In addition, there are other costs, including fixed cost per flight hours, overhaul reserve per hour, and direct cost per flight hour.

> The Unmanned Aircraft Program Manager in Mesa County puts the per-hour operating cost of Mesa County's UAS at $25; a manned helicopter, by contrast, costs hundreds of dollars per hour to operate. The dramatically lower operating cost for unmanned aircraft provides a powerful economic incentive for their adoption. In addition, they can be used in circumstances where a manned helicopter would have been too dangerous or disruptive. (Villasenor, J. 2012 p. 467)

The price point of UAV operation is minuscule when compared to the total operating cost and maintenance of a fully manned aircraft. It seems that the capital used to purchase manned aircrafts could be redistributed for the attainment of UAV. This will offset the operating cost for manned aircrafts, and have a dedicated reconnaissance vehicle available for assessing and surveying damage.

> Despite all the benefits of such reconnaissance systems, one should not forget the disadvantages: the miniaturized navigation systems are prone to drift and in the event of GPS, they may be disrupted easily or fail completely (GPS drop-out in the event of shadowing or multipath propagation), the light mini-drones shift in the wind, which

> directly impacts the quality of images or videos. (Fraunhofer Institute of Optronics & Image Exploitation, 2011, para. 1)

Though this technology has enormous potential in many applications there is still some lack of trust associated with this equipment. This researcher found that human error has been the main drawback in relation to this technology. One thing that needs to be considered concerning the slow integration of drones into everyday life is that they have a high rate of crashes (Grossman, 2013). It has been found that the lack of standardization—and the close proximity of keypads, joysticks, and other hardware—have heightened the potential of UAV miscues. The lack of a human element onboard has actually contributed to the increase in crash rates. It seems that operators seem to take more chances and push the envelope of operation when there is no risk to human life. In addition, there have been other vulnerabilities related to UAV security and control.

> A GPS spoofing attack begins by broadcasting a slightly more powerful signal that produces the correct position, and then slowly deviates away towards the position desired by the spoofer, because moving too quickly will cause the receiver to lose signal-lock altogether, at which point the spoofer works only as a jammer. ("Spoofing Attack," 2013, para. 1)

Some of the complex inabilities of drones are difficult to express. This researcher wanted to explore the factual concepts associated with the delay in implementing this technology into the domestic airspace. According to a Government (2013) report, the following items have been identified as current issues facing drone access to the nation's airspace.

> The inability for UAS to detect, sense, and avoid other aircraft and airborne objects in a manner similar to "see and avoid" by a pilot in a manned aircraft; Ensuring uninterrupted

command and control for both small and large unmanned aircraft remains a key obstacle for safe and routine integration into the national airspace; In a "lost link" scenario, the command and control link between the drone and the ground control station is broken because of either environmental or technological issues, which could lead to loss of control of the drone; Network security: The jamming of the GPS signal being transmitted to the UAS could also interrupt the command and control of drone operations; Progress has been made in obtaining additional dedicated radio-frequency spectrum for drone operations, but additional dedicated spectrum, including satellite spectrum, is still needed to ensure secure and continuous communications for both small and large drone operations. The lack of protected radio-frequency spectrum for unmanned operations heightens the possibility that a pilot could lose command and control of an aircraft. (pp. 14-18)

3. *Where are unmanned aerial vehicles currently being employed?*

As of October 2012, there were 81 authorized domestic drone programs in the United States. These locations can be found in Appendix L. “The Electronic Frontier Foundation (EFF) has been pushing the FAA to release details on all the public safety agencies, military, and security organizations and other groups that have been given permits to fly drones in U.S. airspace,” (2013, May 23, para. 26). This organization monitors all active and inactive UAV programs in the United States. The EFF’s website provides an interactive map that highlights each of the domestic programs and provides pertinent details into each agency’s UAV projects. The organization monitors drone use by the military, universities, and state and local agencies. This researcher found eight programs in Texas that were deemed either current or expired by

EFF, including Gainesville, Arlington, College Station, Conroe, San Marcos, Corpus Christi, Hidalgo County, and Houston.

Some of the pertinent information extrapolated from the EFF site includes launch/recovery procedures, aircraft type, communication systems, ground control station, emergency procedures, flight operation, certifications, training, visual surveillance/detection, and aircraft capabilities. These reports illustrate the capabilities and technologies associated with each particular program. In addition, it also offers a glimpse into each of the technology's viability. This data allows agencies contemplating UAV deployment to compare the various programs. This analysis could assist disaster response teams in choosing or investigating further the options available for their particular jurisdictions. A clear understanding of the parameters associated with the technology must be understood to ensure the workability of the technology.

Many of the drone programs continue to be beta tested in various formats. Though there are many UAV programs that exist across the United States, some still question if the services of this technology can truly be useful in disaster scenarios. If so, can it really make a difference?

> Falcon UAV is a Colorado company that makes a fixed-wing UAV (called a Falcon) that uses GPS and cameras to autonomously generate (among other things) highly accurate maps of the ground. The UAV is hand-launched, with an endurance of about an hour, and generally operates between 300 and 1,500 feet above the ground. It has public safety flight approvals from the Federal Aviation Administration (FAA) to fly in some parts of Colorado. (Ackerman, 2013, para. 1)

This researcher wanted to find true deployments related to this equipment; the recent Colorado floods this past September offered a glimpse into the usefulness of UAV technology. The rainfall made it difficult and/or impossible for airplanes and helicopters to get in and out of the area.

Drones can still fly; although, they are not able to pick up people or drop off supplies, they can make aerial maps to help relief agencies coordinate efforts (Ackerman, 2013).

4. *What are the legal issues related to this technology?*

One of the major fears associated with drone deployment is the issue of unwarranted surveillance. This trepidation has reverberated in many communities across the United States. Political confusion and skepticism on drone deployment in the domestic airspace has stalled implementation of this technology. This has even prompted many law enforcement agencies to pull the plug on their existing programs. Mulrine (2013) remarks on Seattle’s terminating their drone program before it even got started. The program was being considered for search-and-rescue operations and some criminal investigations, but was referred to by protesters as "flying government robots watching their every move.” It seems that the growing pre-disposition against UAV has alienated its capabilities and rendered its operational usefulness moot. This researcher surmises that some community activists have focused on the negative capabilities of UAV as opposed to the positive. This cynicism has generated a movement of “what if” legislation.

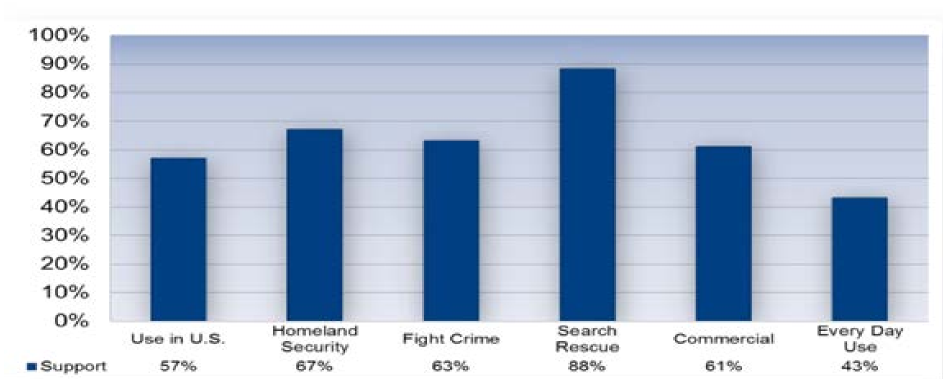
The legal issues related to this technology are based on interpretations of the First and Fourth Amendments. Ironically, UAV capabilities have put these two constitutional rights at odds with one another. The First Amendment guarantees freedom of speech and/or the press, while the Fourth Amendment protects against unreasonable search and seizure. Syed (2013) argues that under existing laws, camera-equipped drones engaged in communicative photography would enjoy First Amendment protection. Despite the operational hurdles concerning public safety, the issues of trespass, data protection, and property law considerations have yet to be resolved. There is recognition as to the usefulness of UAV in the Texas legislation. It is interesting to note that the utilization of this technology in the aftermath of a disaster or related scenarios has support. As noted earlier, Texas House Bill 912 concedes the usefulness of UAV technology. The arguments related to the First and Fourth Amendment are not directed toward disastrous events but to citizens' privacy and security.

Discussions

This research confirms the usability of UAV. The exploration of concepts associated with the deployment of these vehicles gives rise to their value. This technology seems to expand the scope of disaster assessments by enabling emergency response teams to collect and disseminate information at a faster rate. A drone can be up in the air in three minutes collecting data, whereas before it took about 45 minutes to an hour after you arrive on scene of an incident to get any real information (Hertneky, 2013). The focal point of the literature review included concepts, directives, policies, capabilities, and technology associated with UAV operations. All of these topics seem to enhance the practicality of utilizing these vehicles for damage assessments. A study conducted in March 2013 by the Institute for Homeland Security Solutions (IHSS) shows support for using UAV in search and rescue operations as depicted in Figure 4. This was a nationally representative survey with more than 2,000 respondents.

Figure 4

Public Support Type Use



In addition, 100 percent of the individuals interviewed by this researcher understood the value of UAV; all were familiar with the technology.

> UAV offer major advantages when used for aerial surveillance, reconnaissance, and inspection in complex and dangerous environments. Indeed, UAV are better suited for dull, dirty, or dangerous missions than manned aircraft. The low downside risk and higher confidence in mission success are two strong motivators for the continued expansion of the use of unmanned aircraft systems. (Nonami, Kendoul, Suzuki, Wang, & Nakazawa, 2010, p. 3)

The operational linkages illustrated in this investigation show a logical process that can enhance damage assessments. The basic assumption is UAV provide an efficient and effective way for gathering information. It allows disaster assessment teams to get a true picture of the devastation that is easily translatable to local, state, and federal officials. This puts everyone on the same page of understanding.

> In many regards, the absence of UAV highlights a travestied reality in which life-saving technology is limited in its effects by the restrictions of regulating authorities enabling deployment. In turn, while first responders continually put their lives at risk, a life-saving tool is left in reserve. UAV have become an increasingly frontline tool for the U.S. military, and they should well serve a parallel purpose assisting our domestic heroes on the home front. (Minder & Coleman, 2012, para. 3)

It is unimaginable not utilizing equipment and/or tools that could increase operational effectiveness and decrease risk to human life. From a safety standpoint, drones can reduce the risk of exposure to hazardous environments. The continuous exploration of these devices should coincide with incident command strategy and tactics. This systematic integration could establish a baseline for recognizing operational capabilities and ensuring mission interoperability.

It has been determined that UAV give rescue workers reach and distance, thus enhancing their capability to allow rescue teams to see into the heart of a situation as opposed to being impeded by debris and unable to get the true picture of a situation. These vehicles have already been beta tested in various formats. Though these vehicles have been utilized in previous disastrous events, it seems that the voyages are not properly catalogued. These omissions have resulted in this technology being viewed as nominal. It has not garnered the attention needed to overcome the negative overtones. This is unfortunate, since the capabilities of UAV are farther along than most individuals comprehend. Kelly (2013) recognizes that:

> Many government agencies are already testing out drones. The National Aeronautics and Space Administration (NASA) is using them to monitor hurricanes, National Oceanic and Atmospheric Administration (NOAA) employs them in the Artic to monitor wildlife, and the United States Geological Survey (USGS) is using them for mapping and environmental studies. (Kelly, 2013, para. 29)

This expansion and experimentation of use has enabled this technology to trigger interest.

Politics have downplayed the concept of drone functionality and overplayed the sensation of government surveillances. This is evident by sweeping legislation against drones. The legality and morality related to UAV are two concerns that seem to come up. An objective analysis into operational relevancy assists in separating out the negative assumptions. Only then can the cynics extrapolate the applicability of drone technology void of emotion, frustration, and illusions. In order to generate this understanding, agencies need to do a better job of not just telling the story but symbolizing the value.

> People do not just need rational arguments. What they need is a narrative, or the possibility for including events in a meaningful series of facts. Today, technology is justified only by utilitarian considerations. Yet human beings are hardly ‘utilitarian machines,’ they are rather ‘symbolic machines. They need meaning to give a sense to their life. (Mordini, 2007, p. 544)

Over time, disaster research has accumulated a wider range of usable data collected from catastrophes. This has helped researchers in their understanding of a number of complex issues related to community stress levels. It appears that efforts are already underway to deploy more drones before, during, and after disastrous events. “Technological advances provide significant advantage: the newest sensors, microprocessors, and propulsion systems are smaller, lighter, and more capable than ever before, leading to levels of endurance, efficiency, and autonomy that exceed human capabilities,” (Nonami et al., 2010, p. 3). These machines offer agencies a bird’s eye view into the rescue efforts. Having an in-depth knowledge of your incident enhances situational awareness. The benefits of visual communication are easily realized. The timeline for relaying information back to the EOC can be reduced with the utilization of this prescribed technology.

Recommendations

This researcher advocates the use of UAV for deployment in disaster-ridden areas. The practicality of this technology would be beneficial to the disaster assessment process. UAV retooled for civilian and private sector applications are clearly beneficial instruments that strengthen situational awareness and improve the prospects of successful emergency management operations, while at the same time delegating risk of response operations to unmanned drones (Minder & Coleman, 2012). The strategy for the Austin Fire Department would be to collaborate with other agencies that are part of the disaster response contingency. The main measure of the equipment is related to efficiency. The goal is to see if this technology is compatible and practical for gathering information in the realm of community disruptions. The recommended formats for navigating through these conceptual activities are potential strategies for discovering the logical linkages for operating this technology effectively. These applications will coincide with a systematic approach for making the response process better. These recommendations correspond with this researcher's final question.

5. *How can Austin's disaster response teams incorporate unmanned aerial vehicles into their damage assessment process?*

The following are suggestions that AFD should implement for a UAV pilot testing program.

Goal

To test and evaluate the practicality of deploying UAV for damage assessments.

Service Criteria Prioritization

Residents living in the City of Austin and surrounding jurisdictions requiring emergency management response after being impacted by a disastrous event.

Proposed Partners (Public Safety Group)

The Austin-Travis County EOC uses five operational groups to organize the Operation Section of the EOC: public safety, health and hospitals, community services, public utilities, and public works, (2012, February). It is proposed that representatives in the public safety group be tasked with the responsibility of UAV deployments. These members include the following:

- Austin Police Department
- Austin Fire Department

- Austin/Travis County Emergency Medical Services
- Travis County Sheriff
- Travis County Emergency Services Districts
- Texas Department of Public Safety
- University of Texas Police Department
- American Red Cross damage assessment teams (An addition to the safety group due to current responsibilities of damage assessments).

Partnership Activities

1. The Austin Fire Department's Special Operations Battalion Chief and three representatives from the public safety group will be responsible for managing the pilot program. The safety group will define the purpose, goals, objectives, and scope of the pilot program.
2. The Special Operations Battalion Chief will establish the criteria for success. This includes gathering input from stakeholders, technical experts, contractors, sales representatives, homeland security and emergency management teams, and the Travis County Office of Emergency Management.
3. Outline the pros and cons for conducting the pilot program.
4. Establish infrastructure support that guides the pilot program's activities.
5. Incorporate the utilization of unmanned aerial vehicles into the City of Austin's emergency operations plans.

Funding Sources

- If there is a delay in acquiring UAV technology, an initial purchase of a DJI Phantom Aerial Quad-Copter or equivalent for $524.95 could be initiated (see Appendix M). This funding could be a single or shared expense. This small investment could set the stage for the public safety group to become acclimated to the technology. In addition, it would allow for policy and procedural research for damage assessment scenarios.

- Representatives from one of the premium hovering type unmanned aerial vehicle systems offered price points that ranged from $60,000 to $120,000. This range was dependent upon the number of vehicles purchased and any relevant options, such as cameras, video, flight training, service, and maintenance agreements.
- Grant opportunities would be pursued through FEMA to assist with funding the UAV project. Available grants and other funding sources are available through proper application. The following website expands upon some mandatory steps that can get the proposing agency started: http://www.hse-uav.com/uav_grants.htm
- AFD could split the cost of the purchase of the UAV between members of the public safety group (with the exception of the American Red Cross). This would cost each entity roughly between $8,500 and $14,200 each. A prorated purchase and return could be negotiated upon request.
- Each agency would be tasked with pursuing funding to support the UAV initiative through their respective budget offices.
- Inter-local agreements would be pursued for the involvement of agencies outside the city.

Implementation Strategy

1. Examine the Federal Aviation Administration's NextGen implementation plan 2013 which can be found at http://www.faa.gov/nextgen/
2. Review the Texas Emergency Management Executive Checklist for correlating operational objectives to the disaster declaration process (see Appendix A).

3. Research the available unmanned aerial vehicle technology and flight training opportunities.
4. Continue preliminary evaluation of unmanned aircrafts, control systems, ground control stations, data link, and other related support equipment. This would allow emergency management teams to comparison shop and make an informed decision when deciding to go with a particular technology and/or system.
5. Determine if the decisions made concerning the hardware and software performance of the technology can meet the service level demand of a catastrophic event. This includes any criteria set by technical experts.
6. Develop and document response protocols that facilitate deployment for damage assessment action.
7. Develop policies and protocols for UAV flight training and certifications.
8. Assess hardware and software procedures.
9. Test products for functionality and usability.
10. Validate requirements and performance expectations.

A recommendation for future research is to investigate the trends related to UAV autonomy. “Autonomy is commonly defined as the ability to make decisions without human intervention. To that end, the goal of autonomy is to teach machines to be ‘smart’ and act more like humans,” (“Unmanned Aerial,” 2013, para. 25). There are various stages for self-directed control. Currently, UAV technology is nearing the stage of level three on the autonomy control level scale as depicted in Appendix O. Research continues to surge ahead for the ultimate goal of level 10, which is autonomous swarm control. The functionality of these apparatus can enhance the damage assessment process. This is accomplishable through rapid deployment and accurate recording. Arguments relevant to an individual's First and Fourth Amendment rights have stalled the expansive use of these machines. Though some forms of legislation are appropriate, it is this researcher's belief that applicable UAV deployments should not be mixed with unreasonable rhetoric; this decreases the technology's significance. Though not heavily publicized, these machines have already participated in a number of emergencies, including hurricanes, wildfires, rescues, and other related events. These deployments give credence to the relevancy of the technology but unfortunately, in some locations, this is still not enough.

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Appendix A

Retrieved from City of Austin Emergency Operations Plan

The organizational and operational concepts contained in this plan are set forth based on the following authorities:

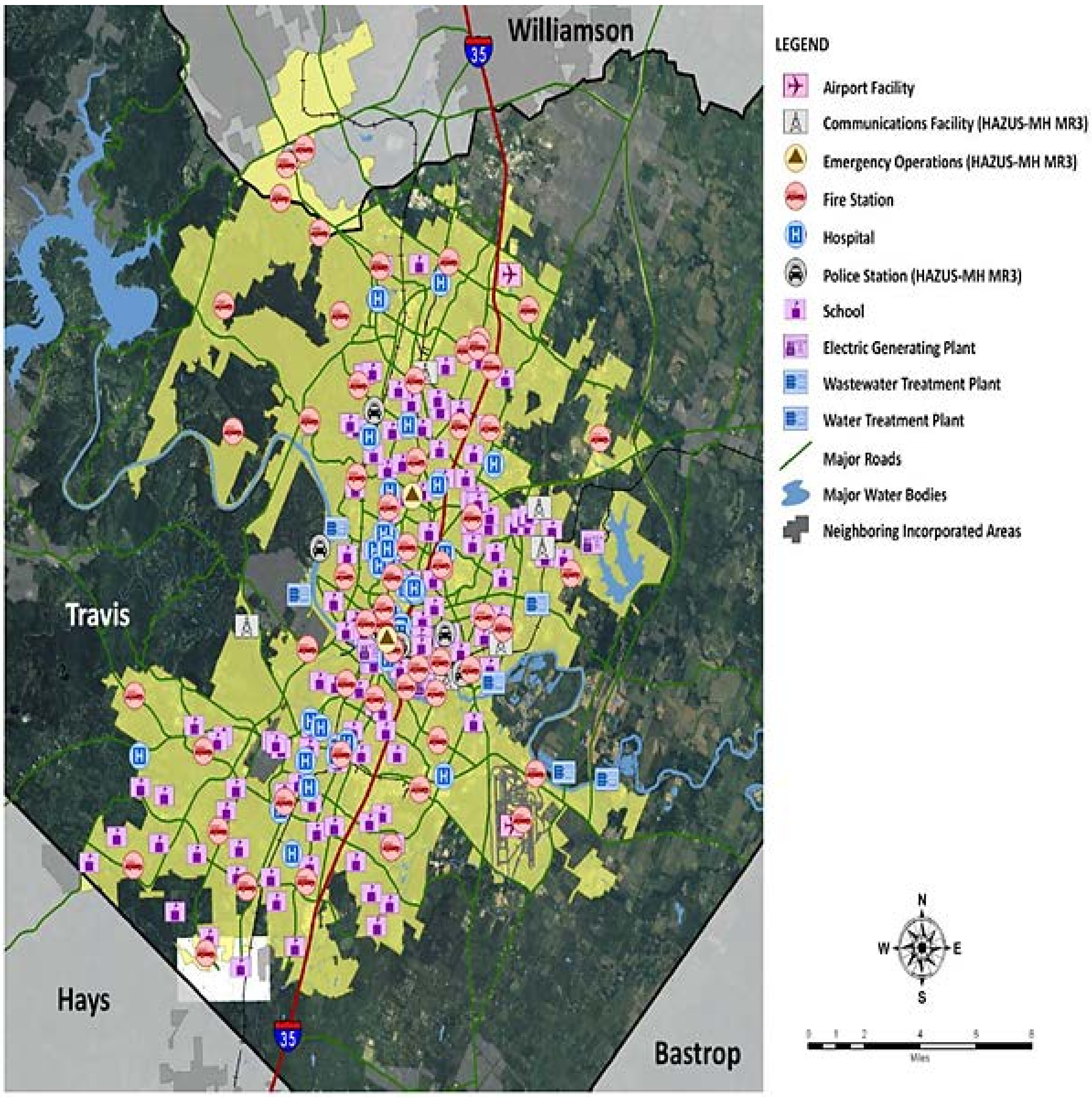
- Robert T. Stafford Disaster Relief & Emergency Assistance Act, (as amended), 42 U.S.C. 5121
- Emergency Planning and Notification, 40 CFR Part 355
- Title 42 - Emergency Planning and Community Right-to-Know
- Hazardous Waste Operations & Emergency Response, 29 CFR 1910.120
- Homeland Security Presidential Directive, HSPD-8, National Preparedness
- Homeland Security Presidential Directive. HSPD-5, Management of Domestic Incidents
- Homeland Security Presidential Directive, HSPD-3, Homeland Security Advisory System
- Title 44 Emergency Management and Assistance, Parts 0-399
- National Incident Management System
- National Response Framework
- Federal Radiological Emergency Response Plan
- Texas Local Government Code, Chapter 203 (Management and Preservation of Records),
- Texas Local Government Code Chapter 229 (Miscellaneous Regulatory Authority of Municipalities)
- State of Texas Government Code, Chapter 418, (as amended), (Emergency Management)

- State of Texas Government Code, Chapter 421, (as amended), (Homeland Security)
- State of Texas Government Code, Chapter 433, (as amended), (State of Emergency)
- State of Texas Government Code, Chapter 791, (as amended), (Inter-local Cooperation Contracts)
- State of Texas Health & Safety Code, Chapter 778 (Emergency Management Assistance Compact)
- State of Texas - Governor's Executive Order (RP-32) Relating to Emergency Management and Homeland Security
- State of Texas - Governor's Executive Order (RP-40) Relating to the National Incident Management
- State of Texas - Governor's Executive Order (RP-57) Relating to implementing recommendations from the Governor's Task Force on Evacuation, Transportation, and Logistics
- State of Texas Administrative Code, Title 37, Part 1, Chapter 7 (Division of Emergency Management)
- State of Texas Emergency Management Plan
- Capital Area Council of Governments (CAPCOG) Regional Response Plan
- City of Austin, City Charter
- City Code § 2-6-22, Ord. 20050804-047
- City Resolution No. 20050929-008

Appendix B

Retrieved from the city of Austin hazard mitigation plan

Austin Critical Infrastructure facilities (general locations)



Appendix C

Retrieved from the Homeland Surveillance & Electronics Website

Frequently Asked Questions about Unmanned Aerial Vehicle (UAV)

- **What is an Unmanned Aerial Vehicle (UAV)?**

An *Unmanned Aerial Vehicle (UAV)* also referred to as an Unmanned Aircraft System (UAS) is a helicopter or aircraft, which can operate under its own control or under the control of a remote human pilot. An aircraft (as defined by 14 CFR 1.1) that is intended to navigate in the air without an onboard pilot.

- **What is a Unmanned Aircraft System (UAS)**

    An unmanned aircraft and its associated elements related to flight operation which may include control stations, data communications links, support equipment, payloads, flight termination systems, and launch/recovery equipment.

- **What is a VTOL UAV?**

A VTOL UAV is a Vertical Take off Landing Unmanned Aerial Vehicle (UAV) which has the ability to take off and land without a runway. Because a VTOL UAV does not need a runway to take off or land, they can be easily be deployed in locations that conventional aircraft cannot.

- **What is the difference between an Unmanned Aircraft System (UAS), a Remotely Operated Aircraft (ROA), and an Unmanned Aerial Vehicle (UAV)?**

    ROA and UAV were terms previously used to identify unmanned aircraft. Currently the FAA and most of the international community uses the term “UAS."

- **What is a RC Model Aircraft?**

A UAS used by hobbyists and flown within visual line-of-sight under direct control from the pilot, which can navigate the airspace, and which is manufactured or assembled, and operated for the purposes of sport, recreation and/or competition.

- **Do I need to get approval from the FAA to fly a model aircraft for recreational use?**
- No. FAA guidance does not address size of the model aircraft. FAA guidance says that model aircraft flights should be kept below 400 feet above ground level (AGL), should be flown a sufficient distance from populated areas and full scale aircraft, and are not for business purposes.

- **Are their restrictions for model airplanes?**

Yes! Although a hobbyist does not need a license of COA to fly RC model RC airplanes and helicopters must also obey FAA Rules and Regulations. Model Aircraft operations that are conducted in accordance with an FAA accepted set of standards established and administered by a community based association as discussed in Section 2.2, shall otherwise be exempt from the requirements of any Special Federal Airworthiness Regulation (SFAR) that results from these recommendations.

- **Do I need to get FAA approval for commercial use of a UAV?**

Current FAA Regulations prohibits the use of an unmanned aircraft system for commercial purposes. FAA Rules for opening the National Air Space (NAS) in 2015 for commercial usage.

- **If I fly a UAS for business purposes, such as new technology development, am I required to get approval from the FAA?**

Yes. There are presently two methods of gaining FAA approval for flying UAS: Special

Airworthiness Certificates - Experimental Category (SAC-EC) for civil aircraft, and Certificates of Waiver or Authorization (COA) for public aircraft.

- **What's the difference between public and civil aircraft?**

A public aircraft is one that is only for the United States government or owned and operated by the government of a state, the District of Columbia, or a territory or possession of the U. S. or a political subdivision. Operators of public aircraft include DOD, DOJ, DHS, NASA, NOAA, state/local agencies and qualifying universities. Civil aircraft means other than a public aircraft.

- **Do I need a License to operate to fly a UAV in the National Airspace (NAS)?**

Before you can operate a UAV in National Airspace System (NAS) you must have a Certificate of Authorization (COA).

- **Who can receive a COA to fly a UA in the NAS?**

Only public agencies operating an unmanned aircraft.

- **How do I obtain a COA?**

The UAS COA process is managed in Washington, DC, FAA Headquarters in the UAS Group (AJV-13). Contact AJV-13 for assistance. The process includes opening a COA website account, which has an application that can be populated on-line. Public aircraft are tied to government agencies, therefore credentials must be provided.

- **Are FAA issued pilot certificates required to operate civil UAS?**

It depends on where you intend to operate, but in all cases you need to be additionally trained in all specific details of the UA being operated.

- **How long does the process take?**

  From our experience, depending on the complexity, from 2 months to 1 year. But, 60-90 days is typical.

- **What is a “Public Agency?”**

  Any agency that operates a public aircraft (14 CFR Part 1.1). If you receive funding from the federal government at some level, you are probably a “Public Agency.” A public agency can never operate under the guidelines of Advisory Circular 91-57 (Model Aircraft Operating Standards).

- **Are there Grants available for the purchase of a UAV for government public agencies?**

  Yes, grants are available for the purchase of an unmanned aerial aircraft. FEMA is a great source for UAV grants.

- **Does Homeland Surveillance & Electronics LLC offer Grant writing services?**

  Yes! Our team of experienced Grant writers can help with your grant writing?

- **Is financing, leasing or rental available?**

  Yes! Homeland Surveillance & Electronics LLC will help you arrange financing, leasing or rental of our products.

- **Is there training available?**

  Homeland Surveillance & Electronics LLC offers several comprehensive training courses to qualify you on all aspects of our products as well as special law enforcement training procedures.

- **If I want to operate a civil aircraft, how do I obtain an experimental airworthiness certificate?**

  The Aircraft Certification Service – Production and Airworthiness Division (AIR-200) at FAA headquarters in Washington, D.C. holds this responsibility and can be reached by telephone (202) 385-6346 (202) 385-6346 FREE. All questions regarding the process and procedures required to obtain an experimental certificate will be answered by AIR-200.

- **Can I fly a UAS under a COA or experimental certificate for commercial purposes?**

  No. Currently, there are no means to obtain an authorization for commercial UAS operations in the NAS. However, manufacturers may apply for an experimental certificate for the purposes of R&D, market survey and crew training.

- **How long does the process take to obtain an experimental certificate?**

  From our experience, depending on the system and operational complexity, the process may take from 60 to 90 days.

- **Is a FAA issued pilot certificate required to operate civil UAS?**

  Yes. If the aircraft is issued an airworthiness certificate a pilot certificate is required.

- **Is the FAA considering a special type of airspace for UAS?**

  Currently there are no actions being taken to establish a "special UAS airspace". This "special UAS airspace" would be counter to the idea of integrating unmanned aircraft into the NAS because it would be segregating, not integrating.

- **What about commercial operations? What are the obstacles to standards, certification, and operating procedures?**

All operations conducted in civil airspace must meet minimum levels of safety. Public UA operators have the ability to self-certify their equipment and personnel, but civil operators are certified by the FAA. We believe civil operators will benefit from the collaboration between the FAA and the public operators. Presently, the FAA is drafting a rule to address small UAS.

- **What do you think the FAA will have to do to address the UAS industry changes and growth?**

The UAS industry has grown largely as a result of supporting the defense organizations and this is reflected in the type of systems that have been developed. However, operations in civil airspace have different priorities. Civil performance standards are often more stringent, especially in the areas of reliability. Public expectation for a safe aviation environment drives our very high standards.

- **Can a civilian company operate an UAS as part of a business?**

Currently, civilian companies may not operate a UAS as part of a business without obtaining a Special Airworthiness Certificate - Experimental Category (SAC-EC). However, this SAC-EC is very limited in scope of operational use. Contact FAA for details or see FAA Order 8130.34.

- **What are FAA Temporary Flight Restrictions (TLR)?**

TLR's are used for operations in the vicinity of disasters or hazards; For Presidential and VIP movement; Operations in the proximity of Space Flight Operations; Management of aircraft operations in the vicinity of aerial demonstrations and major sporting events Special Security Instructions - While not a TFR, 99.7 instructions usually have the same effect as a TFR and is included in this reference

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- **What does Auto Flight Management mean?**

Pilot-in-Command (PIC) is able to maintain stable flight without constant direct intervention. To at least some degree, control surface movements result from sensors and software automation on-board the aircraft.

- **What is Collision Avoidance?**

Considered a last resort maneuver of an aircraft to avoid an imminent collision. Without the maneuver a collision might occur.

- **What is Conflict Avoidance?**

Activity which seeks to ensure that aircraft remain safely separated and well clear of each other as to not present a collision hazard.

- **What is a Control Station?**

Equipment, not on the aircraft, used to maintain control, communicate, guide, or otherwise operate an unmanned aircraft.

- **What are Data Communications Links?**

All links between the unmanned aircraft and the Control Station which includes the command, status, communications, and payload links.

- **What is Launch/Recovery Equipment?**

Equipment, not on-board the aircraft, used to launch and recover an unmanned aircraft which could also include unique navigation and differential positioning equipment used for autonomous landing.

- **What is Mode C Veil?**

The airspace within 30 nautical miles (NM) of an airport listed in Appendix D, Section 1 of 14 Code of Federal Regulations (CFR) Part 91 (generally primary airports within Class B airspace areas), from the surface upward to 10,000 feet mean sea level (MSL). Unless otherwise authorized by Air Traffic Control (ATC), aircraft operating within this airspace must be equipped with automatic pressure altitude reporting equipment having Mode C capability. However, an aircraft that was not originally certificated with an engine-driven electrical system or which has not subsequently been certified with a system installed may conduct operations within a Mode C veil provided the aircraft remains outside Class A, B, or C airspace; and below the altitude of the ceiling of a Class B or Class C airspace area designated for an airport or 10,000 feet MSL, whichever is lower. [Directly quoted from the Federal Aviation Administration's (FAA.s) Aeronautical Information Manual: Official Guide to Basic Flight Information and ATC Procedures, February 14, 2008].

- **What is Pilot-in-Command?**

  Same as 14 CFR 1.1

- **What is Manual Flight Control?**

  PIC is able to directly control the aircraft such that control inputs made at the Control Station are translated directly into corresponding control surface positions. Augmentations which help maintain flight stability are permitted.

- **What is a UAS Flight Crewmember?**

  A pilot, visual observer, payload operator or other person assigned duties for a UAS for the purpose of flight.

- **What is a UAS Pilot?**

  A person exercising control over an unmanned aircraft during flight.

- **What is Visual Line-of-Sight?**

Unaided (corrective lenses and/or sunglasses exempted) visual contact with aircraft sufficient to be able to maintain operational control of the aircraft, know its location, and be able to scan the airspace in which it is operating to decisively see and avoid other air traffic or objects.

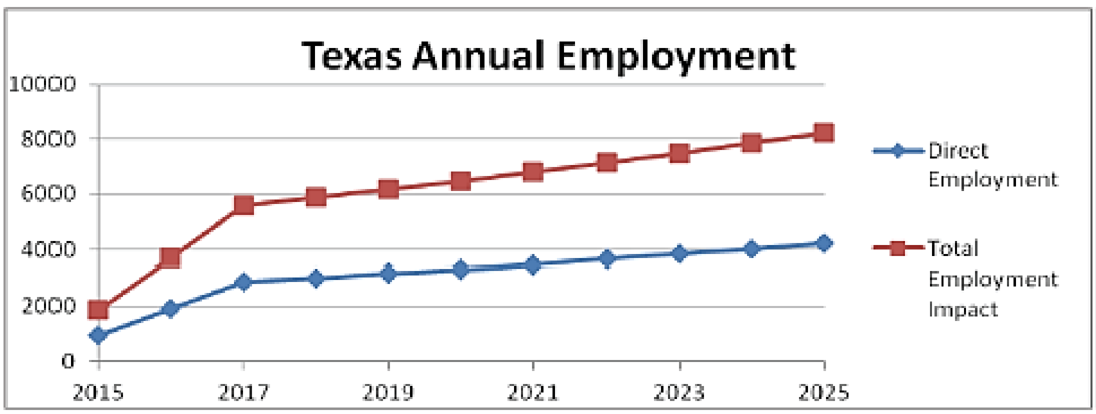
- **What is a Visual Observer?**

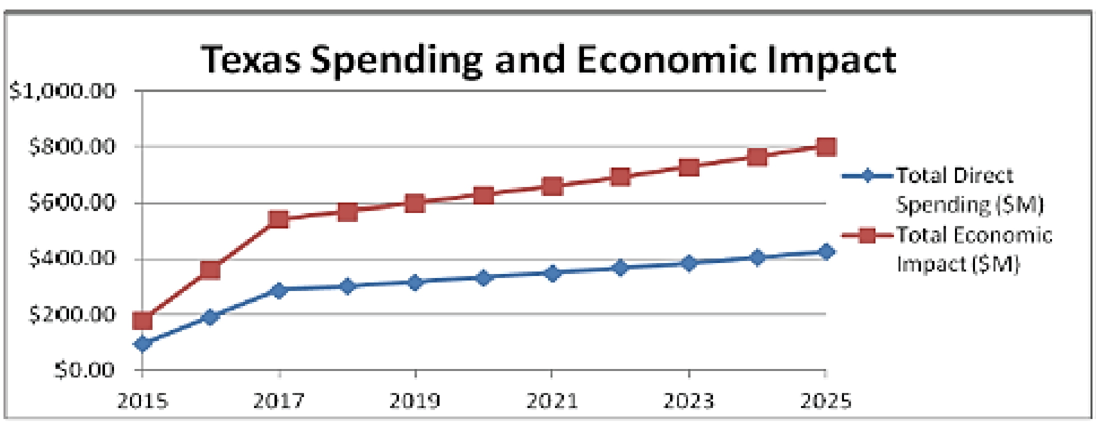
  A UAS flight crew member who assists the UAS PIC in the duties associated with collision avoidance. This includes, but is not limited to, avoidance of other traffic, airborne objects, clouds, obstructions, and terrain.

Appendix D

Retrieved from the Association for Unmanned Vehicle Systems International Website

Texas Economic Impact						
Year	Direct Employment	Total Employment Impact	Total Direct Spending ($M)	Total Economic Impact ($M)	Total State Taxes ($K)	Percent Change Over Previous Year
2015	958	1863	$96.15	$181.08	$0.00	
2016	1916	3725	$192.30	$362.17	$0.00	100%
2017	2875	5588	$288.44	$543.25	$0.00	50%
2018	3018	5867	$302.87	$570.42	$0.00	5%
2019	3169	6161	$318.01	$598.94	$0.00	5%
2020	3328	6469	$333.91	$628.89	$0.00	5%
2021	3494	6792	$350.61	$660.33	$0.00	5%
2022	3669	7132	$368.14	$693.35	$0.00	5%
2023	3852	7488	$386.54	$728.01	$0.00	5%
2024	4045	7863	$405.87	$764.41	$0.00	5%
2025	4247	8256	$426.16	$802.63	$0.00	5%





Appendix E

Retrieved from the American Civil Liberties Union (ACLU) website

Status of Domestic Drone Legislation

State	Status	Notes
Alabama	Passed Senate committee; legislature adjourned without further action	
Alaska	Resolution adopted creating drone task force; legislature adjourned without further action	Task force is to recommend drone policies and legislation
Arizona	Passed House; legislature adjourned without further action	
Arkansas	Legislature adjourned without taking up proposed legislation	
California	Bill introduced; legislature adjourned without further action	
Florida	Legislation enacted, goes into effect July 1, 2013.	
Georgia	Bill introduced; legislature adjourned without further action	Resolutions honoring the aerospace/drones industry also passed in both houses.
Hawaii	Bill introduced; legislature adjourned without further action	
Idaho	Legislation enacted, goes into effect July 1, 2013	
Illinois	Legislation enacted, goes into effect Jan. 1 2014	
Indiana	“Study group” resolution passed Senate committee; bill introduced; legislature adjourned without further action	

Kansas	Bill introduced; legislature adjourned without further action	
Kentucky	Bill introduced; legislature adjourned without further action, but interim study hearing on drones held Aug. 21.	
Maine	Passed both chambers, VETOED by governor	
Maryland	Bill introduced; legislature adjourned without further action	
Massachusetts	Introduced	
Michigan	Introduced	
Minnesota	Bill introduced; legislature adjourned without further action	
Missouri	Passed House; legislature adjourned without further action	
Montana	Legislation enacted, goes into effect Oct. 1, 2013	
Nebraska	Bill introduced; legislature adjourned without further action	
Nevada	Bill introduced; legislature adjourned without further action	
New Hampshire	Dead for this year	Passed House committee; tabled in House.

New Jersey	Passed Senate	
New Mexico	Died in committee	
New York	Introduced	
North Carolina	Bill introduced; legislature adjourned without further action	
North Dakota	Dead for this year	Passed House, defeated in Senate.
Ohio	Introduced	
Oklahoma	Dead for this year	Bill held over until next session; interim study hearing on drone privacy issues to be held Sept. 26
Oregon	Legislation enacted	
Pennsylvania	Introduced	
Rhode Island	Bill introduced; legislature adjourned without further action	
South Carolina	Passed House Committee; legislature adjourned without further action	
Tennessee	Legislation enacted, goes into effect July 1	
Texas	Legislation enacted, goes into effect Sept. 1	
Vermont	Bill introduced; legislature adjourned without further action	

Virginia	Legislation enacted, goes into effect July 1, 2013.	
Washington	Not brought up for full House vote before deadline, so dead for this session.	
West Virginia	Bill introduced; legislature adjourned without further action	
Wyoming	Died in committee	

Appendix F

Retrieved from the Texas Emergency Management Executive Guide

SENIOR EXECUTIVE CHECKLIST

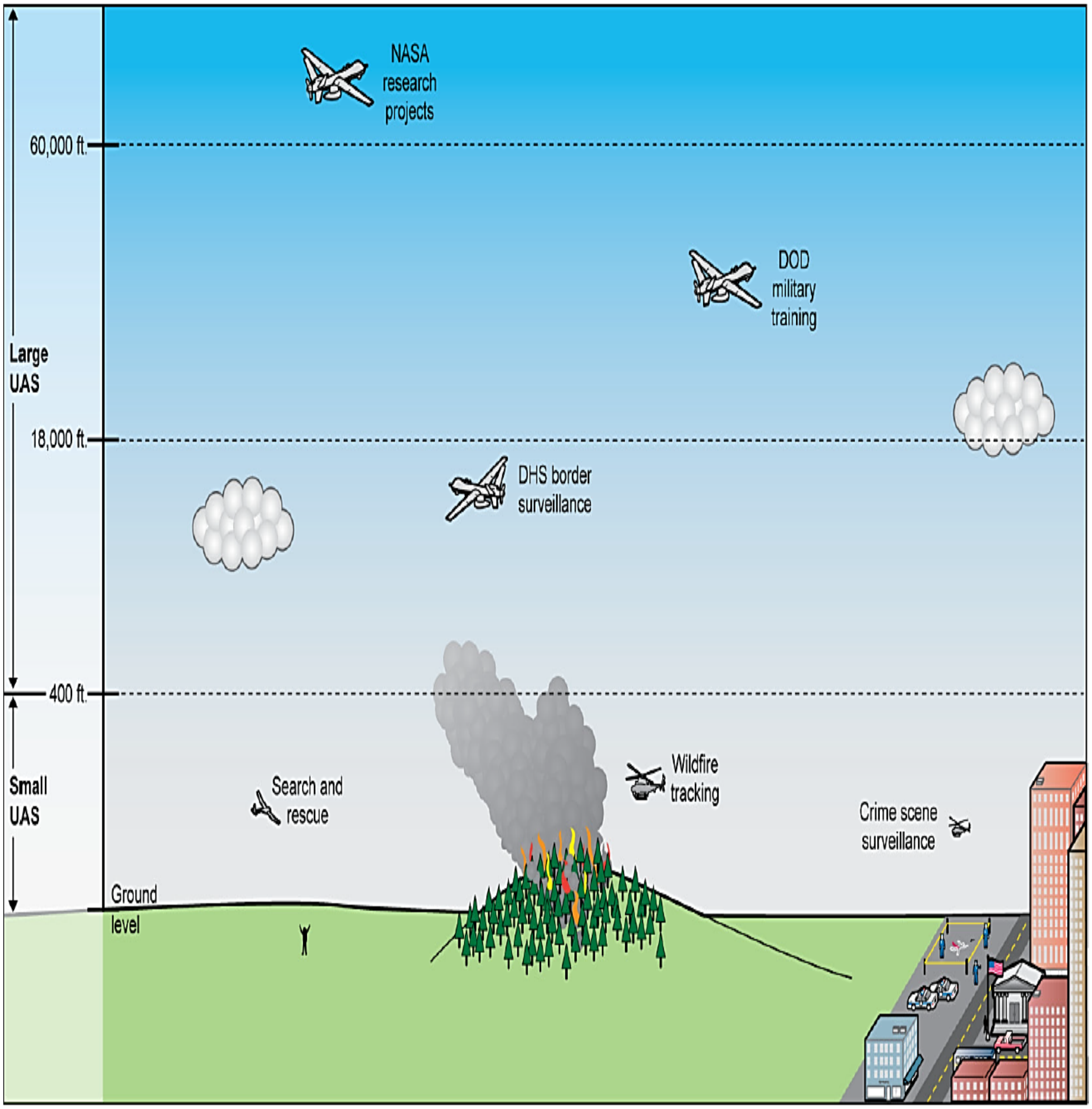
In the event a jurisdiction exceeds or expects to exceed its response capabilities during a major emergency or disaster, the following steps should be taken to obtain further assistance:

- [ ] Contact the local Office of Emergency Management.
- [ ] Activate any applicable mutual aid agreements.
- [ ] Notify the disaster district chairperson (DDC) for that district. If the DDC is unable to meet the local jurisdiction's needs, he/she will contact TDEM.
- [ ] The mayor or county judge should sign a statement declaring a local disaster and submit with a cover letter.
- [ ] The jurisdiction should prepare a cover letter to the Governor requesting disaster assistance from the state.
- [ ] The jurisdiction should begin to prepare the Disaster Summary Outline (DSO).
- [ ] As soon as possible, all jurisdictional departments should begin gathering initial damage estimates. These figures need not be exact, but are necessary to complete the DSO as a basis for obtaining a Presidential Disaster Declaration.
- [ ] The letter requesting state disaster assistance, the local proclamation of disaster, and the Disaster Summary Outline should be faxed to TDEM at 512-424-2444 within ten days from the date of the disaster.
- [ ] The state of Texas, if necessary, will contact the federal government for additional aid.
- [ ] The federal government will determine what type of declaration, if any, will be issued for the incident, based on losses documented in the DSO.
- [ ] If a Presidential Disaster Declaration is issued, FEMA and TDEM will establish a local disaster field office (DFO). Once the DFO has been established, FEMA and State personnel will request initial meetings with representatives of the most seriously affected departments and will require transportation and guidance to inspect damaged areas of the city.
- [ ] When a Presidential Disaster Declaration is issued, note which categories of Public Assistance (A-G) have been declared and if Individual & Household Program (IHP) Assistance has been included in the declaration.
- [ ] If the local jurisdiction is authorized for Individual & Household Program Assistance (IHP), FEMA and the state will establish disaster relief centers (DRCs) where citizens affected by the disaster may go to obtain further federal assistance after teleregistration through the 1-800-621-FEMA (3362), or TTY 1-800-462-7585 for the speech or hearing impaired.
- [ ] FEMA will ask for several preliminary informational meetings with representatives of the government entities and non-profit organizations eligible for public assistance (PA). It is essential that key department and elected leaders attend.
- [ ] FEMA will further call for a meeting with representatives from each entity eligible for PA. This meeting will explain the process for obtaining reimbursement under PA and answer questions about project eligibility. At this point, FEMA will assign a public assistance representative to work directly with the local jurisdiction. This representative will be available for further meetings with single departments or groups of departments and will assist with development of project worksheets.

Appendix G

Retrieved from the United States Government Accountability Office (GAO) Report

Examples of current uses for UAS and their Altitudes of Operations



Appendix H

Retrieved from the Leptron Website

Appendix I

Retrieved from Insidegnss website

UAV Classification

	Category (acronym)	Maximum Take Off Weight (kg)	Maximum Flight Altitude (m)	Endurance (hours)	Data Link Range (Km)	Example	
						Missions	Systems
Micro/Mini UAVs	Micro (MAV)	0.10	250	1	< 10	Scouting, NBC sampling, surveillance inside buildings	Black Widow, MicroStar, Microbat, FanCopter, QuattroCopter, Mos-quito, Hornet, Mite
	Mini	< 30	150-300	< 2	< 10	Film and broadcast industries, agriculture, pollution measurements, surveillance inside buildings, communica-tions relay and EW	Mikado, Aladin, Tracker, DragonEye, Raven, Pointer II, Carolo C40/P50, Skorpio, R-Max and R-50, Robo-Copter, YH-300SL
Tactical UAVs	Close Range (CR)	150	3.000	2-4	10-30	RSTA, mine detection, search & rescue, EW	Observer I, Phantom, Copter 4, Mikado, RoboCopter 300, Pointer, Camcopter, Aerial and Agricultural RMax
	Short Range (SR)	200	3.000	3-6	30-70	BDA, RSTA, EW, mine detec-tion	Scorpi 6/30, Luna, SilverFox, EyeView, Firebird, R-Max Agri/ Photo, Hornet, Raven, phantom, GoldenEye 100, Flyrt, Neptune
	Medium Range (MR)	150-500	3.000-5.000	6-10	70-200	BDA, RSTA, EW, mine detec-tion, NBC sampling	Hunter B, Mücke, Aerostar, Sniper, Falco, Armor X7, Smart UAV, UCAR, Eagle Eye+, Alice, Extender, Shadow 200/400
	Long Range (LR)	-	5.000	6-13	200-500	RSTA, BDA, communications relay	Hunter, Vigilante 502
	Endurance (EN)	500-1.500	5.000-8.000	12-24	> 500	BDA, RSTA, EW, communica-tions relay, NBC sampling	Aerosonde, Vulture II Exp, Shadow 600, Searcher II, Hermes 450S/450T/700
	Medium Altitude, Long Endurance (MALE)	1.000-1.500	5.000-8.000	24-48	> 500	BDA, RSTA, EW weapons delivery, communications relay, NBC sampling	Skyforce, Hermes 1500, Heron TP, MQ-1 Predator, Predator-IT, Eagle-1/2, Darkstar, E-Hunter, Dominator
Strategic UAVs	High Altitude, Long Endurance (HALE)	2.500-12.500	15.000-20.000	24-48	> 2.000	BDA, RSTA, EW, communica-tions relay, boost phase intercept launch vehicle, airport security	Global Hawk, Raptor, Condor, Theseus, Helios, Predator B/C, Libellule, EuroHawk, Mercator, SensorCraft, Global Observer, Pathfinder Plus,
Special Task UAVs	Lethal (LET)	250	3.000-4.000	3-4	300	Anti-radar, anti-ship, anti-aircraft, anti-infrastructure	MALI, Harpy, Lark, Marula
	Decoys (DEC)	250	50-5.000	< 4	0-500	Aerial and naval deception	Flyrt, MALD, Nulka, ITALD, Chukar
	Stratospheric (Strato)	TBD	20.000-30.000	> 48	> 2.000	-	Pegasus
	Exo-strato-spheric (EXO)	TBD	> 30.000	TBD	TBD	-	MarsFlyer, MAC-1

Appendix J

Photos from Leptron Avenger flight demonstration

Appendix K

Qualitative Interview Questions

Thank you in advance for your participation in this interview. This review is part of an applied research project for the National Fire Academy. This study will assist the Austin Fire Department in understanding the capabilities of unmanned aerial vehicle technology and the benefits that it could provide during the aftermath of a disaster.

The purpose of this research is to evaluate the practicality of utilizing Unmanned Aerial Vehicle technology for initial assessments during the aftermaths of major disasters. Before we begin, do you have any questions? Are you comfortable with this interview being recorded? Can you please state your first and last name for the record?

- What are your perceptions concerning unmanned aerial vehicles?
- What has been your experience with unmanned aerial devices?
- How can unmanned aerial devices benefit a damage assessment survey?
- What do you think are the advantages of utilizing unmanned aerial vehicle technology in the aftermath of a disaster?
- What do you think would be the disadvantages of deploying unmanned aerial vehicles in the aftermath of a disaster?
- What societal challenges do you think could be encountered with the deployment of unmanned aerial vehicles during disaster management?
- What are the major obstacles that you foresee in getting this technology as a part of the fire departments response protocol?
- What is your opinion on using the term “drone” when depicting the capabilities of this technology?
- How could this technology be beneficial during an urban search and rescue mission?
- Is there anything else you would like to say about unmanned aerial vehicles that were not covered in these questions?

Appendix L

Retrieved from the FAA website

Drone programs in the United States

1. Arlington Police Department (Texas)
2. Barona Band of Mission Indians Risk Management Office (California)
3. California Department of Forestry and Fire Protection
4. California State University, Fresno
5. Canyon County Sheriff's Office (Idaho)
6. City of Herington (Kansas)
7. City of Houston, TX Police Department
8. City of North Little Rock, AR - Police Department
9. Clackamas County Sheriff's Office (Oregon)
10. Cornell University
11. Defense Advanced Research Projects Agency
12. Department of Energy - Oak Ridge National Laboratory
13. Department of Homeland Security - Science and Technology
14. Department of Homeland Security - Customs and Border Protection
15. Department of the Interior - National Business Center/Aviation Management Directorate
16. Eastern Gateway Community College
17. Federal Bureau of Investigation
18. Gadsden Police Department (Alabama)
19. Georgia Tech Police Department, Office of Emergency Preparedness
20. Georgia Tech Research Institute
21. Grand Forks County Sheriff's Department (North Dakota)
22. Hays County Emergency Service Office (Texas)
23. Indiana State University
24. Kansas State University
25. King County Sheriff's Office (Washington)
26. Lorain County Community College

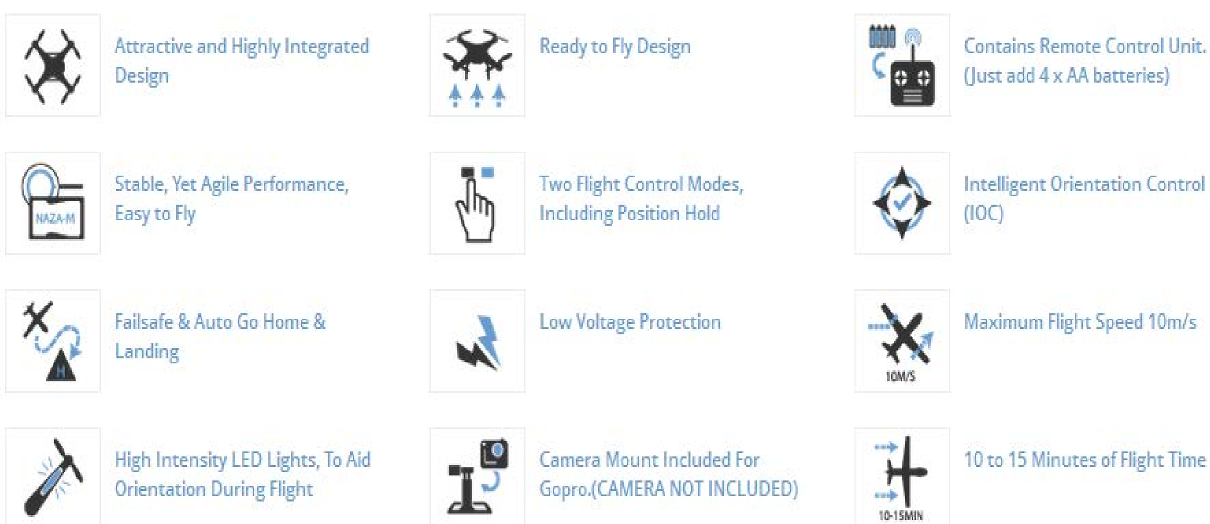
27. Medina County Sheriff Office (Ohio)
28. Mesa County Sheriff's Office (Colorado)
29. Miami-Dade Police Department (Florida)
30. Middle Georgia College
31. Middle Tennessee State University
32. Mississippi Department of Marine Resources
33. Mississippi State University
34. Montgomery County Sheriff's Office (Texas)
35. National Aeronautics & Space Administration
36. National Institute of Standards and Technology
37. National Oceanic & Atmospheric Administration
38. New Mexico Institute of Mining and Technology
39. New Mexico State University - Physical Science Laboratory
40. Nicholls State University
41. Northwestern Michigan College
42. Ogden Police Department (Utah)
43. Ohio Department of Transportation
44. Ohio University
45. Orange County Sheriff’s Office (Florida)
46. Oregon State University
47. Otter Tail County (Minnesota)
48. Pennsylvania State University
49. Polk County Sheriff's Office (Florida)
50. Seattle Police Department (Washington)
51. Sinclair Community College
52. Texas A&M University (TAMU) - Corpus Christi
53. Texas A&M University (TAMU) - Texas Engineering Experiment Station
54. Texas Department of Public Safety
55. Texas State University
56. U.S. Air Force
57. U.S. Army

58. U.S. Department of Agriculture – Agriculture Research Service
59. U.S. Department of Agriculture - Forest Service
60. U.S. Department of Energy - Idaho National Laboratory
61. U.S. Department of Energy - National Energy Technology Laboratory
62. U.S. Department of Justice - Queen Anne's County Office of the Sheriff
63. U.S. Department of State
64. U.S. Marine Corps
65. U.S. Navy
66. University of Alaska, Fairbanks
67. University of Arizona
68. University of California, Davis
69. University of California, Merced
70. University of Colorado, Boulder
71. University of Connecticut
72. University of Florida
73. University of Michigan
74. University of North Dakota
75. University of Oklahoma
76. University of Wisconsin
77. Utah State University
78. Virginia Commonwealth University
79. Virginia Polytechnic Institute & State University
80. Washington State Department of Transportation
81. West Virginia University

Appendix M

Retrieved from DJI website

DJI Phantom Aerial UAV Quad-copter



Appendix N

Retrieved from the Autonomous Flying Robots Book

Trends in UAV autonomy