Virginia Polytechnic Institute and State University

Drone Technology and University Public Safety Program Proposal

Honors Superstudio

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December 3, 2020

Introduction

Drones are a form of aircraft that are very high-tech, controlled remotely by people away from the vehicle, and used to conduct many tasks. These devices are both cost-effective compared to other surveillance technology and have strong surveillance and reconnaissance skills (Sexton, 2016). Drone technology is a relatively new field that has recently found footing in many different subject areas over the past few years. While they originally were intended for military use, unmanned aerial vehicles (UAVs) are now being developed academically, recreationally, and for all types of professions. In the last year, the rise of a global pandemic has drastically changed the way societies all over the world are operating. Communities are wearing masks, socially distancing, and prohibiting gatherings to limit virus exposure to high risk individuals (Lu, 2020).

Some communities are beginning to utilize drone technology in their police forces to safely enforce social distancing guidelines and maintain a safe environment. For example, local police forces in New Jersey, state police in Western Australia, local police in Italy, and some police forces in England are all planning how to use drones to enforce laws (Gupta et al., 2020). Drones can be used to monitor individuals in many public locations including parks, transportation methods, and beaches. Body heat temperature sensors can be put onto drones to aid in determining the amount of persons present in a particular location, and if the number detected is in violation of rules, loudspeakers placed on the drone can be used to inform people to disperse. This loudspeaker communication via drone can help inform the public about the constant changing rules in many different locations (Gupta et al., 2020).

There are many costs associated with drone technology use that must be considered in a plan involving these vehicles. One of the largest challenges in this implementation is community concerns and public perception. Ensuring that the community understands, approves, and is involved in the collaboration of police with UAVs will be an ongoing process. Other challenges to this implementation include regulations and policies, technology, privacy, financial and legal concerns, and liability. Despite these many concerns, there are many benefits including preservation of officer safety, greater coverage of terrain, collection of information, and enhanced recording of criminal activity (Valdovinos, 2016).

As of 2004, the FAA chose three universities to use as test sites for Unmanned Aerial Vehicles; the University of Alaska, Texas A&M, and Virginia Tech (Morris, 2015). Since then, drone technology has been developed significantly and is beginning to be used for many different applications, including public safety (Bennett, 2019). It is predicted that the option to use drone technology to enhance and promote safety on college campuses before expanding to cities and communities will be more successful, as, “colleges and universities want to be on the forefront of this high-tech market (Morris, 2015).” This project aims to develop a program proposal that can be used by Virginia Tech campus to both enforce and inform students about the constantly changing COVID-19 guidelines. The project addresses this question: How can Virginia Tech Police use drone technology to enhance university public safety and mitigate impacts of the COVID-19 pandemic? The overall goal of this project is the eventual

implementation of drone technology in community and university public safety; new solutions contributing to the campus GND/green technology plan.

This project incorporates many distinct aspects of both the Green New Deal as well as Virginia Tech's sustainability plan as a baseline for the intended program. Our project envisions the development of a single drone prototype to be tested and used on campus by the Virginia Tech police. However, after a few years of testing, we would like to see similar programs being adapted into college campuses on a wider scale and possibly even national use of this drone for public safety purposes. Drones are a much cleaner and more sustainable technology compared to standard practices. The Rifkin outline of the Green New Deal discussed many initiatives that needed to be taken in order for a Green New Deal to be successful. Four distinct points in his list are directly correlated with our project.

Our drone prototype will require a charging station which will likely be stationed at the base of its operations, for instance, the Virginia Tech Police Station. Rifkin's 5th initiative, which notes the important addition to infrastructure, specifically "the installation of energy storage technology in homes, commercial buildings and industrial and institutional facilities" (Rifkin, 2019, 224) closely aligns with the implementation of this charging station. While Rifkin is primarily addressing a need for a backup power network, in case of climate disaster or cyber attack, our program could aid in the push to make Virginia Tech adhere to the standards Rifkin sets.

Rifkin's initiative number 18 discussed the need to teach the next "student generation" to "learn skills and develop talents that will enable them to create new businesses and become gainfully employed in the green new deal economy" (Rifkin, 2019, 228). Virginia Tech has already begun working to adopt this initiative by offering classes like the Honors Superstudio to provide students an opportunity to engage in discourse over correlations between different aspect areas including data, innovation, policy, education, and jobs. The addition of drone technology into public safety on campus, as our project would, allows for students and faculty to learn new skills and hands-on experience with an increasingly common innovation. This will pave the way for outreach on all future Green New Deal policies. The incorporation of these public safety drones would also provide education to the student generation on the COVID-19 virus, ways to stay safe, and how to ensure others are staying safe. This way of spreading knowledge to the masses through drones would allow for a more rapid sharing of information, and more opportunity for those willing to develop new talents that pair with the Green New Deal initiatives.

One of the most well-known aspects of Virginia Tech is the quality and quantity of research and development the school produces. This university is at the forefront of innovative thinking in all different fields, and because of this it is an ideal location to develop an ambitious program like the one proposed here. The 21st of Rifkin's initiatives states that as a nation, we must be prioritizing the funding of research institutions to substantially increase research and development, and therefore innovation, in all areas that accompany the transformation into green technologies and the third industrial revolution infrastructure (Rifkin, 2019,229). Our project

directly adds to the Virginia Tech green technology infrastructure by improving upon it with drone technology abilities.

In initiative 23, Rifkin stresses the need for us to join with other nations through informal and ongoing collaboration (Rifkin, 2019, 230). While this project is a long way off from global integration, it is important to work nationally with other universities, police, and communities that will benefit from this technology. In this project, this is done largely by researching and studying areas that have prototyped a similar program or incorporated drone technology into their public safety initiatives and how or why they succeeded or failed.

This report is an initial program proposal for drone technology use for university public safety. Three different areas of focus are addressed in this report by the research team. The three focuses will include an extensive case study of similar programs adopted in other locations, with an analysis of their successes and failures, a proposed survey to be sent to Virginia Tech students on drone technology and the use of UAVs on campus and a CANVAS module outline used to inform Virginia Tech students of the campus drone guidelines, and a description of current Virginia Tech policies related to the proposed program and their challenges and needed adoptions.

The case study method consists of a literature review of communities using drone technology and the analysis of logistics in adapting a drone public safety program in these locations. Reports from other police departments, communities, and countries using drones for policing were also used. Combinations of keywords used to find reliable references included; (drone OR UAV OR unmanned aircraft OR unmanned system) AND (college OR university OR campus OR student OR) AND (safety OR COVID-19 OR pandemic OR public safety OR security OR coronavirus) AND (police OR community OR policing OR police department OR local police).

The database used by Virginia Tech (WorldCat.org) as well as Web of Science will be the primary databases used to gather information. From this information, a survey was developed to gauge the Virginia Tech student body's willingness or opposition to the future implementation of drone technology for these purposes. As a system of drones used in tracking student location, movement, and interaction raises ethical concerns regarding student privacy, understanding the viewpoints of students is key to ensuring our solution garners as much support as possible. The survey will be anonymous to avoid the process of Institutional Review Board (IRB) approval of research methods. Ideally, the survey should be distributed using simple random sampling from a list of current VT students, but as that method is not possible due to sampling and time limitations, we have created predicted results to discuss instead.

Studying existing Virginia Tech campus plans including the *Virginia Tech Fall 2020 Covid19 Operational Plan* and the *2019 Jeanne Clery Act Report* is imperative to the implementation of the proposed drone plan. Ideas generated on how these plans can become more efficient, innovative and sustainable incorporating new drone technologies were made after careful analysis and consideration of current Virginia Tech policies.

This research method combines three integral pieces to develop a baseline prototype program to be developed and used by the Virginia Tech Police Department and Virginia Tech campus for enhanced modern school public safety.

UAS Terms and Technology

There are two major classes of common use drones, commercial and modular. Commercial drones, such as DJI drones, are prebuilt to serve whatever programming they come with.These drones are built for a specific purpose, such as photography or cinematography. The other class of drones are modular drones which are built with a handful of core components and are usually designed so that the purpose of the drone can change based on its programming. These drones are often referred to as first-person view (fpv) drones because they are operated through goggles that are connected to an onboard camera.

There are two major different fpv systems, analog and digital. Each mode has its benefits as well as its challenges. Analog does not broadcast as clear of a picture, but has less lag time. On the other hand, digital broadcasts have a much clearer picture but have a slight lag which is not always good when it comes to flying (DJI). A prime example of the differences between an analog and digital is a television Older televisions are grainy in comparison to their digital counterparts, which paint a high definition picture.

Different types of batteries are used with different drones. A drone has to be built with components that can handle the differences in the power levels associated with a certain type of battery. The main classes of batteries are either 4 cells (4s) or 6 cells (6s). The more cells one has, the more power is available; however, the cost of added weight must be taken into consideration.

FPV drones are built with a multitude of components that must communicate together to complete the intended task (FPV, 2019). First, a drone is built on a frame. Frames come in different shapes and sizes. They are usually made out of carbon fiber or titanium due to its strength and lightweight. The different options for frames mostly differ in the design and the intended purposes. The two main types of frames are freestyle frames and racing frames. Freestyle frames are used to perform tricks and stunts, therefore, these types of frames are created heavier and to be more durable,allowing them to hold up after multiple crashes. Racing frames are the opposite, designed to be lightweight to gain faster speeds. Unlike freestyle frames, racing frames s typically have less durability

The main components of a quadcopter are the flight controller (FC), the electronic speed controller (ESC), the receiver (RX), and the video transmitter (VTX). The flight controller acts as the brain of the drone. One could compare it to acting as the motherboard of a computer, in that it controls nearly every aspect of the drone. Most of the electronic components directly attach to the flight controller via either pins or direct soldering. The electronic speed controller electronically connects the flight controller to the motors. These controllers come in one of two possible ways,, individual boards or 4-in-ones, which contain 4 ESCS in a single board. These

send electrical outputs to the motors to change the speed of the motors. They are controlled by the Flight Controller.

The motors attach directly to the frame and come in different kilovolt (kV) ranges. The different kV's are used for the different cell types as well as to accommodate a specific torque needed to generate a net lift. In general, a quadcopter incorporates 4 motors, two motors spin clockwise, while the other two spin counterclockwise. It is important to note that propellers are attached to motors and come in CW and CCW configurations. Next, a receiver is needed. This is the direct link between your handheld controller and the quadcopter. Linking the two together by binding a controller with the specific receiver. The bind has a range from between a few inches to over a mile, depending on the type of receiver used.

Finally, the VTX component relays the signal from the camera to the goggles. An individual can change the power consumption on many of the VTXs available for longer or shorter ranges, but it will compromise flight time as it uses more or less power. The VTX is also connected to the camera, which is used to allow the drone operator to see what the drone is seeing. Together the VTX and the Camera relay video information to the goggles which are worn by the drone operator.

In an interview with Virginia Tech Police Officers (see Appendix A) discussing the future possibility of a prototype drone in collaboration with Virginia Tech, some ideas on what the police officers would like to see on the drone were created (Tarter, Pasquarell, Williams, & Zario, 2020). We imagined and brainstormed that the prototype would be built on a frame between 5 to 7 inches. It would have guards enclosing the propellers for maximum thrust efficiency, as well as protection in case of an accident. The Virginia Tech Police Department strongly suggested that it would have to be able to fly for a duration of at least twenty to thirty minutes. To meet the requirements for a variety of tasks, the drone prototype would have to be modular. To do this, a rail system could be used so that components such as a spotlight, loudspeaker, microphone, and a global positioning system unit could be attached.

Review of Current Virginia Tech Policies

Virginia Tech strives to be an innovative campus and in 2018 Virginia Tech first began drone implementation with the opening of the Virginia Tech Drone Park. As the campus pushes to be more innovative and sustainable, drone technology must be used outside of the cage. There are four main initiatives that our project is looking at that directly connect to the Virginia Tech campus.

The *Virginia Tech Policy 5820 on the Operation of Unmanned Aircraft Systems* helps students, faculty, and researchers understand the necessary process to use drones both on campus and at the drone park (Foust, 2019). It also covers the requirements necessary to operate drones along with the risks and responsibilities. If a drone policing drone network is going to succeed, officers would have to be able to fly outside of the drone park without the tedious task of getting

constant waivers. There is a very good possibility that with the implementation of a drone police program, waivers could be placed in effect for an extended period of time. Police operators would be granted use of drones as long as they follow strict adherence to the *FAA 107* policy on drone operations (Tarter, Pasquarell, Williams, & Zario, 2020). It is interesting to note that the *5820* policy does not contain an authority of use (Foust, 2019). In addition, since it is an intuitive, not a law, the punishment for breaking the initiative is little more than the confiscation of equipment or a warning of misconduct. This could eventually be a problem if drones take a more active role on the Virginia Tech campus.

The *Virginia tech Fall 2020 Covid-19 Operational Plan* was enacted last semester and over the summer, and discussed a plan to deal with the COVID-19 pandemic over the fall 2020 semester. Included in this plan was the implementation of social distancing practices and monitoring, as well as Covid safe personal protective equipment. The fall semester of 2020 required new operations to, "optimize safety, education, and operations for the university community" (Virginia Tech, 2020). As this program would bring drones that can be used to aid officers with monitoring and observing social distancing practices, this policy is directly related to the program. When discussed with Virginia Tech police officers, they noted that it wasn't their primary goal to press for masks, but moreover found that speaking to students one on one was more effective at addressing the issues. The officers also directly noted that "What policy states is what's enforced" (Tarter, Pasquarell, Williams, & Zario, 2020). This could be accomplished easier with an eye in the sky provided by drone monitoring. When the officers see a violation of these practices, they could send a drone out to tell the students to adhere to the regulations. In discussion with the Virginia Tech officers they stated that an important use of drones was to monitor large crowds as well as maintain the safety of the Virginia Tech community.

The next document that was directly correlated to campus police, as well as drone implementation, was the *2019 Jeanne Clery Act Report*. This document is the annual report that discusses all the campus security as well as fire safety for all Virginia Tech campuses. The Virginia Tech police department is tasked to maintain the safety of thousands of Virginia Tech students, faculty, and staff 24 hours a day 7 days a week on 3 distinct and large campuses. In the plan, it states that "The university meets the global demands of the future, the Blacksburg campus is constantly adapting to fulfill learning and research needs" (Virginia Polytechnic Institute and State University, 2020). Currently, the Virginia Tech police department has two trained FAA 107 drone operators and 3 DJI drones. These drones are currently being used to "look at large crowds from at a distance, look into traffic crashes, and to look into big events on campus such as protests." the officers explained**.** (Tarter, Pasquarell, Williams, & Zario, 2020) The officers we talked to were enthusiastic about using more drones in the future. They also mentioned that there will have to be a few different models of drone to meet specific needs. For example, we discussed a 3 inch drone with guarders to be used possibly in the dormitories and buildings while a larger more robust drone would be used in outdoor areas.

The last document related to establishing a drone program on the Virginia Tech campus was the *Virginia Tech Sustainability 2019-2020 Annual Report*. Virginia Tech seeks to be a

leader in national sustainability and wants to enact a multitude of programs to reduce Greenhouse Gas Emissions (GGE), reduce transportation emissions, and to engage faculty and staff in researching and enacting cleaner practices. Specifically, the very first point in the report states that "Virginia Tech will be a leader in campus sustainability" (Virginia Tech, 2019). This is correlated and significant to our project because with drones, comes the inherent use of cleaner and more sustainable energy management. Point three of the sustainability report addresses the reduction of Campus GHG Emissions. The report states: "Virginia Tech will establish a target for reduction of campus GHG emissions to 80% below 1990 emission level of 188,000 tons by 2050. Interim targets from 2006 emissions of 316,000 tons will be: for 2012, 295,000 tons (on path to 2025 target); for 2025, 255,000 tons (2000 emission level); and for 2050, 38,000 tons (80% below 1990 emission level)" (Virginia Tech, 2019). As an alternative to using the standard cars which have a high carbon footprint, we suggest that we implement drones to accomplish the same tasks and possibly go beyond the tasks being completed currently. Point ten of the report deals with engaging students, faculty, and staff with sustainable practices. Noting: "Virginia Tech will engage students, faculty, and staff through education and involvement to develop and implement innovative strategies for efficient and sustainable use of energy, water, and materials in all university-owned facilities" (Virginia Tech, 2019). A major goal for our project is that we want to incorporate a module to inform students', faculty, and staff about the Virginia Tech policies and regulations, in addition to the sustainable practices that drones can be used to accomplish.

Case Study Analysis

An outline of successful implementations of drone technology for COVID-19 management and/or increased public safety through local police departments is shown below:

China

China, as the first country to face the COVID-19 virus, has been able to make great use of drone technology to counter the outbreak. On top of this, China is home to MicroMultiCopter, a leading drone manufacturing company. Since the Coronavirus outbreak, MicroMultiCopter has deployed over 100 drones around several major cities in China. They have been able to successfully survey and observe crowds and areas (Chamola et al. 2020, 15). These drones have been useful in preventing viral infection by alerting and alarming people if their distance is less than the required amount or if they are walking around in areas without a mask. Similar practices are occurring in Spain and Kuwait (Kumar et al 2020, 2). Similar drones were also found to be used by Chinese authorities at highway checkpoints since February, when the COVID outbreak was spreading domestically (Lu 2020, 11). Some of these drones were equipped with infrared technology and used in residential areas. These drones allowed for large-scale temperature measurements (Chamola et al. 2020, 17).

India

Many states in India including Delhi, Kerala, and Assam are using drones to make announcements during their surveillance. In these states, the government has given police officials special permissions to use this technology to monitor, medicate, sanitize, analyze data, and pave the way for future decisions to be made. Maharashtra is one of the more progressive states, as it is generating data reports on drone covered areas (Kumar et al 2020, 3). Cyient, a global technology solutions company, has provided police in Telangana with advanced unmanned aerial spectrum monitoring technology for monitoring the COVID-19 virus (Chamola et al. 2020, 16). Each of the drones are equipped with a camera along with artificial intelligence that can spot people between a 150m to 1km range. If the drone detects humans that are not adhering to the distance requirements set, it will alert the police forces (Lu 2020, 10). Thousands of drones have been deployed all over India for these purposes, and data shows that there is a very high success rate of these drone systems and networks.

Spain

Spain is the first country in Europe to implement drone technology into pandemic management practices. Recently, the Spanish military had adopted drone technology into Agriculture management, using systems from DJI, a leading Chinese drone manufacturer. These drones have been used to spray insecticides over public spaces. According to DJI, their drones have a 16 liter load capacity, and are capable of disinfecting approximately one tenth of a kilometer in one hour (Chamola et al 2020, 18). In Madrid, police authorities are using equipping their drones with a loudspeaker, to inform its community of the most recent guidelines that have been put in place due to the state of emergency (Chamola et al 2020, 16).

Australia

The Australian Department of Defense is exploring the use of drone-based COVID-19 health monitoring platforms (Kumar et al. 2020, 1). The State police in Western Australia plan to use drones to enforce social distancing in public areas like recreational parks, public transports, and beaches (Gupta et al 2020, 3). A drone adaption being used in Australia is the addition of sensors in the drones body that can determine a person's temperature, respiratory rate, and pulse. This network of monitoring and medication has proven to be very effective (Kumar et al 2020, 2).

Some other important and interesting cases to note include a trial in North Dakota that was able to convict a man from evidence that had been obtained from a drone (Sexton 2016). In Mesa County, the Sheriff's Office has been using drone technology for several years. They credit their success to their Mesa County Safety Fair. At this annual fair, the UAV team showcases the technology and gives the members of the community an opportunity to see them, understand them, and ask questions about them (Valdovinos et al 2020, 47).

While there are many success stories on utilizing drone technology in government and police forces, there are many times where an attempt at implementing a drone system failed. In many different states and federal agencies including locations in New Jersey, Pennsylvania, and Delaware, there is a struggle to adopt drone practices as legislation prevents their use without first obtaining a warrant. The process of obtaining a warrant is so long and complex, many agencies opt to avoid the integration all together (Sexton 2016).

The U.S. Department of Homeland Security also tried to fund drone technology for increased public safety. They funded the purchase of two unmanned aerial systems for the Seattle Police Department. Unfortunately, public outcry occurred almost immediately after the drones were purchased. This overwhelming concern by citizens of lost privacy and worries of being spied on led the mayor to completely disband and cancel the program. In this case, the drones never even got to fly at all. After this massive failure, the drones were relocated and the department began funding the San Jose Police Department in developing an implementation program. A similar outcry occured in San Jose following the reallocation of funds, this time coming from newspaper articles and media outlets calling for the drones to be returned. The public was again heard, and the drone plan was demolished (Valdovinos et al 2020, 17).

In the United Kingdom, the Derbyshire police forces uploaded a video onto social media showing people exercising at Peak District as a public service announcement to wear masks and be socially distant. This video was taken via drone footage, and the public criticized the police force for sharing the video on the media platforms (Lu 2020, 11).

Evidence from these case studies presented shows that two major sources of failure with regards to a drone safety program are legal blockages and public opinion. This suggests that the focus of a team working to implement drone technology onto Virginia Tech campus must pay careful attention to the concerns of the campus community and lay out and plan a legal framework to adopt drone technology use.

Cost-Benefit Assessment

Based of off research done in the case studies section above, the following challenges to a campus drone implementation program have been determined as follows;

1. Lack of Clear Government Policies
2. Low drone operational reliability and technological restraints
3. Community understanding and approval

A cost-benefit analysis for a program like the one we propose is difficult to analyze as every individual has their own personal views on privacy and safety and the balance between the two. Chris Sexton, professor of law and public policy at Rutgers University sums this up perfectly, commenting in his article on Drone Use by Law Enforcement that “the interesting thing about the equilibrium between privacy and security is that both interests are quite difficult to put a value on.” (Sexton 2016) This is where getting feedback from the impacted community becomes essential. Careful integration of drone technology, including a slow assimilation of the

drone into the community and transparency through every step of the process, will increase community support for drone technology. It is important to express to individuals that the drone is not meant to work on a specific individual. The drone will not pinpoint a person and hover over them, track them, or analyze their data through identifying who they are. The system would work on a much more broad basis that allows for anonymization (White 2020, 31). A drone-based localization system, or one that would determine distances between multiple people, would circulate an area of interest and calculate position. Then the drone would gather a range of measurements to calculate each person's position and report the data to a monitoring station (Kaniewski and Kraszewski 2018, 46).

The understanding by citizens of this system would greatly reduce this obstacle in the effort to develop a drone safety program. Some outreach suggestions that are recommended to improve the dialogue with the community includes; outreach as early and often as possible, create situations and opportunities that will give input from the stakeholders, explain policies and guidelines that will protect people's privacy and safety, put an emphasis on the benefits drone technology will bring, and develop and maintain complete transparency throughout the program, "Assuring the community that your department will be 100% accountable for any and all use of the drones and the data it collects is the first step in the process of obtaining community consensus" (Valdovinos et al 2020, 47). Stakeholders to note include the media, "community policing advocates recommend police partnerships with the media as a beneficial strategy for helping to raise public awareness and encourage participation in community-based projects" (Valdovinos et al 2020, 63), nonprofit organizations, lawmakers, community members, community groups, police officers, and the government.

Legal regulations are also an unclear obstacle when it comes to implementing a drone program. The Federal Aviation Administration has guidelines one must follow when flying drones, along with state and local drone policy. Virginia Tech also has a drone policy in place, however, it is not often communicated towards students and there is no clear definition of who is in charge of upholding the rules. The balance between what a drone can do legally and what it should do is also difficult to decide. For example, "If you said to people, 'You've been told to isolate, therefore if you're seen out and about we've got drones patrolling the parks etc and you're going to get a heavy fine', obviously that would work technically, but politically it would be a disaster" (White 2020, 33). There must be a clear definition of what a drone can and cannot do in certain situations and locations.

In this era, where technology is able to overcome physical boundaries, there is no distinct line between public and private information. Drones are unique because they hover, and therefore wouldn't be constituted as trespassing (Sexton 2016). Lawmakers who are in favor of a drone implementation may argue that by deploying more drones for pandemic monitoring and surveillance a significant amount of money would be saved, as well as human lives. Lawmakers that may be against the use of drones for coronavirus management would argue that because the drones can record, watch, and send data, they are an unnecessary breach of privacy.

Along with social implications for drone use, there are financial costs associated with kickstarting a system like the one we propose. First, any officer or person involved in drone operations, in any way, must undergo a certain amount of training and acquire a certification. Training typically takes around 30-40 hours for a certificate to fly an unmanned aerial system and can cost up to $3500 (Valdovinos et al 2020, 62). There are also costs involved with keeping up with FAA regulations. On top of training costs, maintenance costs are fairly high, considering the drones would need to be deployed in large numbers. Operating costs are also a consideration.

Community Support

Due to the unpredictable successes and failures of drone surveillance programs worldwide, we find there is a need to ensure community backing of a similar program *before* implementation (see Case Study Analysis above). To this end, we have designed a survey and have started designing a CANVAS module. The purpose of this survey is to understand how the Virginia Tech student population, the community that is most affected by our project, feels regarding the use of drones for surveillance. Using the search string, "(survey OR questionnaire) AND (police OR policing OR enforce) AND (drone* OR UAV OR "unmanned aerial vehicle")," prior research notes that communities often fear drones due to certain innate characteristics of drone use. For example, one survey conducted by Zwickle et al. (2019) found that safety and privacy were the main concerns associated with drone use. This article informed many of the questions we created for our survey as well (Zwickle et al., 2019). The answers from our survey would more accurately represent the concerns of the VT student population, but as we are constrained for time, we will assume that VT students had similar answers to the population in this article (Zwickle et al., 2019). From our data, we will work to design an informative CANVAS module that teaches students how drones can (and can't) be used and provides useful links for students interested in flying drones.

To obtain the most representative sample population, we would use a simple random sample of students via the Virginia Tech email system, selecting individuals at random from a list of current Virginia Tech students. As access to this list may be limited, we can also post flyers around campus with a QR code to our survey to gather results. If we choose to expand this survey into the Blacksburg population, we can post flyers in neighborhoods chosen randomly within the town. One limitation of these acquisition methods is that older individuals may be less able to participate, resulting in an age bias.

To begin designing our CANVAS module, we looked to Virginia Tech's existing online modules like AlcoholEdu. These modules had a general outline: they provide concise information about an existing policy and/or give students advice about the correct action in a situation before quizzing them to ensure they retain the information (*AlcoholEdu, Diversity, Equity and Inclusion, and Sexual Assault Prevention*, n.d.). In the case of the drone module, we can do much the same by presenting policies and limitations regarding drone use and asking questions about our information. Policies that we can teach include *FAA UAS Rule 107*, which

guides the licensing of new drone pilots, and *Virginia Tech Policy 5820 on the Operation of Unmanned Aircraft Systems*, which sets the rules for flying drones on campus. There are also "common sense" rules that we can reinforce, such as telling students not to fly drones in dorm hallways or at eye level.

When considering whether our module is applicable to other universities or communities, one should note that our module will contain a multitude of information specific to Virginia Tech's students and policies. The purpose of collecting student opinion is to integrate their responses into our module: we are trying to address the parts of drone surveillance that most worry the population. While there will be many similarities between the scenario at Virginia Tech and those elsewhere, communities looking to use our program themselves should adapt our version using community input as well.

From our interview with VT Police officers, we learned that they heavily supported the idea of an informative module for VT students. They emphasized that students that crossed drone-related conduct boundaries often didn't know a boundary even existed. If a system were in place to require VT students to learn about Virginia Tech's UAS policy before flying, the officers felt that ignorance (and therefore misconduct) would be greatly reduced. They even offered to have the chief of police make a short video addressing students that would participate in our module (Tarter, Pasquarell, Williams, & Zario, 2020).

Program Implementation and Evaluation

The steps towards a final program implementation include (Appendix E):

1. Background research
    a. Research and select a drone system that has the requirements necessary for policing
        i. Analyze all benefits and challenges
    b. Research related legal policies
        i. Work with Virginia Tech campus policy
        ii. Lay out legislation to protect privacy and other rights
        iii. Determine data collection methods and storing capabilities
        iv. Highlight potential problems and obstacles
        v. Understand the Federal Aviation Administration Regulations (FAA)
2. Needs assessment
    a. Determine if campus is ready
        i. Get input from community and stakeholders
        ii. Build a relationship through dialogue with community members
        iii. Communicate policies and regulations to public
        iv. Cost-benefit research to find need
3. Preparing and Planning
    a. Develop operating plan

        i. When will drones be used?
        ii. How to enforce procedures?
        iii. What measures will be taken to ensure protection of rights?
        iv. When will a warrant be needed?
        v. Procedure guidelines for warrantless operations?
    b. Create formal policies
    c. Assemble a team to enforce and use drones
        i. Begin training
        ii. Team members suggested; Supervisor, commanding pilot, observer, video sensor operator
    d. Present the plans to community and media
        i. Transparency and engagement
4. Implementation and Maintenance
    a. Keep up with training
    b. Provide updates continually
    c. Outreach early and often
    d. Evaluate impacts of program continually
    e. Maintain communication

The research done and proposed plans developed in this essay are meant to be preliminary research for a complete drone implementation to be proposed for the Virginia Tech campus. Much of the research presented is specific to the Virginia Tech campus and Blacksburg area. For a community looking to implement a similar program, it is suggested research be done on the policies that would impact a drone implementation program including the current community, state, and federal guidelines.

Conclusion

"Cameras on every corner, Google, Facebook, cell phones: the data-mining regime is well entrenched, for good or ill, and a few aerial shots from drones, the thinking goes, are not going to change much." (Sexton 2016) A successful integration of drones is predicted so long as the law enforcement implementing the technology is able to balance the benefits of using UAVs with preservation of safety, privacy, and security. Making certain that the community is involved in and understands and trusts law enforcement drones is a continual process. Good communication of policies and regulations while protecting safety and privacy to ensure accountability is imperative.

Appendix A - Police Interview Transcript

The following is a written overview of an interview conducted with the Virginia Tech Police Department on Friday, November 13th (Tarter, Pasquarell, Williams, & Zario, 2020).

What are current steps being taken by VT police to encourage social distancing on campus?

Guilliams: Fun ways to encourage, big orange signs saying 6 feet apart and officers are placing them between people. Programming ideas online, zoom, etc. In person guidelines, taking temperatures, masks, distancing.

Pasquell: Not responsibility to take action. During move in and on some occasions. Speaking to students and one on one. Enforcing guidelines and rules. Work closely with RA's to assist in conduct referrals. Issues with large crowds, hostile, substance abuse calls. Went on rounds with RA's. Trying to educate on COVID. Blacksburg passed an ordinance to remove campus from the Blacksburg law on COVID-19 pandemic. Presentations for international students, LLC's, using COVID part of the presentation.

What technology has VT police utilized in enforcing VT COVID guidelines?

Guilliams: Temperature sensors/readers, signs, not too much technology

Pasquell: K95 masks used for officers, clear visors, PPE equipment. Mobile command unit - truck that has satellite connection and media room with ventilation for interior vehicle. Run by generator. Radios tuned to local dispatches. Mobile unit for flu vaccinations. Radio show 3:30-5:30 pm. Discussing COVID19 in the radio show, people all over the world listen to them. Looking into police vehicles that self clean, consulted with the health department/Mccomas to be more clean for COVID, have not purchased. Internet to keep up and aware with COVID guidelines. Housing residence life and Schiffert work closely with.

How (if at all) does VT Police use drone technology today?

Guilliams: In infancy part of drone program. Legislation out there. DJI came out in summer and talked to everyone about drones. Hardware could be used to spy from China. Looking at using drones for large crowds at distance, cannot fly over people. Traffic crashes and big event logistics use (ex: protest). Not a lot of interface between COVID and drone technology.

What were some challenges VT Police faced or faces regarding the implementation of drone technology in law enforcement?

Guilliams: Biggest challenge is getting officers interested in drone technology and certification (2 officers are certified and trained currently). Waivers to fly are difficult, some departments in the New River Valley area without this, problems with liability. FAA waivers difficult to get, big obstacles facing. How to run the drones and use them for a period of time. Long period waivers.

Zario: Law enforcement is push back, community belief. Emergency management perspective: disaster assessments and damage, pedestrian flow in and out affected areas, less

restrictions for police. Police need to file a request to fly. Pilots surrounding the area are flying (not sure if they have waivers or not). In interest of public safety: allowed to do a little more. Emergency management has 2 drones and 2 pilots and are learning to do this. Lane Stadium restrictions and Airport restrictions prevent police usage (Chicken Hill lot can't fly because of the airport nearby). Time needed to get out and navigate obstacles before we have to use them.

How are VT police enforcing the Virginia Tech drone policy?

Haven't really had this drone technology issue. Numerous drones found on rooftops. Chair of the UAS oversight committee is the AVP of emergency management. They review the flight requests for use on campus. Submit requests to them and go through UAS OC. Voted on by members of this committee. Can police officers enforce the policy? It is not a law…? Can give a CR and that is about it. Enforcement is lacking.

What sustainability practices do VT Police follow when enforcing?

Tarter: Cameras are being used to patrol.

How do you see drone technology playing a part in future VT Police green practices?

Tarter: Drones to patrol the area before a situation escalates.

Zario: Person fell off of huckleberry trail on bike, police took a while to manage this, drone would have been faster.

Tarter: Drone to see situations sent to the security center (like pocket dialing).

Zario: Greener, but costlier(?) at least in upfront costs. Weather, laws, etc. Will be the future, upfront costs are a big issue.

Other Important Comments from the Officers

Chula Vista police department got buy-in from the community. Worked really well for the police department. Using drones a LOT. Yorktown and Poquoson department utilizing drones. Reach out to the Arsenal (have jammers).

Police are looking for more information on drones without any of the programming that coding prevents PD from utilizing these drones. Would love to work with us on this. Because a lock out would defeat the purpose of everything.

Very positive feedback on drone module idea for canvas page. Can foresee the deputy chief doing a quick video interview for a module talking about drone technology. Module would help people be more informed about the Virginia Tech drone policy. Give people knowledge (VERY enthusiastic of this).

Information on WING and its operations with regard to laws and regulations. Regulation from government to civilian sector and hoops to jump through to achieve is difficult. Blacksburg did not want WING, they went to Christiansburg. Afraid of commercialization.

Initial policy for drones here at VT were for helping people walk on campus at night (emergency management). A lot of policies to incorporate. Financial aspect of which department would pay for it.

Design aspect for drone features:
Spotlight, loudspeaker/speaker, camera, better battery/longer (critical), camera, night vision camera, infrared.
On scale you can run down the hallway of Prichard. Lane Stadium, Burress, the drillfield to start(more critical areas are these). FPV would be most popular with better battery life. Transmitting video feed from aircraft to the emergency center. Travelling across the campus to the TV.
(They have Mavok and Inspire 2)

Speaking to local government and local news about this.

Module is KEY. VERY interested in helping with this. Chief and MAAP and Drone park(Sarah) explaining policy.

Appendix B - Survey Questions

This section lists the questions asked within our survey (https://www.surveymonkey.com/r/MWTNLMK). The survey was designed to be anonymous. The format of this section is as follows: Questions are listed in a numbered list with answer choices and a brief reasoning for the question underneath.

1. What is your level of familiarity with drone technology?
    a. Have used drones multiple times/Very knowledgeable - Never used one before/Not very knowledgeable
    b. This question lets us differentiate the rest of the survey based on experience with drone use. Less experienced individuals may have different concerns than those who fly drones regularly
2. What is your opinion of current surveillance methods (primarily CCTV cameras) used throughout public spaces?
    a. Opposed - In Favor
    b. As drones would be used for a similar purpose, understanding how our sample feels about existing surveillance methods gives us a starting point for community support
3. Where do you stand on the use of drones to monitor public spaces?
    a. Opposed - In Favor
    b. We can compare the answers to this question to question two to gauge the support behind drone surveillance specifically.
4. Are you concerned about potential invasions of privacy that accompany law enforcement drone surveillance?
    a. Very concerned - Not at all concerned
    b. Again, comparing this question to question three gives us community support of law enforcement.
5. Do you feel that the added security behind drone surveillance is worth potential invasions of privacy?
    a. Very much worth it - Not at all worth it
    b. This directly addresses the juxtaposition presented in the article by Zwickle et al. where security and privacy are the post prevalent concerns regarding drone use (2019).
6. Please list any additional concerns you may have regarding drone technology and surveillance.
    a. Text entry
    b. This is a space for individuals to list other concerns they may have.

Appendix C - CANVAS Module Outline

This section includes a general outline for our CANVAS module. The module serves two main purposes: Educating participants about the restrictions behind drone use on campus and showing them where they can look if they are interested in flying drones themselves.

1. The Introduction section presents potential use cases for drones and generates interest in flying drones. Potentially, multiple different models of drones are also introduced
2. In this section, key points from *Virginia Tech Policy 5820 on the Operation of Unmanned Aircraft Systems* will be presented. After a certain set of information, there will be a small (5 question) quiz to make sure participants have retained the information.
3. In the next section, *FAA UAS Rule 107* is introduced
4. This section will include a video by the chief of VTPolice. The chief will speak directly to the participants to show that VTPolice will respond to infractions of *Virginia Tech Policy 5820 on the Operation of Unmanned Aircraft Systems*.
5. The final section presents useful links, such as the website where students can apply for their drone pilot licenses or where limitations to drone flight are found. These links can also be emailed separately to participants if they choose.

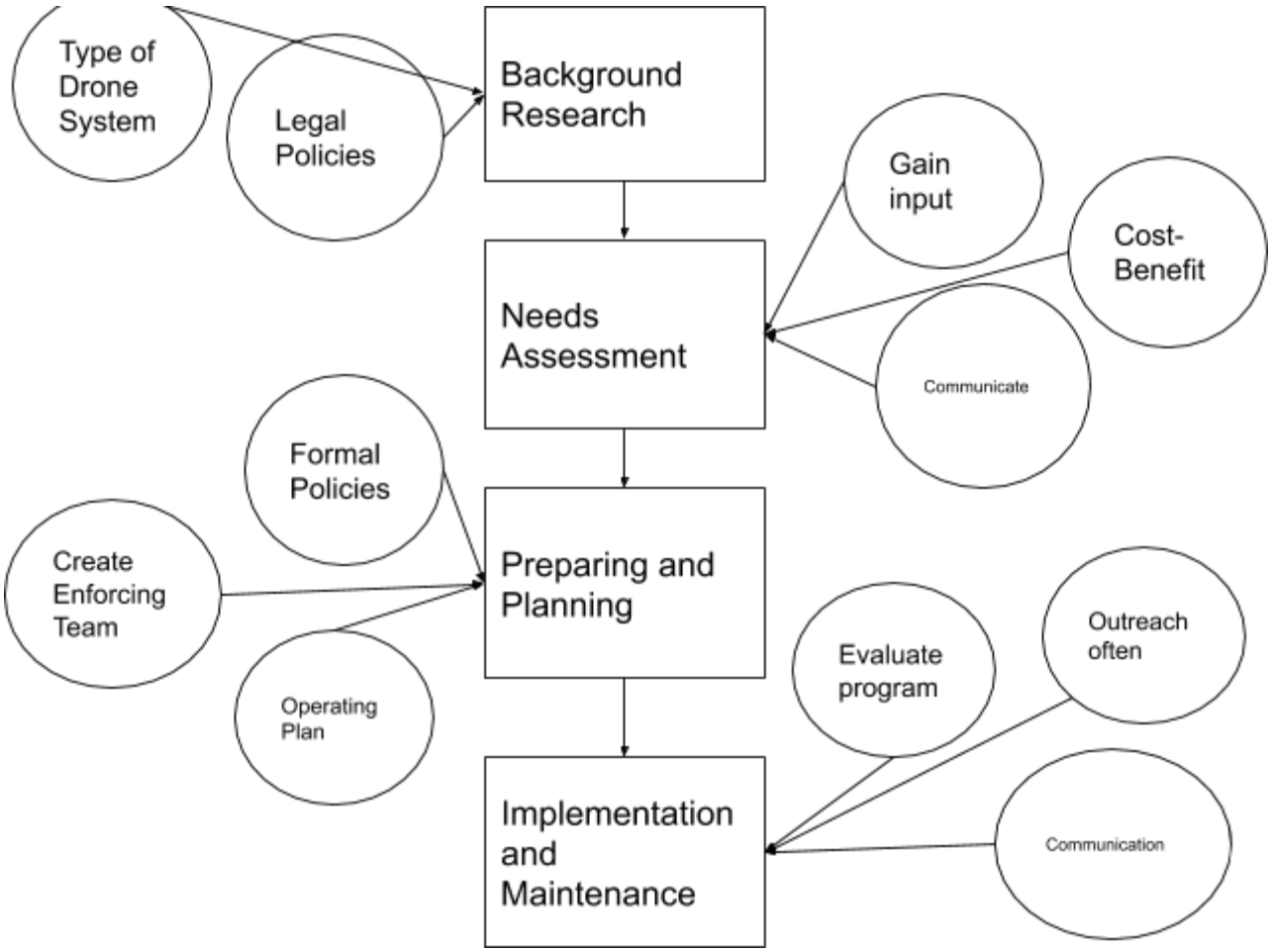
Appendix D - Individual Contributions

Madeline Hower - Worked on research and writing for introduction, case study analysis, cost-benefit analysis, program implementation and evaluation, conclusion, and Appendix A

Cason Kerrick - Worked on research and writing for introduction, UAS terms and technology, review of current Virginia Tech policies, Appendix A and Appendix F

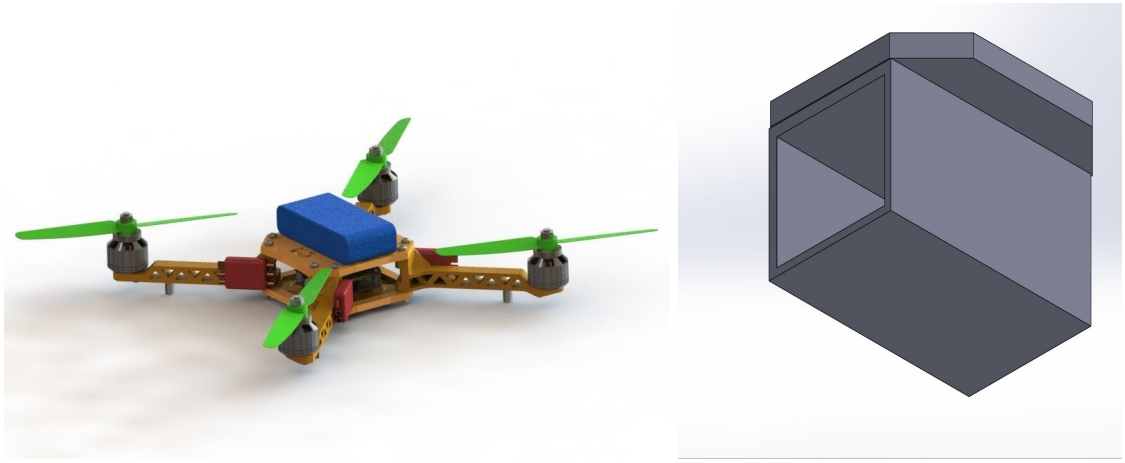
Sunny Makwana - Worked on research, development, and writing for introduction, community support, Appendix A, Appendix B, and Appendix C

Appendix E - Flowchart



Appendix F - Computer Aided Design model of Drone

Concept 1: (Ezekiel, 2020)



This was the original concept for a drone that we looked at when we first proposed this project. It contains all the major components rendered in Solidworks CAD software. We envisioned that the frame would be made out of a tough PLA material so that it would be easily manufactured and customizable. The blue component is supposed to represent the battery which would be a lithium ion battery of the 6s type. The red components are the ESC's used to control the battery. Our original idea did not include a camera but as we went through the brainstorming process we decided a camera was a necessity. Attached to the frame would be a modular secondary component that would be used for housing the extra components (microphone, speaker, display,esc) as necessary.

Concept 2:(Teshome, 2020)

This second concept is more like what our prototype drone could look like. It is a 5 inch frame composed of carbon fiber with 5 inch air ducts surrounding the propellers. The ducts help promote thrust while also aiding in safety. Further, the ducts prevent the propellers from getting caught in an obstacle and provide some leeway in the event of a minor collision. The camera is enclosed in the front of the drone providing the operator with visibility directly in front of the quadcopter. Protruding out of the back are the receivers which are necessary to promote good video quality as well as reception for the receiver. On the top of the frame would be the lipo battery. It is on the top because they can be explosive if faced under a large load of pressure or in the event of puncture. It is less likely that this would happen with the battery on top. Under the quadcopter would be a rail system which would allow users to attach components directly to the center region of the frame. Thes components would directly conform to the mission requirements and could include cameras, microphones, speakers, spotlights or whatever is needed.

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