Effective Usage of Unmanned Aerial Vehicle Technology in Emergency Operations in Canada

by

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COMMITTEE APPROVAL

The members of Mukesh Chand's Thesis Committee certify that they have read the thesis titled *Effective Usage of Unmanned Aerial Vehicle Technology in Emergency Operations in Canada* and recommend that it be accepted as fulfilling the thesis requirements for the Degree of Master of Arts in Disaster and Emergency Management:

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Abstract

The use of Unmanned Aerial Vehicle (UAV) technology is increasing globally and if applied in the field of Public Safety (PS), could prove useful in providing solutions to challenges in emergency operations. The purpose of this research is to identify and analyze the underpinning regulatory framework that impacts effective usage of UAV technology in the PS domain. The research includes a study of governance arrangements including current Canadian Aviation Regulations, Emergency Management Act, Canadian Criminal Code and their underpinning legislation and policies in order to assess and interpret their impacts on the use of UAVs in PS agencies. It is informed by experiences and lessons learnt by these agencies.

The knowledge gained can be extended to PS agencies who are contemplating the use of UAV technology in their services in order to reduce risk. UAV is of great interest as one of the disruptive technologies that is revolutionizing the way emergency operations are carried out and with this hope that useful solutions or recommendations can be made.

Keywords: Emergency Management, disruptive technology, drone, Technology Acceptance Model, Public Safety, response, unmanned aerial vehicle

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List of Acronyms

BVLOS	Beyond Visual line of sight
CAR	Canadian Aviation Regulations
CCC	Criminal Code of Canada
DND	Department of Defence
EM	Emergency Management
OD	Origin-Destination
PS	Public Safety
ROA	Remotely Operated Aircraft
RC- Helicopter	Remote Controlled Helicopter
RCMP	Royal Canadian Mounted Police
RPV	Remotely Piloted Vehicle
RRU	Royal Roads University
TAM	Technology Acceptance Model
TC	Transport Canada
SAR	Search and Rescue
UAS	Unmanned Aircraft Systems
UAV	Unmanned Aerial Vehicle
UVS	Unmanned Vehicle System
VLOS	Visual-line-of-sight

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Acknowledgements

Determination, perseverance, innovation together with forward thinking are of essence in responding to PS and in this day and age; we rely a lot on technological advancements. My purpose for this research came from the idea of enhancing public safety through the use of technological advancement. I have been fortunate to work in the public safety discipline where timely response is of essence in saving lives and safety of general public. I hope this project highlights the challenges that can be overcome and opportunities that can be leveraged through the use of UAV technology in public safety and emergency operations.

I am expressing my special appreciation and thanks to my academic supervisor, Peter Anderson, for his unwavering patience, support and wisdom in mentoring me. His advice, consistent encouragement, extensive experience and genius ideas were absolutely priceless in this process. Also I am very grateful to my thesis committee member Dr. Mark Seemann for his support, academic direction and genuine help in getting me through this endeavour.

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Dedication

This paper is dedicated to all individuals using UAV technology and who are involved with the public safety and emergency management discipline and are translating the vision of the technological advancement into reality. Without their hard work and dedication, this vision would be nothing more than just simple ideas or the thought process. Hopefully through effective UAV technology usage in emergency operations, it can make a difference in saving or losing lives.

Topic

Effective Usage of Unmanned Aerial Vehicle Technology in Emergency Operations in Canada.

Chapter 1: Introduction

Unmanned Aerial Vehicles (UAVs) are vehicles flown by unmanned aircraft systems which includes the aircraft and all the equipment required to control it. UAVs are a component of an aircraft which include a flying unit, a ground-based controller, and a system of communications between the two. "UAVs come in all sizes: Some fit in the palm of a hand, while others are as large as full size aircraft. There are two main types of UAV: fixed wing, which resemble airplanes and need runaways, and vertical takeoff and landing, which can hover." (Steen, 2014, p.18). Eisenbeiss (2004) defined UAV which covers all vehicles, which are flying in the air with no person onboard with aircraft controlling capability on the ground. Other terms or names used for UAV are drones, Remotely Piloted Vehicle (RPV), Remotely Operated Aircraft (ROA), Remote Controlled Helicopter (RC- Helicopter), and Unmanned Vehicle Systems (UVS) and model helicopters. The flight of UAVs may operate with various degrees of autonomy, either under remote control by a human operator or by computers.

The use of UAVs is rapidly increasing globally (Nebiker, Annen, Scherrer, & Oesch, 2008) and, if applied in the field of Public Safety (PS) and Emergency Management (EM) could prove to be useful in providing solutions to relevant challenges in public safety discipline. Public Safety Canada, the federal government department, is responsible for helping Canadians and their communities protect themselves from emergencies and disasters related to all kinds of hazards including natural, human-induced and technological. It is through national leadership in the development and implementation of policies, plans and a range of programs and the Emergency Management Act that mandates the roles all stakeholders must play in Canada's emergency management system (Public Safety Canada, 2017). While EM Act is a national legislation, I have also incorporated a provincial jurisdiction thus BC was chosen because it is

my province of residence. Emergency Management BC is the Province's lead coordinating agency for all emergency management activities, including planning, training, testing and exercising, to help strengthen provincial preparedness. This work is done in collaboration with local governments, First Nations, federal departments, industry, non-government organizations and volunteers. All the activities associated with disaster are covered in emergency management and for the purposes of this research, disaster associated activities in terms of prevention/mitigation, preparedness, response and recovery are included in emergency management operations. The major distinction between the federal and provincial government jurisdiction in emergency management is that federal government is largely policy centred while the province has the greater operational mandate for engagement.

Coifman, McCord, Mishalani, & Redmill (2004) state that UAVs could potentially result in a cost-effective approach and a rapid response for a wide array of applications in EM, including incident response, coordination amongst a network of first responders, emergency vehicle guidance, and search and rescue operations. UAV has been integrated or implemented in the PS agencies such as police and fire rescue services and to study the effectiveness of such technological implementations. “At least 160 police and fire departments acquired drones in 2016, more than in the past three years combine. Police and fire departments in the U.S. are buying more drones than ever before.” (Glaser, 2017, para. 1).

UAVs are used in a variety of disciplines ranging from aerial photography, shipping and delivery, safety inspections for buildings, crop monitoring, storm tracking, forecasting hurricanes, tornadoes including EM and PS. In 2005, Hurricane Katrina caused widespread devastation on the Mississippi Gulf Coast. Documentation of infrastructure response to such an

event is an important objective in disaster operations and as well as in research but the task can be hazardous. Collecting detailed information of an affected area while keeping costs down is challenging (Adams & Friedland, 2011). Especially for large scale disaster events, such as hurricanes, access and provisions may not be available to survey teams for a very large geographic area. This makes field data collection even more challenging and difficult. Pratt, Murphy, Stover, & Griffin (2006) explored the utility of UAVs for conducting structural damage inspections of several multi-story commercial buildings damaged by Hurricane Katrina. Using a helicopter UAV equipped with a digital camera capable of both still and video imagery, the study found that UAVs have great potential for post-disaster data collection and assessment although implementation issues such as obstacle avoidance, site access, sensor coverage, and weather conditions were identified. Because of travel limitations caused by floods, dam failure, landslides, and infrastructure damage following 2009 Typhoon Morakot in Taiwan, a helicopter UAV was deployed to collect post disaster imagery to support post-disaster reconnaissance, disaster restoration and reconstruction assessments (Chou, Yeh, Chen, & Chen, 2010).

Another example of UAV use is transportation surveillance and assisting law enforcement. UAVs could be employed for a wide range of transportation operations and planning applications such as incident response, monitor freeway conditions, coordination among a network of traffic signals, traveler information, emergency vehicle guidance, track vehicle movements in an intersection, measurement of typical roadway usage, monitor parking lot utilization, estimate Origin-Destination (OD) flows (Puri,2005). The advantage of UAVs is that they can move at higher speeds than ground or surface vehicles as they are not restricted to traveling on the road network. Unmanned vehicles have advantages over manned vehicles as most of the functions and operations can be implemented at a much lower cost, faster and safer.

UAVs may potentially fly in conditions that are too dangerous for a manned aircraft, such as evacuation conditions, or very bad weather conditions. UAVs are used for transportation surveillance data because it can view a whole set of network of roads at a time and inform the base station of emergency or accidental sites together with the report on severity of disaster damage areas. The base station can then choose the best route and inform the police cars as needed (Puri, 2005).

Purpose of Study

The primary objective of this research study is to explore the underpinning regulatory framework including current legislation, regulations and policies governing the use of UAVs in PS and EM agencies in Canada. It explores policy and legal challenges faced by PS and EM agencies when adopting the UAV technology and how these challenges were overcome. The research study understood the opportunities created by using UAV in the police, fire departments and search and rescue agencies and how these opportunities brought value to emergency operations for these PS agencies. The study explores how policy and regulation guided these initiatives.

UAV commonly known as a drone is an aircraft without a human pilot onboard. During 2017, Transport Canada (TC) carried out various public consultations via online forum “Let’s talk drones”, regulatory engagement sessions and written feedback via email. As of January 2018, TC website posted proposed rules for UAVs in Canada. TC website also shows the current rules and overview of proposed changes when Canada’s new regulations for UAVs becomes law.

UAVs as an emerging technology with greater usage in other disciplines drew my attention and interest to study how the regulatory framework affects the usage of UAVs in PS agencies in Canada.

Theoretical Framework

There has been significant prior research focused on technology acceptance model (TAM). In 1985, Fred Davis suggested the TAM. TAM models how users come to accept and use a technology. UAV is an emerging technology and relates how users accept and use UAV in EM and PS discipline. The advantage of UAVs is that they can move at higher speeds than surface vehicles as they are not restricted to traveling on the road network or facing obstructions. UAVs have advantages over manned vehicles as most of the functions and operations can be implemented at a much lower cost, faster and safer (Puri, 2005).

"TAM examines the mediating role of perceived ease of use and perceived usefulness in their relation between systems characteristics (external variables) and the probability of system use (an indicator of system success)." (Legris, Ingham, and Collerette, 2003, p.191). The model suggests that when users are presented with a new technology, a number of factors influence their decision about how and when they will use it:

• Perceived usefulness (PU) - This was defined by Fred Davis as "the degree to which a person believes that using a particular system would enhance his or her job performance" (Davis, 1989, p.320).

• Perceived ease-of-use (PEOU) - defined this as "the degree to which a person believes that using a particular system would be free from effort." (Davis, 1989, p.320).

TAM is predictive, but its generality does not provide the information necessary to understand acceptance behaviour or guide meaningful intervention identification for the purpose of enhancing adoption (Venkatesh, 2000).

Conceptual Framework

The use of emerging technology such as UAVs is changing how the EM and PS discipline are evolving. UAVs are replacing conventional ways of doing business in these disciplines making it disruptive technology. For example, the long endurance capability of the UAV greatly contributed to its use in the earthquake disaster in Haiti. The Global Hawk UAV flew daily missions from Maryland to Haiti due to insufficient infrastructure near or in Haiti. A typical mission lasted 14 hours and collected up to 700 high-resolution images (Petcoff, 2010). Of greater interest is how policy research can reflect on how governance shapes the opportunities that UAV can generate for these PS agencies.

For this study, policy research is used as a framework to achieve better understanding of effective usage of UAV technology in emergency operations. Effective usage in this study means to depict desired results in achieving public safety. The following concepts were chosen for this framework: UAV Experience, UAV Benefits, UAV Opportunities, UAV Challenges, UAV Best Practices, UAV Current Legislation, and UAV Training, Management and Integration (See Figure 1.1). I have created figure 1.1 to help better understand the key concepts and to depict the link between the concepts and this research study. These concepts and terms were used to examine the existing literature as well as the survey questions and data to answer the research questions.

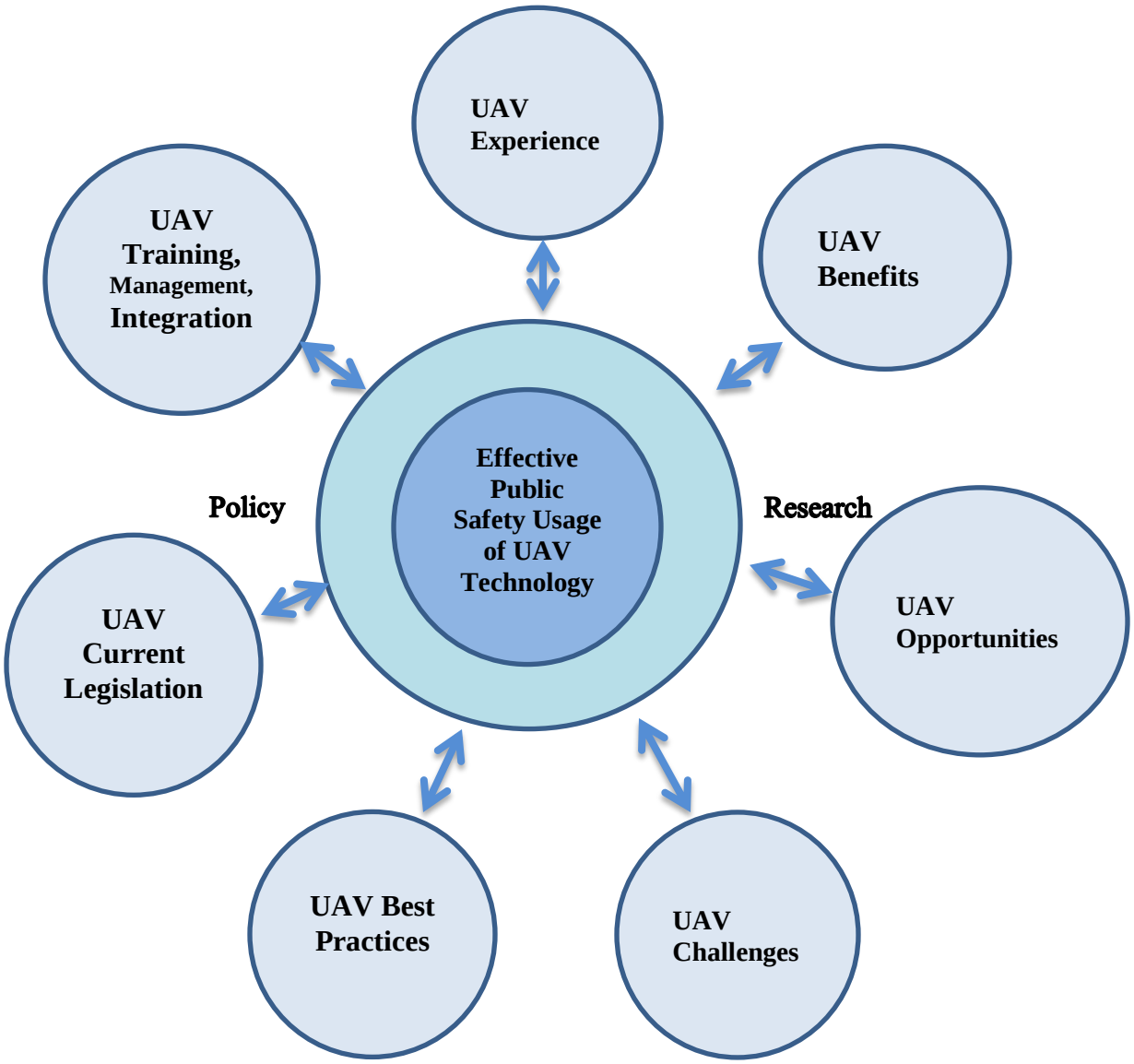

Figure 1.1: Conceptual Framework on the effective usage of UAVs in emergency operations

Significance of Research

There is a clear lack of research on effective public safety usage of UAV technology in EM and PS disciplines that needs to be addressed. Usually gadgets are created and later enhanced or modified as technology gets better and policy research and regulations are normally lagging. During disasters, agencies have a "whatever it takes" attitude (Donahue, 2006, p. 142) because "real events have socially mobilizing effects" (Berlin & Carlstrom, 2008, p. 183). UAVs can lead to a low cost mechanism in achieving a rapid response for a variety of applications in PS agencies such police, fire rescue service, search and rescue operations.

Canadian Aviation Regulations (CARs) and policies affect how UAVs can and cannot be used in Canada which can have serious implications for EM and PS operations. One of the serious considerations is how UAVs are implemented within current settings in regards to aviation safety, public safety, and security and privacy legislation.

This research study includes the analysis of governance arrangements including current CARs and Aeronautics Act, privacy legislation and their underpinning policies in order to assess and interpret their impacts on the use of UAVs for Canadian PS agencies. This research explores and proposes recommendations for increasing efficiency in the use of UAV technology in EM and PS agencies.

Research Questions

Increasing work efficiency and productivity, decreasing workload and production costs, improving accuracy, refining service, customer relations, and resolving security issues are major goals of any business or professional capacity. On this note I have been working in a PS agency for the last ten years and have witnessed technological advancements in a variety of processes

and functions. Keeping this in mind when I undertook the Master of Arts Program, technological advancements always interested me and I combined it in the EM and PS discipline to find solutions to reduce risk.

Adoption of UAV technology leapt from recreational usage to the diverse professional and industrial stage fairly quickly as more and more businesses started to realize its potential, scope and global reach. Technological research is where we use that knowledge and apply it to achieve certain goals because it influences where we go as a society.

The research questions are designed to identify and address the gaps in policy in the usage of UAV technology in PS or EM domain.

Primary question

What are the underpinning governance arrangements that affect the use of UAV Technology in Canadian emergency operations?

Secondary questions

What Canadian legislation and regulations are in existence for UAV technology usage?

How do they both enable and restrict UAV usage by Canadian emergency operations?

What other policy challenges inhibit adoption of UAV technology by emergency operations?

How can these challenges be overcome?

What are the best practices guiding usage of UAV technology?

Organization of Study

This thesis is organized into five chapters.

Chapter 1: Introduction. Chapter one provides the introduction, purpose of study, theoretical and conceptual framework. It further discusses the significance of this research and ends with primary and secondary research questions.

Chapter 2: Literature review. Chapter two provides an overview of relevant literature. The chapter starts with the general use of UAVs and goes into the definition and historical development of UAV. The other categories discussed are UAVs in EM, Search and Rescue, Response and Cost, Environmental, Political, First Responder Safety, Privacy, Safety and finally the role of Policy Research and Regulation.

Chapter 3: Methodology. Chapter three provides a detailed overview of the research methodology, followed by the methodological framework and research design. In research design section, Phase 1 and Phase II together with data sources, data collection methods and analysis methods are included. Later in the chapter, rigor and trustworthiness, role as the researcher with ethical considerations and finally strengths and limitations with expected outcomes are included.

Chapter 4: Research findings and Discussion. Chapter four provides research findings. The research questions are reiterated with findings and discussion which follows from Phase 1 and Phase II of the research. The thematic analysis is done with themes derived from research questions.

Chapter 5: Conclusion and Recommendations. Chapter 5, the final chapter, provides the conclusions and recommendations.

Chapter 2: Literature Review

Chapter Introduction

UAVs, Miniature Pilotless Aircraft or Flying Mini Robots or drones are rapidly growing in popularity. These are just a few names for this flying machine without a human pilot onboard.

Joshi (2017) states that from technically manning sensitive military areas to luring hobbyists throughout the world, UAV technology has developed and prospered in the last few years. Individuals, commercial entities, and governments have come to realize that UAVs have multiple uses, which include:

- Aerial photography for journalism and film
- Express shipping and delivery
- Gathering information or supplying essentials for disaster management
- Thermal sensor drones for search and rescue operations
- Geographic mapping of inaccessible terrain and locations
- Building safety inspections
- Precision crop monitoring
- Unmanned cargo transport
- Law enforcement and border control surveillance
- Storm tracking and forecasting hurricanes and tornadoes

Development of hundreds of more uses of UAVs is underway due to the multiple investments pouring into this promising industry everyday (Joshi, 2017).

Definition and Historical Development of UAV

Eisenbeiss (2004) defined Unmanned Aerial Vehicle (UAV) which covers all vehicles, which are flying in the air with no person onboard with capability on the ground for controlling the aircraft. (1.2 Definition and Historical Development of UAVs in Photogrammetry, para. 1).

The Unmanned Vehicle Systems International Association has, as shown in Table 1-1, classified UAVs as micro, mini, close range, medium range and high altitude long endurance depending on their size, endurance, range and flying altitude. (Eisenbeiss, 2004).

Category Name	Mass [kg]	Range [km]	Flight Altitude [m]
Micro	<5	<10	250
Mini	<25/30/150	<10	150/250/300
Close Range	25-150	10-30	3000
Medium Range	50-250	30-70	3000
High Alt. Long Range	>250	>70	>3000

Table 1.1: UAV Categories defined by UVS International. In the Mini UAV category the numbers depend on the scope of different countries. Adapted from "A mini unmanned aerial vehicle (UAV): system overview and image acquisition," by H Eisenbeiss, 2004, International Archives of Photogrammetry. Remote Sensing and Spatial Information Sciences, 36(5), p.2.

Eisenbeiss (2004) further stated that the development of UAV technology has been strongly motivated by military applications where nations were looking for aerial vehicles, which have the capability for surveillance, reconnaissance and penetration of hostile terrain without the deployment of human beings in areas of high risk. (1.2 Definition and Historical Development of UAVs in Photogrammetry, para. 3).

UAV and Emergency Management

UAVs play an important role from helping to strategize the EM activities from immediate and urgent tactical means to long term strategic deployment. During an emergency situation, the

on-scene activities are of a tactical nature focusing on immediate problem solving, such as fire suppression. Recent earthquakes have also seen UAV deployment for post-disaster imagery collection in Haiti in 2010 (Huber, 2011). After the Haiti earthquake, a private company flew a small UAV to assess orphanage damage in remote mountains near Port-au-Prince (Huber, 2011).

UAVs can assist in all the Disaster and Emergency Management pillars - prevention/mitigation, preparedness, response and recovery (Coppola, 2007; Tierney, Lindell, & Perry, 2001a; Tierney, Lindell, & Perry, 2001b). Pre-incident aerial imagery can be obtained through UAVs. Before an event, these maps can be used to identify high risk areas, a risk assessment can then be conducted and emergency plans can be developed (Claessens, Lewyckyj, Biesemans & Everaerts, 2005). After a significant disaster, the physical structure of an area may change through the alteration of the physical landscape and loss of structures, vegetation and landmarks. Similarly, roads and bridges may be destroyed. As a result of these changes and losses, pre-incident maps may not be an effective tool to plan and manage response and recovery activities. To overcome this limitation, the rapid acquisition of post-disaster mapping will ensure that PS officials have an accurate understanding of the situation on the ground, including the availability of access to the affected areas (Claessens et al., 2005).

During the response phase of a disaster, officials need to quickly establish and maintain their situation awareness of an incident. This situational awareness is established through reports received from the community and agency assets deployed at an incident. Throughout the initial stages of the response, officials operate in a high level of uncertainty and they must try to make sense out of information coming from multiple sources. This information is sometimes incomplete or contradictory; however, the availability of information is critical in directing first

responders to survivors of an incident as quickly and safely as possible. Information has its greatest impact during the initial period following an incident and any delay in obtaining or understanding the information will reduce its value (Rao, Eisenberg, & Schmitt, 2007).

Disasters and their subsequent responses are by their very nature unique social problems (Kreps & Drabek, 1996). In addition to the destruction and disruption caused by the disaster agent, citizens and organizations often cease routine activities and take on new disaster –related tasks and responsibilities (Auf der Heide, 1989). Emergency organizations may also have to find alternative ways of completing their more routine emergency procedures and emergent phenomena are most likely to occur when demands are not met by existing organizations when traditional tasks and structures are insufficient or inappropriate. (Auf der Heide, 1989). The response phase for EM is the search for and rescue of injured persons and survivors after a major incident is a key priority. The ability to rapidly locate injured people will greatly enhance their chances of survival. When managing a major incident over a large geographical area, this task is particularly challenging and consumes a large number of assets. After Hurricane Katrina in 2005, UAVs provided a rapid search capability for remote areas in Mississippi and proved to be significantly quicker than would have been possible by boats and manned helicopters (Johnson, 2005).

UAV and Search and Rescue

There has been a growing interest in the use of UAVs in search and rescue operations. When someone goes missing, the likelihood of finding them is determined by where and how people search. This research is looking at the effectiveness of a variety of search assets both on the ground and in the air. UAVs are attracting a lot of interest and no small amount of

controversy. Significant investment is going into their development yet is surprising how little we know about their use in complex search situations (Henderson, 2017).

The Centre for Search Research in partnership with Northumberland National Park Authority and Newcastle University carried out an operation near Rothbury, United Kingdom to measure the performance of air and ground assets. The use of UAVs in search and rescue operations is being tested in Northumberland, United Kingdom. The study found ground and air assets working together to find randomly distributed targets over a 2km search area. Air assets included fixed and rotary wing aircrafts and UAVs while members of Northumberland National Park Mountain Rescue Team and their air scenting dog searched on foot (Henderson, 2017).

The scale and scope of the revolution in the use of small, civilian UAVs has been rising steadily. In 2010 America's Federal Aviation Authority (FAA) estimated that there would, by 2020, be 15,000 UAVs in the country. More than that number is now sold there every month. By 2007, Canada was home to 220 drone-related companies in all sectors and in the same year, the industry generated an impressive $787 million in total sales (Gersher, 2014). Some analysts think the number of UAVS made and sold around the world this year will exceed one million. But the practical use of these small, remote-controlled aircraft is expanding rapidly. The FAA had by August approved more than 1,000 commercial UAV operations. These involved areas as diverse as agriculture where farmers use UAVs to monitor crop growth, insect infestations and areas in need of watering at a fraction of the cost of manned aerial surveys, land-surveying, film-making, which could fly lower and thus collect more dramatic pictures than a helicopter, security and delivering things. UAVs can also go where manned aircraft cannot, including the craters of active volcanoes and the interiors of caves (The Economist, 2015).

UAV Response and Cost

UAV is a technology driven promise of achieving a cost effective approach and a rapid response for a wide array of applications, from public safety agencies such police, fire rescue service, search and rescue operations. “UAVs could potentially be justified on the basis of primary, emergency-related applications” (Coifman, McCord, Mishalani, & Redmill, 2004, p.6). Some examples of emergency related applications are incident response and verification, coordination amongst a network of first responders, emergency vehicle guidance, and search and rescue operations.

The main objective of early impact analysis after a disaster is to produce geo-referenced data about the affected areas, in support of humanitarian action. Crucial information is the identification of the affected areas and the estimation of the number of people involved. Satellite imageries are mainly used as input data for early impact analysis at small and medium map scale. Analyses aimed at defining the damages to infrastructures and/or to facilities require suitable data for large scale analyses, as far as high resolution satellite images. Unfortunately, such images are not always available in a few days after the event; therefore surveys are preferred (Bendea, Boccardo, Dequal, Giulio Tonolo, Marenchino, & Piras, 2008).

UAVs comes in all sizes, some are as small as a business card while others are large enough to carry a person. An example is a Phantom 3, one of the more popular hobby UAVs, which is made by Chinese manufacturer DJI and sells for less than $600 US. On several occasions this summer, pilots fighting wildfires in California and BC were forced to land their aircraft because UAVS got too close. According to the FAA, airplane and helicopter pilots reported almost 240 close calls with UAVs in 2014 in the U.S. By August of 2015, that number had tripled. The other problem, the FAA is the huge number of people who are applying for

permits to use UAVs for commercial purposes. A typical example of such a UAV is the Chinese-made M6A-Pro, a $13,000 US agricultural UAV that can spray a 10 acre field in an hour and is about the size of a 42- inch television (Brunhuber, 2015).

A UAV system, which includes a ground operating computer, can cost less than $50,000 whereas a new police helicopter can cost up to $1 million. As a consequence, fewer than 300 of the approximately 19,000 law enforcement agencies in the United States have an aviation capability (Finn, 2011). Steen (2014) states that the costs are much less than for flying manned aircraft. The long term projected cost is about $25 per hour whereas planes and helicopters with pilots can cost between $400 and $1,200 per hour to operate. UAV has a rapid launch compared to manned aircraft, where the pilots must get to the vehicle and potentially taxi before takeoff. UAVs are both fast and highly manoeuvrable. If UAV's can provide such a great help to public safety agencies at such a low cost why aren't they greatly used in this discipline. The next sections will address other factors such environmental impact, political considerations, safety and privacy which impacts UAV operations and its implications on policies affecting UAV usage in EM and PS disciplines.

Information Technology for Humanitarian Assistance, Cooperation and Action (ITHACA), a non-profit association with the main goal to carry on operational and research activities in the field of geomatics for analysis, evaluation and mitigation of natural and manmade hazards is developing a low cost mini UAV devoted to the early impact analyses. The aim of the UAV project is to develop a low cost aerial platform capable of autonomous flight and equipped with a photogrammetric payload for rapid mapping purposes. The main requirements for this type of UAV are to be easily transportable and usable on the field, autonomously, by a couple of operators (Bendea et al, 2008).

UAVs are mostly low cost systems and flexible and therefore a suitable alternative solution compared to other systems. UAVs are mostly used in military applications for recognition, environmental observation, maritime surveillance and mine removal activities. Non-military applications are environmental surveillance, rice paddy remote sensing and spraying as well as infrastructure maintenance (Eisenbeiss, 2004). Eisenbeiss (2004) stated that the main application of UAVs could be defined with observation, maintenance, surveillance, monitoring, remote sensing and security tasks.

Environmental Impact

UAVs are considered more environmentally friendly. Their environmental impacts include less noise and air pollution, in comparison with piloted aircraft.

Political Considerations

For political considerations, UAVs can speed up assessment of disaster impact and recovery. The information obtained is real time and has the ability to access inter-jurisdictional areas quickly. For political expediency, faster and more accurate decisions can immediately be made and such decisions can be supported using the real time data.

First Responder Safety

UAVs can make a difference between saving and losing human lives. It also reduces the risk to first responders by helping to guide them out of harm's way. UAVs can save lives, as well as keeping parks clean and traffic moving. Frank Roma, a fireman, rescued two boys from a river in Maine with the help of a UAV. The boys were stuck on a rock in the middle of a powerful current. Mr. Roma employed a UAV to carry a line out to them, along which he passed life

jackets that they were able to put on before an inflatable boat went out to perform the tricky manoeuvre of picking them up (The Economist, 2015).

Unmanned Aircraft Systems (UAS) are a developing technology currently used for military and homeland security purposes that is quickly being developed for transition to public safety, first responder, and commercial applications in the United States. (Letterman, Schanzer, Pitts, Ladd, Holloway, Mitchell, & Kaydos-Daniels, 2013). Two pilot studies were designed to gauge the level of awareness and support for the use of UAS to better understand public and law enforcement concerns and perceived barriers to adoption. The survey indicated that in the "level of support for UAV applications, well over half of the general public indicated support for any application (57%), and higher levels of support for applications in homeland security (67%), fighting crime (63%), search and rescue (88%), and commercial applications (61%)" (Letterman et al., 2013, p.2). (See Figure 2.1)

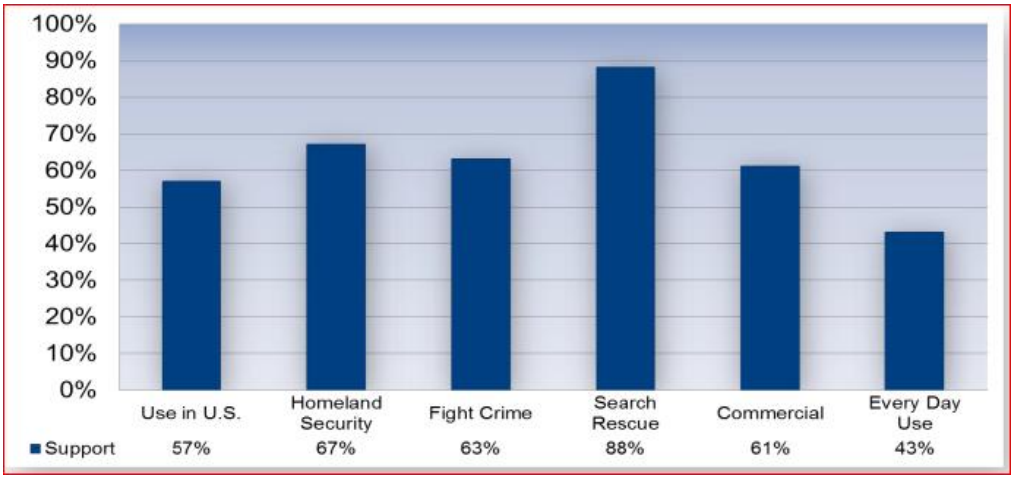

Figure 2.1. Public Support by Type of Use. From "Unmanned aircraft and the human element: Public perceptions and first responder concerns," by J. Eyerman, K. Hinkle, C. Letterman, D. Schanzer, W. Pitts, K. Ladd, J. Holloway, S. Mitchell, and S. Kaydos-Daniels, 2013, Institute for Homeland Security Solutions. Copyright 2013 by RTI International. Reprinted with Permission.

Privacy Concerns

UAVs or drones are viewed as a technology of "new surveillance" and it is questionable whether it is ethically acceptable to monitor people from the air without their knowledge, and at what point this might become an unacceptable infringement of privacy. UAVs present unique privacy challenges, due to the manner in which they may collect information from unique vantage points. The use of UAV technology raises a broad range of issues that relate to collection, retention, use, disclosure of personal information. The potential for institutional or other abuse, arising as a result of the inappropriate use of this technology, suggests a need for safe handling of such information to prevent intrusions into privacy. UAVs are used by government agencies, commercial entities, and small personal entities. Even when model aircraft is used by private individuals for recreational purposes, privacy issues must be addressed (Cavoukian, 2012).

However, for public safety purposes, greater consideration has to be taken into account between saving lives and averting risk due to privacy concerns. The uses of UAV (and model aircraft) technologies raise a broad range of issues that relate to collection, retention, use, disclosure, and eventual safe destruction of personal information. The potential for institutional or other abuse, arising as a result of the inappropriate use of these technologies, suggests a need for safeguards tailored to prevent intrusions into privacy and liberty. Whether sensor enhanced UAVs are used by government agencies, commercial entities, or small personal entities – or whether model aircraft are used by private individuals for recreational purposes – privacy issues must be addressed. UAVs present unique privacy challenges, due to the manner in which they may collect information. While some of the sensor equipment on board UAVs may be commonplace in the consumer electronics marketplace, the ability to gather information

dynamically from unique vantage points would appear to distinguish UAV use from other video surveillance cameras, and from data collected using cell phone technology.

In the pilot study, although the support was fairly high for UAV applications, most respondents reported high levels of concerns with the transition to the domestic airspace, noting that they were somewhat concerned or very concerned with the potential monitoring outside our homes and in public spaces (67%), safety issues (65%), and the ability of the government to regulate use (75%) (See Figure 3.1) (Letterman et al., 2013).

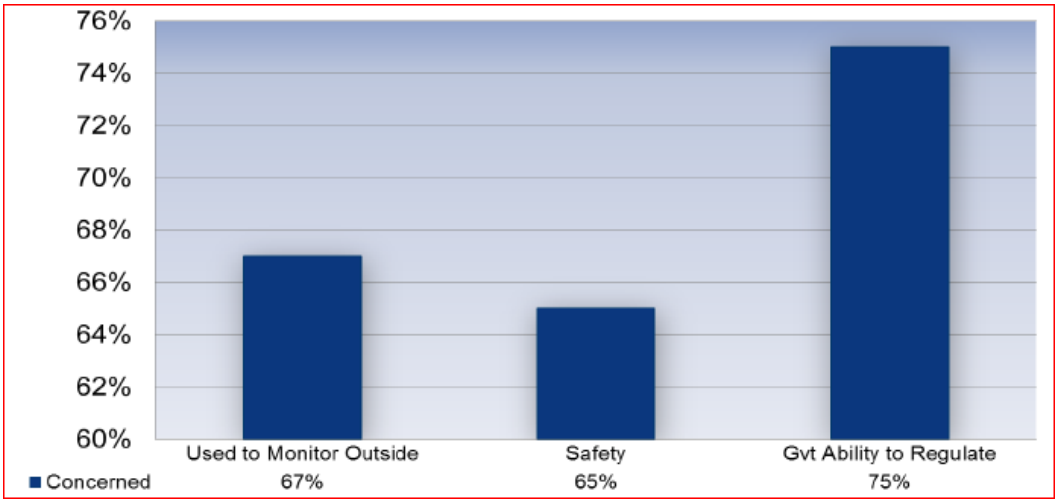

Figure 3.1. Public Support by Type of Use. From "Unmanned aircraft and the human element: Public perceptions and first responder concerns," by J. Eyerman, K. Hinkle, C. Letterman, D. Schanzer, W. Pitts, K. Ladd, J. Holloway, S. Mitchell, and S. Kaydos-Daniels, 2013, Institute for Homeland Security Solutions. Copyright 2013 by RTI International. Reprinted with Permission.

UAV Safety

Significant future UAV operations are expected to emerge and the type and magnitude of mitigation employed to meet system safety standards will vary significantly between classes of UAVs (Weibel & Hansman, 2004). It may be possible to operate small UAVs, such as those

classified as Micro or Mini UAVs, away from the most densely populated areas where safety considerations are taken into account.

Further, UAVs come with costs and benefits and one of the potential benefits of UAVs is that they could fill a gap in current border surveillance by improving coverage along remote sections of the Canada/U.S. border (Haddal & Gertler, 2010). The range or the vast area covered by UAVs is a significant asset when compared to border agents on patrol or stationary surveillance equipment. Despite potential benefits of using UAVs for national security, various problems encountered in the past may hinder UAV implementation along the border. The high accident rates of UAVs have historically been multiple times higher than that of manned aircraft (Haddal & Gertler, 2010).

Benefits of using UAV Technology

The benefits of using UAV technology are extensive. Depending on the organization and the responsibilities undertaken, there are varying benefits but one common theme which emerges is that it can be accomplished without putting first responder's lives or the public at risk with minimum cost.

1. Low cost in comparison to airplanes or helicopters. The use of UAV technology is relatively inexpensive when you consider the cost of a manned aircraft and the risk to those on board to accomplish the task.
2. Easy to fly in different / difficult weather conditions as opposed to aeroplanes and helicopters, night searches, terrain, populated areas, flights down gullies on mountain-side, and other narrow gorges.

3. Reduces risk of injury to personnel and able to access dangerous or hazardous areas such as chemical spills or able to open highway faster. Delivering an item e.g. a defibrillator, drugs, or a lifesaving line.
4. Better investigations in capturing the best available evidence in the form of aerial photos or videos of a crime scene or motor vehicle collisions. UAV increases the ability to get the totality of evidence in relation to photographs in real time or with minimum lapsed time. It is critical information and evidence to be collected at the time instead of at a later time when the scene had already been cleaned and or changed over time.

5. Provides situational awareness or high stress situations - a video camera for surveillance, monitoring a crime scene, search and rescue, or traffic reconstruction or unfolding situation, be it for monitoring of a high risk situation or searching for lost/missing persons.

Opportunities with UAV Operations

There are many opportunities in PS such as the following:

1. The opportunity to collect mass amounts of data in a short period of time which leads to situational awareness of the operation of an unfolding incident such as forest fires or flooding, locating/identifying lost or missing persons and the ability to obtain photographs and video of collision and crime scenes at the time, prior to evidence being lost.
2. The opportunity to save money in comparison to manned helicopters or aeroplanes.
3. The opportunity to collect the necessary information strategically such as locating/identifying/recording of evidence or search and rescue efforts, visual

observations for tactical operations, border patrol as well as other matters of national security. Other opportunities to collect information on major events, surveillance, site survey, accident reconstruction, forensic Identification, border integrity or drugs smuggling.

4. Lifesaving possibilities

Using UAV in Public Safety Agency

UAV operations are heavily regulated by the federal government through Transport Canada. They make the rules and legislation governing what UAV operations can and cannot be carried out. Any use of a UAV outside of recreational use is subject to a Special Flight Operating Certificate (SFOC) which outlines the parameters for which the UAV must be operated under. Any agency or person operating for an agency without a Special Flight Operating Certificate is in violation of the Aeronautics Act and is subject to the appropriate actions.

While there are many profiles and mandates, any PS agency would have benefits using UAV in their operations such as:

1. Fire Service can use UAV to conduct a scene survey and identify hazards and can quickly locate/identify “hot spots” in and around structures. A UAV with a Thermal Camera would be particularly useful in this capacity.
2. Paramedics can use UAV to conduct a scene survey and identify hazards as well as locating/identifying victims and conducting an initial triage or assessment of their injuries. All of this can be accomplished safely, prior to accessing a site.

3. Police can use UAV for surveillance, monitoring a crime scene, search and rescue, or traffic reconstruction or unfolding situation, be it for monitoring of a risky situation or searching for lost/missing persons.
4. Search and Rescue can use UAV for night flying and using infra-red imagery or thermal imagery are important.

Role of Policy Research and Regulation

Policy research plays a significant role in technology being adopted in regulatory discipline. Drafting of new or amending regulations, governance requirements and roles and responsibilities are defined so that long term sustainable development is reached at various levels. Participation of different stakeholders and community is required.

UAVs are a relatively mature technology currently used for military and homeland security purposes that are quickly being developed for transition to public safety, first responder, and commercial applications (Letterman et al., 2013). Two pilot studies were designed to gauge the level of awareness and support for the use of UAS to better understand public and law enforcement concerns and perceived barriers to adoption. The general public reported a fairly low level of awareness, with a little less than half (44%) reporting that they knew just a little or nothing at all about UAS applications (see Figure 4.1) and the law enforcement community reported a slightly lower level of awareness, with more than half (51%) reporting that they knew just a little or nothing at all about UAV applications (see Figure 4.1) (Letterman et al., 2013).

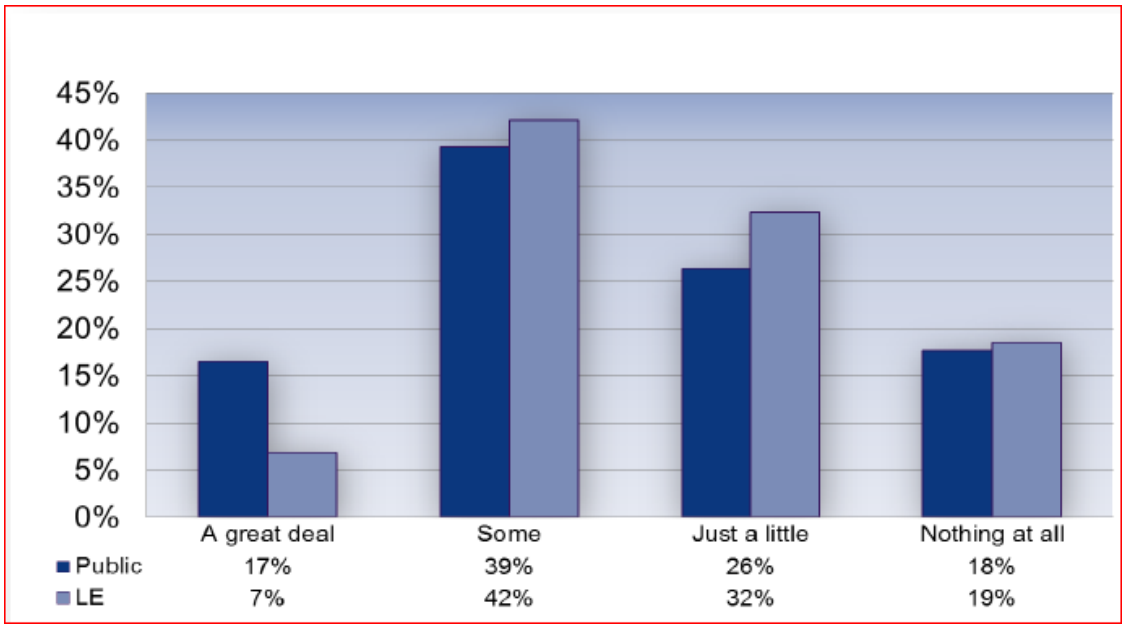

Figure 4.1. Public Support by Type of Use. From "Unmanned aircraft and the human element: Public perceptions and first responder concerns," by J. Eyerman, K. Hinkle, C. Letterman, D. Schanzer, W. Pitts, K. Ladd, J. Holloway, S. Mitchell, and S. Kaydos-Daniels, 2013, Institute for Homeland Security Solutions. Copyright 2013 by RTI International. Reprinted with Permission.

When asked about potential applications for their policing mission, the most frequently reported potential application was for search and rescue operations (93%), followed by photo flights for crime scene investigations (81%), drug location and interdiction (73%), investigations and criminal surveillance (72%), and emergency response (66%) (See Figure 5.1) (Letterman et al., 2013).

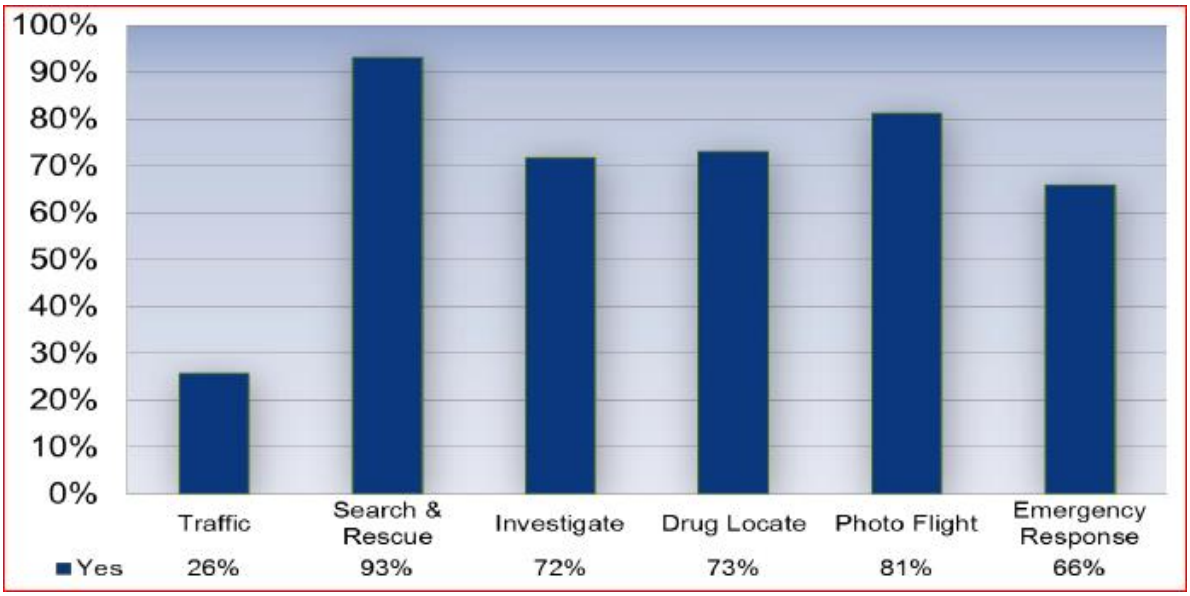

Figure 5.1. Public Support by Type of Use. From "Unmanned aircraft and the human element: Public perceptions and first responder concerns," by J. Eyerman, K. Hinkle, C. Letterman, D. Schanzer, W. Pitts, K. Ladd, J. Holloway, S. Mitchell, and S. Kaydos-Daniels, 2013, Institute for Homeland Security Solutions. Copyright 2013 by RTI International. Reprinted with Permission.

During 2017, Transport Canada (TC) carried out various public consultations via online forum "Let's talk drones", regulatory engagement sessions and written feedback via email. As of January 2018, TC website posted proposed rules for UAVs in Canada. TC website also shows the current rules and overview of proposed changes and Canada's new regulations for unmanned aerial vehicles when it becomes law.

Chapter Summary

This chapter introduces the use of UAVs in various industries and builds on the definition, historical development and categories of UAV. It highlights the UAVs role in EM, SAR and builds on response and cost, environmental impact, political considerations, first responder safety, privacy concerns and UAV safety. Later the benefits, opportunities and PS

usage of UAVs discussed. The chapter concludes with the role of policy research and regulation on UAV technology.

Chapter 3: Methodology

Chapter Introduction

In this chapter I provide the overview of my research methodology, followed by the methodological framework and research design. In research design section, I explain the Phase 1 and Phase 2 together with data sources, data collection methods and analysis methods. Later on in the chapter I discuss rigor and trustworthiness, my role as the researcher and ethical considerations and issues. I discuss the strengths and limitations of this research and expected outcomes.

Overview

A mixed methods approach was used where documentary research was used as the primary method, followed by email interviews from personnel from EM and PS agencies.

Documentary research method refers to the analysis of documents that contain information about the phenomenon we wish to study (Bailey, 1994). The use of documentary sources is widely used in mainstream social research; documentary research is not new, having been extensively used by such classical social theorists as Karl Marx and Emile Durkheim (Mogalakwe, 2006). Documentary research method or the use of documentary sources in social research is just as good as and sometimes even more cost effective than social surveys, in-depth interviews or participant observation (Mogalakwe, 2006). Mogalakwe (2006) states that there are two types of documents that are used in documentary study, namely primary documents and secondary documents. For this study, the documentary research methods included primary sources such as government statutes, regulations, policies, studies, public proceedings and other

documents. Secondary sources included scholarly studies and journals. Tertiary documents included newspaper articles and other media or social media documents.

This research included a study and analysis of governance arrangements including current CARs, Criminal Code of Canada (CCC) and Transport Canada (TC) regulations and their underpinning legislations and policies in order to assess and interpret their impacts on the use of UAVs. It will also be informed by experiences and lessons observed by public safety agencies in Canada and elsewhere that have implemented UAV programs in their operations or have used UAVs on a trial basis.

The use of semi-structured interviews allows participants to share their views and experiences with the researcher (Creswell, 2014). The use of one-on-one interviews allows the researcher to engage with participants on a personal level (Creswell, 2014). Interviews will include a variety of questions exploring the participants' backgrounds, experience with UAV, benefits and opportunities of UAV usage, best practices in the use of UAV technology, restrictions, challenges, training and collaboration with other agencies. Public safety agencies in their daily routines come through many challenges such as lack of resources or policy restrictions or governance arrangements restricted through roles and responsibilities. Although first responders may come in contact with the concepts of strategic long-term planning and personnel support in a disaster event, public safety agencies look at these concepts differently when solving events that have "extraordinary public safety challenges" (Rojek & Smith, 2007, p. 592).

The benefits of a qualitative approach include the ability to ask in-depth questions and explore topics in detail while obtaining information that may enhance the current issue of seeking information to enhance the usage of UAV technology in the Canadian public safety domain.

Methodological Framework

Creswell (2014) states that pragmatism as a world view arises out of actions, situations, consequences and solutions on the problems. My research interest is based on the use of emerging technology to seek, understand, learn and advance risk reductions in the emergency management in the public safety discipline. This research will be a qualitative research study.

The second part of this research involves use of email interviews where a set of semi-structured questions were sent out to individuals from various public safety agencies. The data was collected, collated, analyzed and results/findings established using thematic analysis.

Research Design

Overview

As mentioned above, this research used a qualitative mixed methods design incorporating documentary research and email surveys. Research began with a literature search and review on UAV technology, its application in the public safety sector and associated policy/regulatory issues. Concurrently, documentary research was conducted on underpinning Canadian legislation, regulations and policy on UAV use, particularly with respect to PS use, followed by academic articles or journals and finally through newspaper, magazine or online media articles. Once the participants were identified and invited, informed consent addressed and the email interview process began. After all the interviews were completed, data analysis commenced using categorizing (Kvale, 1996). The categories and themes were derived from the research questions. The research consisted of Phase 1 as Documentary Research and Phase II consisted of email interviews.

Phase I: Documentary Research

Data Sources and Collection Methods

The documentary research method was selected as the primary research method. The data was obtained from documentary sources such as primary, secondary and tertiary documents. The primary documents consulted consist of government legislated documents such as CARs, Aeronautics Act, CCC. The secondary sources include academic or journal articles while tertiary document sources include magazines, newspapers, social media, online sources such as Google scholar and targeted websites of relevant agencies.

Phase II: Email Interviews

The use of e-mail interviews to collect qualitative data has expanded as Internet access and use have become more widespread and prevalent and offers a new technique for conducting semi-structured interviews which can enhance the efficiency and effectiveness of qualitative research. The goal of both observation and in-depth interview methods is to improve understanding of social and cultural phenomena and processes rather than to simply produce objective facts about reality and make generalizations to given populations (Fidel, 1993; Pettigrew, Fidel, & Bruce, 2001; Wang, 1999).

Exploring the value of e-mail interviewing in qualitative research and knowing under what conditions it can be most effective and how to implement it should be useful to researchers. This knowledge could be particularly useful to those who study people who prefer to be interviewed online rather than face-to-face, as well as people who are not easily accessible or are geographically far apart (Meho, 2006).

Email interviewing has become a viable tool for qualitative research and e-mail interviews cost considerably less to administer than telephone or face-to-face interviews. Researchers can invite participation of large or geographically dispersed samples of people by sending them e-mail messages individually or through, message boards, or discussion groups, rather than making long-distance telephone calls, using regular mail, or traveling to the location of participants. The use of e-mail in research also decreases the cost of transcribing. Data from e-mail interviews are generated in electronic format and require little editing or formatting before they are processed for analysis. E-mail also eliminates the need for synchronous interview times and allows researchers to interview more than one participant at a time, because a standard interview schedule or list of questions can be sent individually to several participants at once, irrespective of their geographical location or time zone (Meho, 2006).

The time period required to collect e-mail interview data varies and this variation is because it may take days or even weeks before a respondent replies to an e-mail message. Although e-mail interviewing limits the research to those people with access to the Internet, this method enables a wide scope of participants.

In contrast to face-to-face and telephone interviewing, e-mail interviewing enables researchers to study individuals or groups with special characteristics or those often difficult or impossible to reach or interview face-to-face or via telephone. Moreover, e-mail enables the interviewing of shy people or people who do not or cannot express themselves as well in talking as they do in writing, especially when the language used in communicating with participants is their second one (Karchmer, 2001).

E-mail allows the researcher to interview groups or communities that would not and could not have been studied otherwise. Recruiting in e-mail interviewing studies is done in

multiple ways, including individual solicitations, snowballing, or invitations. Because these are the same methods employed by online survey researchers, it was not surprising that e-mail interviewing researchers face similar problems in recruiting participants. It was found that e-mail interviewing offers unprecedented opportunities for qualitative research, providing access to millions of potential research participants who are otherwise inaccessible. The method can be employed quickly, conveniently, and inexpensively and can generate high-quality data when handled carefully (Meho, 2006).

Data Sources and Collection Methods

As in face-to-face and telephone interactions, most e-mail survey studies use an interview schedule for data collection (Meho, 2006). This process took place from October 13 to November 30, 2017 which included semi–structured surveys; the questions are listed in (Appendix 1). The use of semi- structured questions during the surveys allows the researcher to explore the experiences of the participant and the meaning the participant attributes to the experience. The semi-structured approach supports asking questions building on the responses received (Kvale, 2007). Probes or follow-up questions are generally used to elaborate and clarify participants' responses or to help elicit additional information and depth from informants. Unlike face-to-face and telephone interviews, e-mail interviews do not allow direct probing; it can be done only in follow-up e-mails, which can take place (Meho, 2006). During the interview process the interviewer can reword or clarify the question to further investigate the answers the participant has given. Further, asking open ended questions elicits more information and allows the participant to expand on the question rather than just a couple word answer (Kvale, 2007). The benefits of a qualitative approach include the ability to ask in-depth questions and explore

topics in detail while obtaining information that may enhance the current issue of seeking information to build on UAV technology usage.

The data collection process involved seven qualitative email surveys, during which information and answers to questions were compiled in a binder. A total of 35 of email surveys were sent out, mostly to RCMP employees in different provinces involved with UAVs, military officials, Transport Canada, Search and Rescue volunteer individuals. For data management purposes, names were removed and labelled, while electronic files were backed-up with copies. The collected data was read after each email interview to complete field notes (O'Leary, 2010). The data was added to a spreadsheet and all names were removed, assigning numbers to each participant. Potential themes and emerging patterns were noted as soon as data collection began.

The email interview consisted of 15 questions. Further simple clarification was followed up by email and no further probing conducted into the answers provided.

Surveys included a variety of questions exploring the participants' backgrounds, experiences and best practices in UAV technology usage (Appendix 1). The format consisted of semi-structured approach and included open ended questions including probing questions on the challenges and opportunities gained by the use of UAV technology in the public safety agencies. Prior to interviewing, the research participants were sent an email requesting for participating together with the informed consent. Informed consent was obtained as per the copy attached in Appendix 2. All documentation has been kept strictly confidential. All data including written transcripts will be destroyed after one year.

Data Analysis Methods

As mentioned earlier, this research study employed a mixed methods approach where the primary research used documentary research analysis and the secondary research was email interviews. Document analysis is a form of qualitative research in which documents are interpreted by the researcher to give meaning around the chosen topic and in this case will be on Effective Public Safety Usage of UAV Technology in Emergency Operations. Analyzing documents incorporated coding content into themes similar to how focus group or interview transcripts were analyzed.

On completion of the email survey process, all data was collected, collated and analyzed using a thematic process.

Thematic analysis, as described by Guest, MacQueen and Namey (2012), is a qualitative research method incorporating inductive analysis which has a descriptive and exploratory nature (p. 7). The thematic data analysis process mirrored the process described by Conolly (2003) for coding, theming and contextual categorization. The coding process helps to identify tags or labels. Moving from coding to theming is the first stage in managing the data, providing the researcher the opportunity to move from copious codes to a manageable number of themes (Conolly, 2003). To move the data forward, drawing out key concepts from the story, the themes are categorized into divisions or categories, where themes can be brought together through interconnected ideas (Marshall & Rossman, 2016). This interconnectedness should demonstrate relationships between themes. Linked relationships develop when codes appeared to come together and analysis will link to different themes.

Outliers are elements of data (codes) that do not automatically fit within themes or contextual categories (Creswell, 2014). "In the qualitative inquiry, because it is inductive and relatively flexible, we can use deviant cases to further inform our research questions" (Guest, MacQueen, & Namey, 2011, p. 94). Outliers provide an opportunity to look deeper and do an in-depth analysis which provides for deeper understanding (Creswell, 2014).

Rigor and Trustworthiness

This research study was carried out within strict academic guidelines. Krefting (1991) described qualitative research as the study of the empirical world from the viewpoint of the person under study. To ensure credibility, dependability and transferability, the researcher would share the information from the transcripts individually with the participants to ensure the accuracy of the information collected during the interview process (Marshall & Rossman, 2016). Identifying the researcher's biases throughout the research from beginning to completion will assist in credibility, reliability and trustworthiness of the results.

Two underlying principles were identified. The first is that behavior is influenced by the physical, sociocultural, and psychological environment. This is the basis for naturalistic inquiry. The second assumption is that behaviour goes beyond what is observed by the investigator. Subjective meanings and perceptions of the subject are critical in qualitative research, and it is the researcher's responsibility to be aware of. Based on the above, I made sure that the research process from the beginning to the end was done truthfully and could be replicated to get similar results.

Role as Researcher

My role as a researcher is independent and an objective stance was undertaken consistent with the guidelines defined in the Royal Roads University (RRU) School of Humanities Thesis Handbook. The research was conducted with strict academic rigor. There is no personal relationship with any participants or the organization. This research will be purely to fulfil the academic requirements to graduate with the Master of Arts credential.

Ethical Considerations and Issues

All requirements and applications in regards to ethics were made to the RRU ethical board and the approval was granted and all protocols were strictly adhered to. All data collected has been kept in the strictest confidence with no requirements to get any personal identification of the research subjects in any part of the research study. The participants are professionals in their careers, well-educated and had the ability to freely give consent or deny without any consequences. The information obtained will not breach any personal privacy or put any subjects at risk. The participants are neither vulnerable nor seen to be vulnerable in any situation. The research subjects will be provided with the executive summary of the findings if they express interest in receiving it.

Strengths of this Study Limitations

The strength of this research study is that it has potential impact on EM agencies who are contemplating the use of UAV in the emergency operations. The recommendations provided will assist the agencies for better integration of UAVs in their daily operations. The agencies will also gain from the best practices guiding UAV operations.

Expected Outcomes

In addition to submitting my final report to Royal Roads University in partial fulfillment for a Master of Arts degree, I will also be sharing an executive summary of the research findings with EM or PS agencies contemplating the use of UAV technology for knowledge mobilization. The knowledge mobilization will assist these EM and PS agencies who are contemplating about implementing the UAV technology in emergency operations in the near future. This research summary may also be made available for publication in EM or PS or Technological journals.

Chapter Summary

In summary this chapter outlines the research methodology and the research design for my mixed methods research including Phase 1 and Phase 2. Later it highlights the rigor and trustworthiness that this study can be replicated with similar findings. My study in collaboration with PS agencies or departments researched and proposed usable recommendations for increasing efficiency in the use of UAV technology. The strengths of this research are discussed. One of the expected outcomes is knowledge mobilization to PS agencies.

Chapter 4: Research Findings and Discussion

Chapter Introduction

In this chapter, the research findings are presented and discussed. In Phase I of this study, the documentary research analysis was completed using primary, secondary and tertiary documents. In Phase 2 the findings from the email interview are presented. In both phases, the findings were analysed and discussed using thematic analysis from the key themes of the research questions. The research questions include the underpinning governance arrangements affecting the use of UAV technology in Canada, current Canadian legislations and regulations for UAV technology, policy challenges and how to overcome such challenges together with best practices guiding UAV technology. The key themes derived from research questions are discussed as follows:

Legislative and Regulatory Framework

Governance Arrangements Affecting UAV Technology in Canada

There is a multitude of ideas and motives that are affecting the emergence of UAV technology. UAV is one of the disruptive technologies that is governed by a number of acts, regulations, and orders by various regulatory / law enforcement bodies. The current legislation that are affecting UAV operations including those carried out by PS agencies are Criminal Code of Canada (CCC), Aeronautics Act, Canadian Aviation Regulations (CARs), TC Interim Order # 8, Radio Communications Act.

As UAVs become more popular, sophisticated and dangerous, Canada is working on new rules to rein in the use of UAVs in our increasingly crowded skies. Canada is looking at bringing in updated UAV regulations in the near future, replacing its existing safety guidelines

with stricter rules requiring licensing, training and registration. In Canada, close calls between UAVs and aircraft are on the rise, and the consequences of a collision could prove deadly (Goodyear, 2015).

UAV is of great interest as one of the disruptive technologies and is revolutionizing the way operations are carried out in different industries. Disruptive in the sense it is changing the way of operating UAVs. It is with this hope that useful solutions or recommendations can be made in the public safety agencies with the use of UAV technology.

One of my research participants indicated that he has been in partnership with a university which has been involved in testing the use of UAVs in emergency management. It included the use of a UAV in response to a mass casualty incident simulating a terrorist attack, as well as the use of a UAV to provide an Incident Commander with real-time aerial oversight of a major event such as a large outdoor music festival. In the first study, the UAV was used to gain access to an unsafe location and provided first responders the opportunity to locate, identify and triage victims. It also allowed first responders to identify existing hazards such as live wires, unstable structures, and potential improvised explosive device.

Transport Canada

All UAV operations, including those carried out by PS agencies, are governed by Transport Canada (TC) by way of the Aeronautics Act and the CARs. Under the current framework, in order to obtain and hold a UAV pilot's licence the following criteria must be met, minimum 14 years of age while under supervision (16 years without an adult), have a Category IV Medical Certificate, complete a course of instruction (Ground School and pass a Transport

Canada written examination) and practical training on the category of UAV and system specific training provided by the manufacturer (Transport Canada, 2017).

The content of the knowledge subject areas must possess are: air laws and procedures, classes of airspace, flight instruments, navigation, flight operations, meteorology, human factors and theory of flight.

All UAV flights in Canada require an operator to have a Special Flight Operations Certificate (SFOC), have an approved safety plan, and to carry appropriate insurance. Other stipulations depending on the circumstances may be enforced, including calling local air traffic control or TC representatives on the day of the operation. Current rules normally only allow flights that stay within line-of-site. This severely limits the distance a UAV can fly on a mission. The operators must maintain visual sight of the UAV and be able to tell which direction it is facing.

Canadian Aviation Regulations

Canadian Aviation Regulations (CARs) are the rules that govern civil aviation in Canada. UAVs are also subject to CARs, which state that it is illegal to do anything with an aircraft that puts aviation safety at risk, as well as any existing municipal, provincial or federal laws. Public awareness and enforcement are lacking and when current rules were created, very few people had access to UAVs. Now, anyone can buy them anywhere and Transport Canada needs to create better public awareness about its safety guidelines. Commercial and research UAV operators are better educated about the rules because they have to obtain Special Flight Operator Certificates (SFOCs) from Transport Canada and let the government know what kind of UAVs they're using, where they're using them and why (Goodyear, 2015).

CARs require UAV operators to apply for a SFOC so TC can ensure operators use their UAV reliably and safely. Each SFOC contains conditions for where and how to fly, such as: maximum altitudes, minimum distances from people and property.

CARs 623.65 (d) Unmanned Air Vehicle states

> "(2) An application for a Special Flight Operations Certificate for the purpose of conducting the flight of an unmanned aircraft other than an unmanned free balloon or a model aircraft shall be received by the appropriate Regional Transport Canada General Aviation Office, at least 20 working days prior to the date of the proposed operation or by a date mutually agreed upon between the applicant and Transport Canada" (Transport Canada, 2017). (See Appendix 3).

Special Flight Operations Certificate is required if you fly a UAV for anything other than fun, including for work or research. Examples include survey work, agricultural work, inspections, academic research, police work, aerial photography and videography, including for real estate (Transport Canada, 2017).

Criminal Code of Canada

The Criminal Code of Canada (CCC) is a law that describes criminal offences and procedures in Canada. Below are some of the criminal code violations that may be applicable to the operation of UAVs.

CC Sec. 430 (1) (d) Mischief, CC Sec. 249 (1) (c) Operation of an aircraft that is dangerous to the public, CC Sec. 77 (e) Endangering Safety of Airport or Aircraft, CC Sec. 253 (1) Operation

while impaired (aircraft) and CC Sec. 162 (1) Voyeurism and CC Sec. 219 Criminal Negligence. (Criminal Code, 2017). (See Appendix 4 for full Criminal Code details).

While the CCC has various sections restricting the aviation aspects of UAV it also specifies acts of criminal negligence. Everyone is criminally negligent who in doing anything, or in omitting to do anything that it is his duty to do, shows wanton or reckless disregard for the lives or safety of other persons (Criminal Code, 2017). It could be interpreted that UAV as a tool in an emergency where if one has the UAV at their disposal but fail to act in order to save lives or safety of others could be subject to this section of the Criminal Code. Good Samaritan law (Good Samaritan Act of 1996) provides legal protection for volunteer rescuers in emergency situations. These laws are meant as a way to encourage others to act by removing the threat of legal liability for injuries or other problems that could result from their intervention. No court cases have been found dealing with this act and the UAVs.

Restrictions on UAV Operations

UAV operations are unique. The restrictions are clearly laid out by the use of SFOC. Any use of a UAV by a PS organization is considered “non-recreational”, therefore requires the user or agency to obtain an SFOC. This process itself is considered a restriction in that the agency cannot simply deploy a UAV without first applying and being granted an SFOC. The specifics of the SFOC also impose restrictions on the use of the UAV, such as times, locations, type of UAV, purpose of UAV. Many agencies lack the resources such as human or financial required complying with such processes. A SFOC can enable the use of a UAV where a “non-recreational” user would not be allowed to do so in proximity of an airport/aerodrome, where “non-recreational” users are not allowed to fly.

The Aeronautics Act (1995) was not written originally with UAV's in mind and many of the sections need to be changed. Other restrictions are those placed by Transport Canada that may restrict what public safety is trying to accomplish and Industry Canada needs to allow for PS officials to use jamming equipment to counter against nefarious use of UAV's. In a practical sense, there is little current limitation on the use of UAVs for genuine operational situations. There are restrictions based on safety, privacy, and the perception of the public toward UAV operations. Other restrictions on PS agencies is their inability to operate in certain conditions particularly in urban settings due to restrictions on proximity to structures, people and restricted air spaces due to proximity to airports.

The beyond visual line of sight (BVLOS) is the main limitation that restricts the use of UAVs for Search and Rescue (SAR). Without going beyond line of sight, flights are limited to less than a kilometer and there are restrictions on flights over built-up areas. BVLOS is very restrictive and UAV operators have to be competent and safe operators. Now that UAVs are integrated in the airspace, someone will have to monitor the airspace. One research participant mentioned that despite a national SFOC, the police still have to ask the permission of a park warden prior to landing or taking off in a National Park. Either exemption or modification would help a great deal or, have a standing authorization from Parks Canada.

There are also technical restrictions apart from Transport Canada requirements to operate within the operating limits of systems such as batteries not being able to operate at or below -20 degrees Celsius. However, such platforms have been observed operating at colder temperatures but, the companies refuse to modify their specifications and TC cannot find a way to impose such technical requirements.

Current Rules - Flying your UAV safely and legally

If you fly UAV for fun and it weighs more than 250 g and up to 35 kg, you do not need special permission from Transport Canada to fly. Following the basic safety rules below allows keeping people, aircraft and property safe. If you fly where you are not allowed or choose not to follow the rules below, you could face fines of up to $3,000 (Transport Canada, 2017).

The flight rules are, fly your UAV below 90 m above the ground, at least 30 m away from vehicles, vessels, and the public (if your UAV weighs more than 250 g up to 1 kg), at least 75 m away from vehicles, vessels, and the public (if your UAV weighs more than 1 kg up to 35 kg), at least 5.5 km away from aerodromes (any airport, seaplane base, or areas where aircraft take-off and land), at least 1.8 km away from heliports or aerodromes used by helicopters only, outside of controlled or restricted airspace, at least 9 km away from a natural hazard or disaster area, away from areas where operation could interfere with police or first responders, during the day and not in clouds, within your sight at all times, within 500 m of your location or closer, only if clearly marked with your name, address, and telephone number (Transport Canada, 2017).

Overview of Proposed Rules for UAV in Canada

Of greater interest is that Transport Canada is currently developing proposed regulations and legislation to govern the increasing number of UAVs and how they will pave for future UAV operations. The proposed rules introduce three categories of UAV are divided into operations from small, limited to complex. (See Appendix 5).

Transport Canada is proposing new regulations for UAVs that weigh 250 g to 25 kg, are operated within visual-line-of-sight, and are used for any purpose such as fun, work or research. The proposed new regulations are easy-to-follow, flexible and balanced, while supporting

innovation and safe recreational use. Each category is based on the size of the device, the pilot, and where the UAV is operated (Transport Canada, 2017).

The rules for very small UAV operations (UAVs more than 250 g to 1 kg) are that pilots must be 14 years old or older and will be required to mark their device with their name and contact information, pass a basic knowledge test, have liability insurance and fly at least 5.5 km from airports, 1.85 km from heliports and 30 metres from people (Transport Canada, 2017).

The rules for limited UAV operations (UAVs more than 1 kg to 25 kg) are that pilots must be 16 years old or older and will be required to mark with their name and contact information, pass a basic knowledge test, have liability insurance and fly at least 5.5 km from airports, 1.85 km from heliports, 150 metres from open-air assemblies of people, 75 metres from people, vehicles, vessels and 1 km from built-up areas (Transport Canada, 2017).

The rules for complex UAV operations (UAVs more than 1 kg to 25 kg) are that pilots must be 16 years or older and will be required to hold a pilot permit that is specific to small UAVs, have liability insurance, register and mark their device with a unique identification Transport Canada will provide, operate a UAV that meets a design standard, follow a set of flight rules, get approval from air traffic control when flying in controlled airspace or near aerodromes, and fly at least 150 metres from open-air assemblies of people unless at least 90 metres high and 30 metres from people, vehicles and vessels. This category is for users who intend to fly in urban areas, within controlled airspace or close to anywhere that airplane, helicopters and floatplanes land and take off (Transport Canada, 2017).

Policy Challenges Inhibiting PS Agencies adopting UAV Technology

While UAV is a fairly new technology in the PS domain, there are numerous policy challenges in adopting it in its operations. One of the major challenges is the lack of human or financial resources to obtain training, qualifications and subsequent application for the necessary SFOC. Most PS agencies suffer from human resource shortages. Due to the urgent/emergency nature of PS first response, the majority of those human resources are required to fulfil their primary duty as a first responder and often times cannot be "spared" to fulfil what could be considered as a support role of UAV operator. The cost of buying UAVs, to train personnel and to maintain the service level places a burden on financial resources.

The second major challenge is keeping the documentation and personnel current in the following categories such as flight logs, training certifications, maintenance logs, Special Flight Operations Certificate applications, policy changes and new technology. The UAV technology evolves or develops rapidly making it hard for policy changes to keep up.

Difficulties of public safety agencies with UAV operations

The major difficulties of PS agencies are the lack of availability of a UAV qualified and licensed operators, and the restrictions of the CARs, Interim Order and specific SFOCs. The SFOC specifically limits UAV operations with respect to: Altitude; Distances from persons, vehicles, buildings; Requirement to maintain the UAV within Visual Line of Sight and the requirement to have another police officer perform the role of Safety Officer/Visual Observer. Inter-agency cooperation and shared use of resources; and, greater exemptions or the lifting of restrictions for emergency first responder situations**.**

UAV rules usually require the pilot to have line of sight of the UAV, which is limiting in some operational contexts; however, TC is working with responder organizations to assess operations out of line of sight, develop procedures, and certify pilots. Once a SFOC has been suspended, all operations get grounded pending an investigation by TC or delegate. The suspension does not get lifted until proof of correction has been done and TC feels confident that the proper remedial actions have been taken as reported by one research participant.

For Search and Rescue, one of the main unanswered questions is how a UAV flight operation will interact with traditional helicopter operations. To overcome such difficulties, UAV operators mentioned a well establish program or dedicated UAV program for all Canadian government agencies.

Overcoming Challenges in adopting UAV Technology

Challenges with UAV Operations

One of the major challenges is the lack of the human or financial resources required to obtain training, qualifications and subsequent application for the necessary SFOC. Most public safety agencies suffer from human resource shortages. Due to the urgent/emergency nature of first response, the majority of those human resources are required to fulfil their primary duty as a first responder and often times cannot be “spared” to fulfil what could be considered as a support role of UAV operator. This can possibly be overcome by more inter-agency cooperation and the “shared” use of UAV operators.

One of the research participants mentioned that the current move is towards ‘approved’ operations, where the UAV, pilot, and organization must meet standards including documentation, training, maintenance, etc. The creation and implementation of these standards

requires collaboration between emergency response organizations and TC and will require the organizations to implement additional requirements.

From a protective perspective, major challenges are having these technologies, tested, validated and integrated, in line with TC authorization to fly beyond visual line of sight as well as the authority to fly fix wing. The transition from quadcopters to fix wing UAV in BVLOS is the current challenge. One of my research participants mentioned another major challenge in the RCMP is whether police personnel should be flying UAV or certified commercial pilot.

Overcoming Challenges in UAV Operations

The challenges can be overcome by inter-agency cooperation and shared use of resources and greater exemptions or the lifting of restrictions for emergency first response situations**.** The major difficulties of Public Safety agencies are the lack of availability of a UAV or qualified and "licensed" operators, and the restrictions of the CARs, Interim Order and specific SFOCs.

Best Practices Guiding Usage UAV Technology

While majority of research participants stated that UAV operations should have an organized mechanism/system of operating UAVs, one of the respondents stated that it would be best is to treat the entire UAV operation as a formalized aircraft operation, with pilots, UAVs, and the operation subject to standards and control, to maximize safety and reliability of the operations. These include completing Pre-flight Plans for each flight which will include emergency procedures, site surveys and securement and flying within acceptable weather conditions at a certain distance from persons or structures, not over built up areas and not while under the influence of drugs or alcohol.

Best practices are set through legislation issued by TC. Due to the heavy regulations and safety concerns, UAV operators must undergo extensive training in order to be deemed qualified to operate UAV's. These include completing Pre-flight Plans for each flight which will include emergency procedures, site surveys and securement and flying within acceptable weather conditions at a certain distance from persons or structures, not over built up areas and not while under the influence of drugs or alcohol.

The most commonly understood best practice is to treat the entire UAV operation as a formalized aircraft operation, with pilots, UAVs, and the operation subject to standards and control, to maximize safety and reliability of the operations.

Other UAV operators have own organizational policies and procedures governing the use of UAVs, and are bound by the conditions of an SFOC.

One UAV operator identified the following steps in developing best practice in UAV operations.

Step 1: Define your concept of operations – what do you want to use them for?
Step 2: Identify your budget – this will help to determine what you want to buy?
Step 3: What are my regulatory guidelines – Can I fly? Who do I apply with?
Step 4: Develop policies and procedures
Step 5: Buy your system(s).
Step 6: Identify/train the pilots.

Another significant point raised in best practices was to have UAV coordinator ascertain training and compliance from the operators. Program must be part of operation as opposed to UAV operator/member working from the corner of their desk.

The best practices in mind for UAV operator in Search and Rescue are:

1. The UAV team consists of trained UAV operators and not SAR volunteers or members of the public who have a UAV and want to help out.
2. The UAV operator trains with the SAR team at least once a year so they gain experience in the SAR environment, and the SAR members gain experience with the UAV's capabilities and the capabilities of the operators.
3. During operations the SAR team provides an "Air Operations Coordinator" who works as a liaison between the UAV operators and the SAR command structure.
4. The Air Operations Coordinator is responsible for ensuring the UAV missions are properly recorded and documented, and to make sure there are no adverse interactions with other aircraft.
5. The Air Operations Coordinator is a part of the operations group for the duration of the task.
6. Ensure imagery analysis workflows are being worked on to get the imagery analyzed properly. From our experience imagery analysis requires a facility away from the main search where the analysis will not be disturbed.

Collaboration with other agencies on UAV operations

Depending on the scope and scale of the organization, collaboration with other agencies was extensive or nil. Some of the organizations participants collaborated were Transport Canada, Nav Canada, Industry Canada, Unmanned Systems Canada, National Research Centre (NRC), Defense, Research and Development Canada (DRDC), Provincial Ground Search and Rescue Association, Search and Rescue teams. In partnership with a local university, one UAV operator

has also been involved in testing and studies relating to the use of UAVs in emergency management. These studies included the use of a UAV in response to a mass casualty incident such as simulated terrorist attack, as well as the use of a UAV to provide an Incident Commander with real-time aerial oversight of a major event. In the first study, the UAV was used to gain access to an unsafe location and provided first responders with the opportunity to locate, identify and triage victims. It also allowed first responders to identify existing hazards such as live wires, unstable structures, and potential improvised explosive device. In the second study, the UAV was used to provide an Incident Commander with real-time aerial imagery of a large outdoor music festival of approximately 20,000 people.

Study Limitations

The limitations I can think of are the sample size or the limiting responses for the semi-structured interview. Due to limited time and resources, this research study was very limited. This research was not exhaustive but was only focused on policy research through documentary research and limited experiences by various EM or PS agencies.

As with any research project, there is only so much that can be done with the provided resources and allocated time limits or deadlines. It is impossible to explore the sky but to seek a star and focus the time and energy on that star which can be translated to my research project.

The research develops assumptions, scope, and limitations. This research is constrained by resources and time, and thus cannot solve or even attempt to solve all of the problems. Thus, a study was carried out on policy research in the usage of UAV technology. This research is limited by the longitudinal effects that it is only one year in duration and cannot include data

over a longer period of time. This will limit the results thus research findings over a longer period of time.

Sample size or lack of available data may play a significant role in limiting the scope of analysis or it can be an obstacle in finding a meaning relationship. This limitation can be a scope or opportunity for future research.

Lack of prior policy research on UAVs may also be a limiting factor in the current research. A thorough literature review is limited which may restrict our understanding for the current research or the scope to undertake.

Other limitations included the access to people, institutions, organizations or documents involving UAVs. PS or EM agencies, mostly government organizations have very restricted access to data and are normally made available on the need to know basis.

Chapter Summary

In summary this chapter presents the findings that were analysed and discussed using thematic analysis from the key themes of the research questions. It included the regulatory framework, governance arrangements affecting UAV technology, what are the current and proposed new regulations for UAV operations, policy challenges, overcoming those challenges to best practices guiding the usage of UAV technology.

Chapter 5: Conclusion and Recommendations

Chapter Introduction

The use of UAVs in EM applications has great potential to deliver environmentally friendly, quick response with reduced costs and many public safety benefits. The development and successful application of UAV technology in PS and EM can greatly assist in reducing risk to PS agencies and/or to the public. The application and usage can further help us understand the behaviour of these UAV autonomous systems and where it can further be customized to suit the EM or PS discipline.

Conclusion

In Canada, the regulation of UAVs falls under the jurisdiction of the federal government. UAVs are mainly regulated by the CARs, standards, guidelines, and circulars issued by TC. The applicable rules and the necessity for a UAV operator to have a SFOC depend upon the use of the UAV, its weight, and whether particular exemptions apply. An instance of exemption could be showing a track record of safe flying, one may qualify for a Standing Special Flight Operations Certificate. PS and EM agencies can apply and get Standing SFOC. The eligibility depends on factors like pilot qualifications and experience, knowledge of relevant regulations and Canadian airspace, and the ability to identify and mitigate risks (Transport Canada, 2017). When agencies such as PS and EM can have these special provisions in terms of Standing SFOC, they can react and respond better in crisis and emergency situations which set them apart from other UAV operators who will need SFOC for each operation.

UAVs that weigh 35 kilograms or less and are used for recreational purposes do not require a government-issued SFOC but are subject to safety guidelines. UAVs that are used for

non-recreational purposes, or that weigh more than 35 kilograms, irrespective of their purpose, require an SFOC to be flown. Specific directions for operating UAVs are set forth in the SFOC. UAVs that weigh less than 1 kilogram or between 1 kilogram and 25 kilograms are subject to exemptions if the operator is able to follow the strict safety conditions.

Transport Canada is in the process of issuing new regulations for UAVs that weigh 25 kilograms or less that will eliminate the current distinction between recreational and non-recreational use. The proposed changes provide a classification system based on the risks involved in the use of UAVS. UAVs weighing 25 kilograms or more will continue to be regulated by the SFOC requirements.

Widespread use of UAVs by the general public including PS and EM agencies is anticipated to increase privacy concerns among citizens nervous about data collection or individual tracking issues which may believe to be intrusive. It must also be considered that the increasing numbers of recreational UAVs can assimilate into EM or PS applications without proper authority or legal mandate.

The balancing act must be envisioned about the proper way to introduce UAVs in EM and PS discipline. While the government PS officials have a structured mechanism of operating UAVs in their operations with required training, this may not hold to the same standard for other private PS professionals or non-governmental organizations, volunteers and ordinary citizens. In a state of emergency EM and PS agencies through standing SFOC may be able to get quick UAV access in their operations. For other agencies without standing SFOC, their operations could be delayed or halted without a prompt UAV access.

To further advance the integration of UAV technology, UAV manufactures or UAV technological research, in collaboration with the PS agencies or departments can explore and propose real-world solutions for increasing efficiency and usage.

This research study has been able to successfully answer the primary and secondary research questions. UAV technology is governed by a number of acts, regulations, and orders by various regulatory / law enforcement bodies. The current legislation that are affecting UAV operations are CCC, Aeronautics Act, CARs, TC Interim Order # 8, Radio Communications Act. These legislative acts enable and restrict UAV operations and these restrictions are laid out by the use of SFOC. Any use of a UAV by a PS organization is considered “non-recreational”, therefore requires the user or agency to obtain an SFOC or have standing SFOC in place. This process itself is considered a restriction. One of the major challenges is the lack of the human and financial resources required to obtain training, qualifications and subsequent application for the necessary SFOC. Most public safety agencies suffer from human resource shortages and duties associated with the administration of UAV area carried out from the side of their desks. The challenges can be overcome by inter-agency cooperation and shared use of resources and greater exemptions or the lifting of restrictions for emergency first response situations**.** One of the best practices is to treat the entire UAV operation as a formalized aircraft operation, with pilots, UAVs, and the operation subject to standards and control, to maximize safety and reliability of the operations.

Recommendations

The following recommendations are informed by the literature and research findings in this study. The order of recommendations is in no order of priority but a list was made as I went

through the responses collected via email surveys. The recommendations in regards to UAV operations for the EM agencies are as follows:

1. One centralized integrated UAV operations unit to serve all government PS and EM agencies by major city/geographic locations. Based on email responses received to address qualified UAV personnel and to save costs, a central integrated agency will serve as a good recommendation for maximum benefit to the region. For example, one UAV integrated unit for all of Lower Mainland, BC. This mechanism will bring cost-sharing arrangements for maximum benefit to the region.
2. Use the same replica system as the airline industry uses for UAV operations. Based on email responses and looking at this as a specialized and regulated industry, it is best to have a systematic operation. Treat the entire UAV operation as a formalized aircraft operation, with pilots, UAVs, and the operation subject to standards and control, to maximize safety and reliability of the operations. This will ensure safety, operational, training and standards are maintained.
3. For record keeping, use a similar replica system as the airline industry uses for UAV operations. A systematic and organized way to keep up to date the following:
    a. Flight logs
    b. Training Certifications
    c. Maintenance Logs
    d. Special Flight Operations Certificate applications
    e. Policy changes
    f. New Technology

4. More educational awareness, knowledge mobilization and more collaboration between inter-agency and intra-agency to share best practices, knowledge and skills mobilization and transfer is required. Knowledge mobilization will assist in overcoming challenges by EM agencies wanting to incorporate UAV in its operations or lessons learnt by agencies that have already incorporated UAVs. This way the skills, techniques and knowledge are passed for maximum benefit to partner agencies.
5. To further advance the integration of UAV technology, UAV manufactures or UAV technological research, in collaboration with the PS agencies or departments can explore further. The opportunity to collect the necessary information strategically and use it as training basis for future missions such as locating/identifying/recording of evidence or search and rescue efforts, visual observations for tactical operations, border patrol as well as other matters of national security. Other opportunities to collect information on major events, surveillance, site survey, accident reconstruction, forensic Identification, border integrity or drugs smuggling.

Chapter Summary

In summary this final chapter presents the conclusion together with recommendations to PS and EM agencies contemplating on future use or integration of UAV technology in their daily operations. As demonstrated through both a review of primary literature and a limited survey of first responders, the development and successful application of UAV technology in PS and EM has the potential to assist in reducing risk to PS or EM agencies or assist in saving human lives.

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Appendices

Appendix 1 - Semi-Structured Questions

Introduction

1. I would like to start by asking you to tell me a little about your professional capacity with your organization? How long you have been with the organization? What is your present role? What are your day to day responsibilities?

Experience with UAV technology.

2. Can you tell me about your experience with UAVs? In what capacity and how you are /were involved with UAV technology?
3. How is UAV helping with your current role?
4. What are the benefits of UAV use in public safety agency operations?

Opportunities with UAV Operations

5. What are the opportunities for public safety agencies using UAV operations?
6. How can other public safety agencies use UAV in their operations?
7. What are the best practices guiding usage of UAV technology?

UAV and current legislation

8. Can you tell me about the current legislation and regulations that are affecting UAV operations?

Legal effects of UAV usage for Canadian Public Safety organizations

9. How do you think these legal arrangements enable and restrict UAV usage by Canadian public safety organizations?

10. What other the restrictions on UAV operations by public safety agencies?

Challenges with UAV Operations

11. What other challenges in training or certification stand in the way of public safety agencies adopting UAV technology? How can these challenges be overcome?
12. Describe the difficulties public safety agencies are experiencing with UAV operations.
13. How can such difficulties be overcome by public safety agencies?

Training and Collaboration

14. How are the training, management and integration of UAV technology done within your organization? Has this entailed establishing new positions?
15. Do you collaborate with other agencies and if you do, can you describe the nature of collaboration?

Further comments, suggestions or guidance.

Appendix 2 – Informed Consent

My name is Mukesh Chand. I am undertaking this research project as part of the Master of Arts in Disaster Emergency Management from Royal Roads University. This university is located in Victoria, British Columbia. You can check with my thesis coordinator, Dr. Jean Slick to confirm this project and my identity. Dr. Slick's telephone number is XXX-XXX-XXXX. The topic of this research project is **Effective Public Safety Usage of UAV Technology in Emergency Operations**. The purpose of this research study is to explore the underpinning regulatory framework including current legislation, regulations and policies governing the use of UAVs in public safety agencies. It will further attempt to understand the policy and legal challenges that are faced by public safety agencies when adopting the UAV technology and how these challenges can be overcome. The research study will try to understand the opportunities created by using UAV in the public safety agencies and how these opportunities will bring value to emergency operations for these public safety agencies. The study will also explore how policy and regulation guides these initiatives. The use of UAVs is rapidly increasing and if applied in this discipline could provide cutting edge solutions to the challenges in public safety service.

The attached questionnaire will take approximately 45 minutes to 1 hour. All information you provide will be kept confidential and you will remain anonymous. The results will be coded and analysed using thematic analysis where broad themes and results will be identified without revealing any identities. Your answers are completely confidential and this is not a test, there are no right answers. At any time you can discontinue this process.

All requirements and applications in regards to ethics has been made and approved by the RRU ethical board. All data collected will be in the strictest confidence with no requirements to get any personal identification of the research subjects in any part of the research study. The information obtained will not breach any personal privacy or put any subjects at risk.

Upon completion of my research project, I will be writing an executive summary on the research findings on the effective public safety usage of UAV technology. If you would like a copy of this executive summary, please email me and thank you for your support on this. If you have any questions about this process or the research being conducted, you can contact me via email: XXXXX **@XXXXX.XXX.**

I would also like to put in a request for your help in locating anyone within your professional circle that is associated with UAV technology and willing to complete my research questionnaire.

By agreeing to complete this questionnaire, you are giving me consent to participate in my research.

Sincerely,
Mukesh Chand.

Appendix 3 – Canadian Aviation Regulations Extract

CARs 623.65 (d) Unmanned Air Vehicle states

"(2) An application for a Special Flight Operations Certificate for the purpose of conducting the flight of an unmanned aircraft other than an unmanned free balloon or a model aircraft shall be received by the appropriate Regional Transport Canada General Aviation Office, at least 20 working days prior to the date of the proposed operation or by a date mutually agreed upon between the applicant and Transport Canada.

(3) The following constitutes an application for a Special Flight Operations Certificate for the purpose of operations in paragraph (1) above:

(a) the name, address, and where applicable, the telephone number and facsimile number of the applicant;

(b) the name, address, and where applicable the telephone number and facsimile number of the person designated by the applicant to have operational control over the operation (Operation Manager);

(c) method by which the Operation Manager may be contacted directly during operation;

(d) the type and purpose of the operation;

(e) the dates, alternate dates and times of the proposed operation;

(f) a complete description, including all pertinent flight data on the aircraft to be flown;

(g) the security plan for the area(s) of operation and security plan for the area(s) to be overflown to ensure no hazard is created to persons or property on the surface;

(h) the emergency contingency plan to deal with any disaster resulting from the operation;

(i) the name, address, telephone and facsimile numbers of the person designated to be responsible for supervision of the operation area (Ground Supervisor), if different from the Operation Manager during the operation;

(j) a detailed plan describing how the operation shall be carried out. The plan shall include a clear, legible presentation of the area to be used during the operation. The presentation may be in the form of a scale diagram, aerial photograph or large scale topographical chart and must include at least the following information:

(i) the altitudes and routes to be used on the approach and departure to and from the area where the operation will be carried out;

(ii) the location and height above ground of all obstacles in the approach and departure path to the areas where the operation will be carried out;

(iii) the exact boundaries of the area where the actual operation will be carried out;

(iv) the altitudes and routes to be used while carrying out the operation;

(k) any other information pertinent to the safe conduct of the operation requested by the Minister."

(Canadian Aviation Regulations, 2017)

Appendix 4 - Criminal Code of Canada Extract

Criminal Code is a law that describes criminal offences and procedures in Canada. Below are some of the criminal code violations that maybe applicable to the operation of UAVs.

CC Sec. 430 (1) (d) Mischief - Every one commits mischief who wilfully obstructs, interrupts or interferes with any person in the lawful use, enjoyment or operation of property.

CC Sec. 249 (1) (c) Operation of an aircraft that is dangerous to the public - Every one commits an offence who operates an aircraft in a manner that is dangerous to the public, having regard to all the circumstances, including the nature and condition of that aircraft or the place or air space in or through which the aircraft is operated; or

CC Sec. 77 (e) Endangering Safety of Airport or Aircraft - Everyone who causes damage to or interferes with the operation of any air navigation facility where the damage or interference is likely to endanger the safety of an aircraft in flight,

CC Sec. 253 (1) Operation while impaired (aircraft) - Every one commits an offence who operates a motor vehicle or vessel or operates or assists in the operation of an aircraft or of railway equipment or has the care or control of a motor vehicle, vessel, aircraft or railway equipment, whether it is in motion or not,

(a) while the person’s ability to operate the vehicle, vessel, aircraft or railway equipment is impaired by alcohol or a drug; or

(b) having consumed alcohol in such a quantity that the concentration in the person’s blood exceeds eighty milligrams of alcohol in one hundred millilitres of blood.

CC Sec. 162 (1) Voyeurism - Every one commits an offence who, surreptitiously, observes — including by mechanical or electronic means — or makes a visual recording of a person who is in circumstances that give rise to a reasonable expectation of privacy, if

(a) the person is in a place in which a person can reasonably be expected to be nude, to expose his or her genital organs or anal region or her breasts, or to be engaged in explicit sexual activity;

b) the person is nude, is exposing his or her genital organs or anal region or her breasts, or is engaged in explicit sexual activity, and the observation or recording is done for the purpose of observing or recording a person in such a state or engaged in such an activity; or

(c) the observation or recording is done for a sexual purpose.

CC Sec. 219 (1) Criminal Negligence - Everyone is criminally negligent who
a) in doing anything, or
b) in omitting to do anything that it is his duty to do,
shows wanton or reckless disregard for the lives or safety of other persons.

(Criminal Code, 2017).

Appendix 5 - Overview of Proposed New Rules for UAV in Canada

Transport Canada is proposing new regulations for drones that:

- weigh 250 g to 25 kg
- are operated within visual-line-of-sight, and
- are used for any purpose (fun, work or research)

The proposed new regulations are easy-to-follow, flexible and balanced, while supporting innovation and safe recreational use.

The proposed rules introduce three categories of drones. Each category is based on the size of the device, the pilot, and where the drone is operated. New requirements are specific to each category:

Very small drone operations.

Very small drone more than 250 g to 1 kg

Most recreational users will fit into this category. The rules that apply are easy to understand and follow.

Pilots must be 14 years old or older and will be required to:

- mark their device with their name and contact information;
- pass a basic knowledge test;
- have liability insurance; and
- fly at least:

    - ✓ 5.5 km from airports

- ✓ 1.85 km from heliports
- ✓ 30 m from people

Limited operations (rural).

Small drone more than 1 kg to 25 kg

This category is for users operating in rural areas (e.g., agricultural purposes, wildlife surveys, natural resources).

Pilot must be 16 years old or older and will be required to:

- mark their device with their name and contact information;
- pass a basic knowledge test;
- have liability insurance; and
- fly at least:

  - ✓ 5.5 km from airports
  - ✓ 1.85 km from heliports
  - ✓ 150 m from open-air assemblies of people (i.e. outdoor concert)
  - ✓ 75 m from people, vehicles, vessels
  - ✓ 1 km from built-up areas

Complex operations (urban).

Small drone more than 1 kg to 25 kg

This category is for users who intend to fly in urban areas, within controlled airspace or close to anywhere that airplane, helicopters and floatplanes land and take off.

Pilot must be 16 years or older and will be required to:

- hold a pilot permit that is specific to small drones;
- have liability insurance;
- register and mark their device with a unique identification Transport Canada will provide;
- operate a drone that meets a design standard;
- follow a set of flight rules;
- get approval from air traffic control when flying in controlled airspace or near aerodromes; and
- fly at least:
    - ✓ 150 m from open-air assemblies of people (i.e. outdoor concert) unless at least 90 m high
    - ✓ 30 m from people, vehicles, vessels

(Transport Canada, 2017)