A QUALITATIVE INQUIRY INTO PUBLIC PERCEPTIONS OF UNMANNED AVIATION SAFETY

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Abstract:

The purpose of this research was to qualitatively study the public's trust and knowledge of unmanned aviation safety through data collection by interviewing research subjects. The researcher sought to determine whether the research subjects would be willing to fly as passengers in Unmanned Aircraft Systems (UAS), and if publicity about the UAS industry, its development and integration into the National Airspace System (NAS) have influenced their perceptions of UAS safety, which could affect their decision to travel as passengers in UAS in the future. The researcher also examined data to identify if any observable Dunning-Kruger Effect existed that would suggest if any of the subjects believed they had more knowledge about the factors that affect UAS safety than what they knew when deciding whether to fly as passengers in UAS.

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CHAPTER I

INTRODUCTION

Manned aviation can be perceived to be so inherently safe, versus other modes of transportation, that few within the public remember the first fatal powered manned aircraft accident; an injustice for the sacrifices made in the history of aviation safety. However, it remains a representation of how far manned aviation safety has progressed, with regards to the public's perception of manned aviation safety and reliability. The introduction section of this dissertation discusses and contrasts manned and unmanned aviation, identifies the statement of the problem, defines the purpose of the study, poses research questions, explains the significance of the study, and identifies limitations of the study. The remaining chapters of this dissertation detail a review of literature, identify the research methods, and address research analysis and findings. In conclusion, the researcher summarizes the study, answers the main research questions, and makes recommendations to improve and advance aviation safety.

Contrasts Between Manned and Unmanned Aviation

At Kitty Hawk, on the Outer Banks of North Carolina, the National Park Service maintains a national monument dedicated to the location where Orville and Wilbur Wright are memorialized in the photograph by photographer John T. Daniels for their achievement of being the first to fly a powered manned-aircraft on December 17, 1903 (Crouch, 1989, p. 263). The monument not only represents the birthplace of manned powered flight, it also represents years of prior development in theoretical and practical engineering designs of aircraft. It also represents the development of aviator skills, the establishment of aircraft maintenance and preventive maintenance techniques, as well as the development of the knowledge in which today's aircraft accident and aviation safety investigation techniques were built upon.

The history of flight and the concepts of aviation safety trace back to the early visionaries whose concepts of flight and aircraft design have made manned aviation safer. These early visionaries date as far back as Greek mythology and the concepts of Leonardo da Vinci. And, they have continued to build upon subsequent contributors resulting in what we know as manned aviation today, a relatively safe mode of transportation in contrast to other modes (Locsin, n.d.).

In the Greek mythology of Daedalus and Icarus, the story details Daedalus' respect for the theoretical dangers of flying too close to the sun because it would certainly melt the wax that secured the feathers to the wings that he had created in order to fly (Montgomery et al., 2000, pp. 4-5). It also illustrates Icarus' lack of respect for the hazards associated with flying too close to the sun, which ultimately resulted in his death. When the wax holding the feathers on the wood structure melted, he was no longer able to fly, and he crashed to earth.

The Greek mythology of Daedalus and Icarus is one of the early theoretical accounts of a fatality associated with the hazards of flying, representing man's early respect for the laws of nature, aerodynamics, and the dangers associated with flight. However, it is known that the first fatality in a powered manned aircraft did not occur until September 17, 1908 when Army First Lieutenant Thomas Selfridge was killed during a test flight with pilot Orville Wright (Thomas Etholen Selfridge, 2006).

Building upon the theoretical concepts of the Greek mythology of Daedalus and Icarus, Leonardo da Vinci, who lived from 1452 to 1519, made significant theoretical engineering contributions to aviation (Montgomery et al., 2000, pp. 5-6). His design illustrations of a theoretical wing structure named the Ornithopter suggested that it could be used for flight. And, his writings on observations of wind and nature that described lift, thrust, drag, and weight were the forces of flight that would later influence mathematical and scientific explanations of aerodynamics, along with the practical fixed wing and rotorcraft design structures of today (Montgomery et al., 2000, p. 185).

It is the concept of this dissertation that manned aviation has progressed from the theoretical concepts of Greek Mythology and Leonardo da Vinci to the practical applications of the Wright Brothers, which have led to what can be perceived by the public to be inherently safe because of the relatively low accident rates of today as compared to other modes of transportation. In fact, when compared to flying in a commercial aircraft versus driving, a person is more likely to die as a result of a car accident versus an airplane accident (Locsin, n.d.).

In comparison to all modes of transportation within the United States (U.S.), a National Transportation Safety Board (NTSB, 2015a) press release identified that in 2013 the aviation industry only realized 443 deaths, 42 in commercial aviation passenger transportation, which was a relatively low number when compared to the millions of flight hours flown industry wide. And, aviation was considered to be relatively safe when compared to the accident statistics in other modes of transportation, in which there were 32,719 deaths in highway transportation, 891 in railway, and 615 in marine transportation (NTSB, 2015a). Overall, the success of manned aviation safety is a result of U.S. Department of Transportation (DOT) Federal Aviation Administration (FAA) regulations, certification, and oversight of manned aviation operations, maintenance and air traffic control. It is perceived that government regulations, and the resultant low accident rates, have influenced the public's perception and trust in manned aviation safety.

However, aviation has drastically changed within the last twenty years. With new technology allowing small unmanned aircraft to be flown by hobbyist and commercial operators for such purposes as aerial photography, the future of transporting passengers and cargo by manned aircraft can be expected to be replaced by unmanned aircraft. In part, it is because of potential decreases in operating costs and expected increases in reliability and safety. Naturally, questions arise as to the flying public's level of knowledge and trust of unmanned aviation safety and the potential for its reluctance to fly in unmanned aircraft in the future.

Simply put, the researcher questioned whether the public trusts that unmanned aircraft are as safe and reliable as manned aircraft, despite their willingness to travel in other modes of unmanned transportation, such as cars, airport trams, elevators, or even rides at amusement parks, fairs and carnivals. This researcher's question also lent itself to further proposed inquiry and research, which this dissertation addresses.

The researcher further questioned the factors that could affect the public's trust in unmanned aircraft safety. Because it was unknown what factors affect the public's trust prior to conducting this research, it was expected that such factors could have included the public's overall lack of knowledge of manned and unmanned aviation safety.

As a result, the future of unmanned commercial passenger transportation, and unmanned aviation as a whole, were in question to the researcher. This was due to factors affecting the Unmanned Aircraft System (UAS) industry, such as; the federal government's lack of progress in meeting congressional mandates to integrate UAS into the National Air Space (NAS); its overall lack of progress in certification of operators and UAS; its lack of establishing and tracking UAS accident and incident statistics; the lack of robust oversight, compliance and enforcement of UAS operators who are both hobbyist and FAA approved operators; and, privacy concerns surrounding UAS.

Additionally, the researcher questioned if the phenomenon known as the Dunning-Kruger Effect could influence public perceptions of aviation safety, which suggests that people think more highly of their cognitive decision-making abilities even when they have limited knowledge in which to make a competent decision (Kruger & Dunning, 1999, p. 1121). For the purposes of this study, the researcher understood that this phenomenon could surface and expose the fact that research subjects could have little or no knowledge of factors affecting UAS safety, but still maintain a belief or perceived understanding about UAS safety above what they actually know that affects their overall opinion and trust. This could affect their willingness to fly as passengers in UAS in the future. It was a research objective to identify if such a phenomenon existed that could expose preconceived research subject bias and concepts about UAS safety.

Statement of the Problem

The FAA's mission is to ensure the safest most efficient aerospace system in the world (Federal Aviation Administration [FAA], n.d.,). At the same time, changes in aviation technology have created a surge in UAS capabilities for hobbyist, prospective commercial operators, and military operators of UAS, shifting demand from manned aircraft to unmanned aircraft to perform similar aircraft missions. These shifts in demand for UAS technology can be observed in the projections for greater transition from manned aircraft operations to unmanned aircraft missions by the United States Department of Defense (Osborn, 2015). These surges are also being seen in civilian aviation and have affected the FAA's ability to stay current with new technology and regulate UAS in an adequate and timely manner to meet its stated mission to ensure safety, while at the same time ensuring efficiency of the industry (Snead & Seibler, 2016).

It is noted by the researcher that the FAA failed to meet congressionally mandated deadlines of the FAA Modernization and Reform Act of 2012 in Public Law 112-95 to integrate UAS into the NAS by September 2015 (Zara, 2016). As a result of increased business interest to develop this new technology to meet increasing product demands, UAS have been operated in the United States without safe integration into the NAS, while the FAA has continued to develop regulations for operations and policy to regulate UAS within the NAS. Unsafe operations of UAS that have occurred are contrary to Federal Aviation Regulations (FAR) historically meant for manned aircraft and have resulted in FAA compliance and enforcement investigations, civil penalties, and lawsuits against the operators.

Examples of unsafe UAS operations are found in reports by commercial airline pilots of near midair collisions with small UAS, which could pose risk to life and property (Berlinger & Cooper, 2015). And, the highly-publicized Pirker vs. FAA enforcement case is another example of unsafe UAS operations in which the FAA claimed was reckless and endangering by flying a UAS above people. The operator faced a $10,000 fine, however appealed the lawsuit, claiming he was acting as a hobbyist, therefore Federal Aviation Regulations did not apply. Ultimately, the NSTB law judge who heard the case remanded the FAA's fine, stating that it had not proved the UAS operations were reckless, however did cite that the FAA had the purview to pursue the case because it had the authority to regulate any aircraft, even small UAS operated by hobbyist, because the operator's small UAS met the statutory definition of an aircraft in accordance with Title 49 of the United States Code (U.S.C.), Part 40102. The operator and the FAA settled the case and the operator, not admitting guilt, paid a fine of approximately $1,000 (Nicas, 2015).

As result of the negative publicity that has highlighted unsafe UAS operations, as well as the FAA's delay in safely integrating UAS into the NAS through aircraft and airmen certification, air traffic control, and development of regulations for the safe operations and maintenance of UAS, the researcher questioned whether the negative publicity has had a positive or negative effect on the publics' perception and trust of unmanned aircraft safety. And, the researcher further questioned whether these factors affected the public's willingness to fly as passengers in UAS in the future.

Prior to conducting this research, relationships between the public's trust of UAS safety and its knowledge of the aspects that affect unmanned aviation safety were not fully known by the researcher. As a result, fully exploring, examining and making the research results available to the industry and government was believed to positively affect the future of unmanned commercial passenger transportation and its safety.

Purpose of the Study

The purpose of this research was to qualitatively study the public's trust and knowledge of UAS safety through data collection by interviewing research subjects. Additionally, the researcher sought to determine whether the research subjects would be willing to fly as passengers in UAS, and if publicity of the UAS industry, its development and integration into the NAS have influenced their perception of UAS safety, which could affect their decision to travel as passengers in UAS. The researcher also examined data to identify if any observable Dunning-Kruger Effect existed that would suggest if any of the subjects believed they had more knowledge about the factors that affect UAS safety than what they knew when deciding whether to fly as passengers in UAS.

Main Research Questions

In this study, the researcher questioned the research subjects' level of knowledge and trust of UAS safety, their willingness to fly as passengers in UAS, the factors that could affect their trust of UAS safety, and whether publicity had a positive or negative effect on their perception and trust of unmanned aircraft safety. The main research questions sought to be answered by this research study were:

1. Do the research subjects trust UAS safety?
2. What factors affect the research subjects' trust in UAS safety?

3. Do the research subjects know and understand the factors that affect UAS safety?
4. What effect has the publicity of UAS had on the research subjects' willingness to fly as passengers in UAS?
5. Is there a relationship between the research subjects' trust and knowledge of UAS safety?
6. Will the Dunning-Kruger Effect be observed in the research findings?

Significance of the Study

The beneficiaries of this study are the regulatory, public, business, and academic interests that are stakeholders in the aviation industry. These beneficiaries will gain a greater understanding of the relationship between the public's knowledge of factors that affect safe operations of UAS within the NAS, and the level of trust the public has in UAS safety.

These beneficiaries can utilize this understanding to increase public trust in UAS safety and foster its development and progress by taking actions and making corrections to the specific aspects of the UAS industry that may contribute to the public's lack of knowledge and mistrust of the reliability and safety of UAS. Of greatest benefit, the beneficiaries will have an opportunity to utilize this information to not only make the UAS product safer, more reliable, and efficient for public transportation, but to also increase public demand for the UAS product.

Limitations of the Study

The researcher acknowledged certain limitations of this research and maintained full consideration for ensuring objectivity, credibility and rationality in the analysis and findings chapter of this dissertation. It is expected that the acknowledged limitations of the research and analysis of findings will generate further research questions and experimental study by the beneficiaries of this study. The following limitations were identified by the researcher in this study:

1. A statistical random sample of the population was not obtained and a purposeful sample was used instead. For qualitative research methods, small purposeful sample sizes from one to 40 are acceptable (Creswell, 2012, p. 209).
2. It was assumed that all of the research subjects would answer the interview questions honestly.
3. Interviews were conducted by telephone and not in person. Due to the lack of availability of all research subjects to participate in the interview process face-to-face, none of the interviews were conducted in-person and all interviews were conducted by telephone to ensure continuity of the study. This limited the researcher's ability to utilize the researcher's professional experience and education in cognitive witness interviewing techniques for analyzing visual cues in order to properly time and ask follow-on questions effectively. As a result, for these telephone interviews, the researcher utilized limited cognitive witness interviewing techniques and focused on audible cues and asked follow-on questions based on the lack of or limited audible responses to open-end questions.

Definitions

Aircraft – any contrivance, as defined by Title 49 U.S.C., Parts 40101-40102, that is invented, used, or designed to navigate, or fly in, the air.

Aircraft accident – defined by 49 Code of Federal Regulations (CFR) Part 830.2, means an occurrence associated with the operation of an aircraft (to include an unmanned aircraft) which takes place between the time any person boards the aircraft with the intention of flight and all such persons have disembarked, and in which any person suffers death or serious injury, or in which the aircraft receives substantial damage.

Aircraft incident – defined by 49 CFR Part 830.2, means an occurrence other an aircraft accident, associated with the operation of an aircraft.

Airship – defined by 14 CFR Part 1.1, means an engine-driven lighter-than-air aircraft that can be steered, also known as a blimp.

Civil aircraft – defined by 14 CFR Part 1.1, means an aircraft that is not a public aircraft.

Manned aircraft – an aircraft operated with direct human intervention aboard the aircraft.

Model aircraft – defined by 14 CFR Part 1.1, means an unmanned aircraft that is flown for the purposes of recreation or hobby that is capable of sustained visual line of sight flight by the person operating it.

N-number – the aircraft registration number assigned to an aircraft by the FAA.

Public aircraft – defined by 14 CFR Part 1.1, a government aircraft owned and/or used for a government purpose, only carrying crewmembers and not carrying passengers, and not operated for compensation.

Rotorcraft – defined by 14 CFR Part 1.1, means a heavier-than-air aircraft that depends principally for its support in flight on the lift generated by one or more rotors, also known as a helicopter.

Small unmanned aircraft – defined by 14 CFR Part 1.1, means a small unmanned aircraft and all of the elements required to control and operate it that includes the communication link, ground control station or handheld controller, and the specific components used to control it, which are all required to safely and efficiently operate it in the national airspace system.

Unmanned aircraft – defined by 14 CFR Part 1.1, means an aircraft operated without the possibility of direct human intervention from within or on the aircraft.

Unmanned aircraft accident – defined by 49 CFR Part 830.2, means an occurrence associated with the operation of an unmanned aircraft system that takes place between the time that the system is activated with the purpose of flight and the time that the system is deactivated at the conclusion of its mission, in which: any person suffers death or serious injury; or the aircraft has a maximum gross takeoff weight of 300 pounds or greater and sustains substantial damage.

Acronyms

AGL – Above Ground Level

AP – Associated Press

ATC – Air Traffic Control

ATCT – Air Traffic Control Tower

CAMI – Civil Aerospace Medical Institute

CFR – Code of Federal Regulations

DHS – Department of Homeland Security

DME – Distance Measuring Equipment

DOD – Department of Defense

DOT – Department of Transportation

FAA – Federal Aviation Administration

FAR – Federal Aviation Regulation

FL – Flight Level

GPO – Government Printing Office

IATA – International Air Transportation Association

ICAO – International Civil Aviation Organization

IFR – Instrument Flight Rules

ILS – Instrument Landing System

IRB – Institutional Review Board

ISIS – Islamic State of Iraq and ash-Sham

MEDA – Maintenance Error Decision Aid

MLS – Microwave Landing System

MSL – Mean Sea Level

NAS – National Airspace System

NHTSA – National Highway Traffic Safety Administration

NM – Nautical Miles

NSC – National Safety Council

NTSB – National Transportation Safety Board

OSU – Oklahoma State University

PIC – Pilot in Command

STC – Supplementary Type Certificate

SMS – Safety Management System

TC – Type Certificate

UAS – Unmanned Aircraft System

UAV – Unmanned Aerial Vehicle

U.S.C. – United States Code

U.S. – United States

VFR – Visual Flight Rules

CHAPTER II

REVIEW OF LITERATURE

The purpose of this research was to qualitatively study the public's trust and knowledge of UAS safety. Additionally, the researcher sought to determine whether the research subjects would be willing to fly as passengers in UAS, and if publicity of the UAS industry, its development and integration into the NAS have influenced their perception of UAS safety, which could affect their decision to travel as passengers in UAS. The researcher also examined data to identify if any observable Dunning-Kruger Effect existed that would suggest if the subjects believed they had more knowledge about the factors that affect UAS safety than what they knew about those factors when deciding whether they would fly as passengers in UAS.

To obtain a better understanding of these topics in order to conduct a thorough analysis of data obtained from the interviews conducted during this research study, as well as to obtain a thorough understanding of the level of knowledge of aviation safety that research subjects have, this chapter details the researcher's review of relevant literature as it relates to the purpose of this study. As such, the researcher aligned the topics of this review of literature chapter with the topics contained within the data collection instrument detailed within the methodology chapter of this dissertation. Specifically, this chapter details; manned aviation regulations, small unmanned aircraft regulations, large unmanned aircraft regulations, aircraft accident statistics, aircraft accident causes, unmanned aircraft human factors, public trust in automation, unmanned aircraft publicity, and the Dunning-Kruger effect.

Manned Aviation Regulations

Of topic within the data collection instrument, it was sought to determine if the research subjects had any knowledge of manned aviation safety regulations in order to contrast and determine if they had any knowledge of unmanned aviation safety regulations. This section of the review of literature chapter examines related parts of Federal Aviation Regulations (FAR) promulgated for the safety of manned aircraft by the FAA. Contrasts to regulations detailed within this section are contained within the Small Unmanned Aircraft Regulations and Large Unmanned Aircraft Regulations sections of this chapter.

It was identified by the researcher during review of 14 Code of Federal Regulations (CFR) pertaining to aviation safety that numerous aircraft, airmen certification, and operations regulations were published at the time of this research. Specifically, the researcher reviewed these aviation safety regulations to determine; if UAS were as technically reliable and safe as manned aircraft; if UAS were licensed the same as manned aircraft; if UAS operators were licensed and trained the same as manned aircraft pilots; if UAS were allowed to operate in the same airspace as manned aircraft; if UAS mechanics were licensed the same as manned aircraft mechanics; and, if UAS were required to be maintained the same as manned aircraft.

Tables 2.1 through 2.12 list Title 14 CFR, Chapter I, Subchapters A through N, aeronautics and space regulations by part and title, as adapted from the Government Printing Office's (GPO) electronic CFR website for FAR's (Aeronautics and Space, 2017). It is noted by the researcher that the parts under each subchapter are not entirely in sequential order and contain gaps in numbering because of reserved numbers by the Government Printing Office for publication of future regulatory parts. Similarly, subchapters L through M were not published at the time of this research and were listed as reserved for future publication. These tables provide an outline for the level and breadth of regulations that pertain to manned aviation safety. However, although the researcher acknowledges that each table in this section outlines the applicable safety regulations within each subchapter by subpart number, not every regulation listed within each table will be addressed in detail within this section. Instead, this chapter will detail and drill down into the regulatory parts that relate topically to the data collection instrument previously addressed within this section.

In Table 2.1, specific regulations within Title 14 CFR, Chapter I, Subchapter A are listed, which prescribe general requirements and lay the foundational framework for aviation language in the aviation safety regulations throughout the remainder of the 14 CFR subchapters discussed within this dissertation. Additionally, it standardizes and defines key terms used throughout the aviation industry in the United States and establishes general requirements for the industry. It also establishes safety management system (SMS) requirements for commercial air carrier operators certificated under 14 CFR Part 119 that will be discussed in detail later within this section.

Table 2.1

Definitions and General Requirements (Aeronautics and Space, 2017)

Part	Title
1	Definitions and Abbreviations
3	General Requirements
5	Safety Management Systems

Key terms defined within 14 CFR Part 1 were; aircraft, meaning a device used or intended to be used to fly in the air; and unmanned aircraft, meaning an aircraft operated without the possibility of direct human intervention from within or on the aircraft.

14 CFR Part 3 establishes general requirements regarding false and misleading statements made in records for type-certificated products and aircraft. It further defines airworthy, where Part 1 did not contain a definition of airworthy, as it pertains to the airworthiness of the aircraft. Airworthy, within §3, means that an aircraft conforms to its type design and is in a condition for safe operation. Type design is further detailed within 14 CFR Part 21, which is addressed later in this section.

14 CFR Part 5, established by the Airline Safety and Federal Aviation Administration Extension Act of 2010 (2010), or Public Law 111-216, requires commercial aircraft operators certificated under 14 CFR Part 119, and subsequently Part 121, to maintain an SMS that meets the requirement of Part 5 that is acceptable to the FAA. Key parts of an SMS referenced within the regulation are a system that contains safety policy, safety risk management, safety assurance and safety promotion.

In Table 2.2, specific regulations within Title 14 CFR, Chapter I, Subchapter B are listed which prescribe general procedural rules for the public and the FAA. In this subchapter, Part 11 applies to the administration and promulgation of aviation safety regulations, specifically the issuance, amendment, and repeal of regulations in public rulemaking by the FAA under Title 5 U.S.C., Part 1, Chapter 5, Subchapter 2, Section 553 for federal rulemaking.

14 CFR Part 13 specifies regulations for public reporting to the FAA of any violations of rules, regulations and orders, as well as the Federal Aviation Act of 1958, the Hazardous Materials Transportation Act, the Airport and Airway Development Act of 1970, the Airport and Airway Improvement Act of 1982, as well as the Airport and Airway Improvement Act of 1982.

Table 2.2

Procedural Rules (Aeronautics and Space, 2017)

Part	Title
11	General Rulemaking Procedures
13	Investigative and Enforcement Procedures
14	Rules Implementing the Equal Access to Justice Act of 1980
15	Administrative Claims Under Federal Tort Claims Act
16	Rules of Practice for Federally Assisted Airport Enforcement Procedures
17	Procedures for Protests and Contract Disputes

In Table 2.3, specific regulations within Title 14 CFR, Chapter I, Subchapter C are listed which pertain to aircraft, including rotorcraft, propeller and engine certification, as well as registration, maintenance and alterations of aircraft and aircraft components. These particular regulations lay the foundation for airworthiness and continued airworthiness of aircraft to ensure continued airworthiness.

Table 2.3

Aircraft (Aeronautics and Space, 2017)

Part	Title
21	Certification Procedures for Products and Articles
23	Airworthiness Standards; Normal, Utility, Acrobatic and Commuter Category Airplanes
25	Airworthiness Standards; Transport Category Airplanes
26	Continued Airworthiness and Safety Improvements for Transport Category Airplanes
27	Airworthiness Standards; Normal Category Rotorcraft
29	Airworthiness Standards; Transport Category Rotorcraft
31	Airworthiness Standards; Manned Free Balloons
33	Airworthiness Standards; Aircraft Engines
34	Fuel Venting and Exhaust Emission Requirements for Turbine Engine Powered Airplanes
35	Airworthiness Standards; Propellers
36	Noise Standards; Aircraft Type and Airworthiness Certification
39	Airworthiness Directives
43	Maintenance, Preventive Maintenance, Rebuilding and Alteration
45	Identification and Registration Marking
47	Aircraft Registration

14 CFR Part 21, pertains to the certification of products and articles, wherein a product is defined as an aircraft, engine or propeller, and an article is defined as an associated part or component of a product. However, §21.1 provides exception to the applicability of this regulation by excluding unmanned aircraft that are subject to §107.

During review, the researcher identified that §21 is quite extensive in safety certification language, promulgating regulatory procedural requirements for the issuance and revision of manufacturing design and production approvals, airworthiness certificates and airworthiness approvals for products and articles. This section also establishes such language as type certificate (TC) and supplemental type certificate (STC), which are associated with a product's approved type design, or properly altered type certificated state. In this section of the regulation, a TC is issued under the FAA's authority codified in Title

49 U.S.C. §44704 when the FAA Administrator determines that a product or article meets minimum standards in its design, manufacture, and performance criteria.

Similarly, under the same authority within Title 49 U.S.C. §44704, and 14 CFR Part 21, the Administrator may also issue a STC for an approved revision to a TC. It is key to note in §21.31 that a TC is issued to an aircraft under an approved type design, which contains all of the FAA approved engineering drawings, specifications, airworthiness limitations, instructions for continued airworthiness required in the associated FAR parts listed within Table 2.3 for airworthiness standards, as well as associated aircraft inspection and maintenance programs. This is noted because the definition of airworthy requires an aircraft to meet its type design, as noted in 14 CFR Part 3.

Although specific airworthiness standards listed in Table 2.3 for FAR Parts 23 through 33 are only applicable to other than unmanned aircraft, §21 is noted to be the foundational certification regulation for the types and categories of aircraft listed within §23 through §33. And, these FAR parts also establish airworthiness standards for a specific aircraft category's; aerodynamics, performance, and flight characteristics; controllability and maneuverability; structural loading, design and construction requirements specific to the category of aircraft; powerplant, system and equipment requirements; as well as aircraft operating limitations.

14 CFR Part 39 establishes airworthiness directive rules that are applicable to products and issued by the FAA under two conditions; when a product has an unsafe condition, malfunction or deficiency; and the condition, malfunction, or deficiency exists, or has the propensity to occur in aircraft having the same type design.

14 CFR Part 43 prescribes requirements for the maintenance, preventive maintenance, rebuilding, alteration, inspection, and recording of such actions in aircraft, engine and propeller maintenance and inspection logbooks. It also describes persons authorized to perform such actions and requirements for approval for return to service. However, it was noted during review by the researcher, that this regulation is not applicable to aircraft subject to regulations contained within §107, which will be detailed later in this chapter.

14 CFR Parts 45 and 47 establish marking and registration requirements for products, articles, and life-limited parts. Markings addressed within Part 45 refers to such markings on products and articles that ensure traceability to a product's or article's type design and ensure they are readily identifiable, and more especially identifiable following an accident, and any resultant fire or other damage. This regulation is applicable to aircraft having a type certificate, thus precluding unmanned aircraft subject to §107.

Registration of aircraft in accordance with 14 CFR Part 47 is required for operating aircraft within the United States, with the exception of certain aircraft operated by government agencies. This section also establishes requirements for proof of ownership and citizenship. Specific registration requirements for small unmanned aircraft in 14 CFR Part 48 will be addressed later in this chapter.

Table 2.4 lists 14 CFR, Chapter I, Subchapter D regulations promulgated for the certification of airmen who are otherwise defined as pilot flight crewmembers, non-pilot flight crewmembers, and airmen who are not flight crewmembers. These regulations specify minimum airmen qualification and proficiency requirements to ensure safe aircraft operations.

Table 2.4

Airmen (Aeronautics and Space, 2017)

Part	Title
60	Flight Simulation Training Device Initial and Continuing Qualification and Use
61	Certification: Pilots, Flight Instructors, and Ground Instructors
63	Certification: Flight Crewmembers Other Than Pilots
65	Certification: Airmen Other Than Flight Crewmembers
67	Medical Standards and Certification
68	Requirements for Operating Certain Small Aircraft Without a Medical Certificate

14 CFR Part 61 prescribes regulations for pilots, flight and ground instructors for manned aircraft operations. With the exception, §61.1 states the rules governing airmen under this part do not apply to those under §107. Similarly, §61.8 states the inapplicability to apply operations under §107 as a justification the meet the requirements under §61. These regulations detail rules for pilot certification, aircraft type and instrument ratings, minimum flight hours, qualification training in flight simulators and flight training devices that are detailed in §60, penalties for drug and alcohol abuse, standards for knowledge and practical tests, recording of flight time in pilot logbooks, specific medical qualifications, proficiency checks, and penalties for falsification of records. The airmen addressed in this part were found to be student pilots, recreational pilots, private pilots, commercial pilots, air transport pilots, flight instructors, ground instructors, and sport pilots.

14 CFR Part 63 prescribes airmen standards for non-pilot flight crewmembers; flight engineers and navigators. This part specifies rules for related certifications and aircraft type ratings, penalties for drug and alcohol abuse, eligibility and minimum qualifications, knowledge and skill requirements, testing, and approved training courses.

14 CFR Part 65 prescribes airmen standards for non-flight crewmembers; air traffic control (ATC) tower operators, aircraft dispatchers, mechanics, repairmen, and parachute

riggers. This part specifies rules for; eligibility and certification; written, oral and practical test standards; skill requirement; recency of experience, ratings and privileges; authorization; limitations of privileges and certifications; type ratings; and, performance standards.

14 CFR Part 67 prescribes airmen medical standards and certification; first-class, second-class, and third-class. These standards require; application; medical examination by an aviation medical examiner who is approved by the FAA; pass specific eye, ear, nose, throat and equilibrium standards; meet mental, neurological, cardiovascular and general health standards; and maintain specific health records in order to maintain a specific medical certificate for the airmen certificate being sought.

In this section of the review of literature, it was noted that 14 CFR Part 68.1 prescribes an exception to the medical certification requirements of §67 for pilots who operate small aircraft, also known as basic med. It was also noted this part became effective May 1, 2017, a date after the researcher conducted this research. This regulation lessens the restrictions found in previous requirements. And, the part also allows operators of small aircraft to operate such aircraft in accordance with §61.113(i) without holding a valid medical certificate issued under §67. However, specific conditions under §61.113(i) must be satisfied to operate under this rule. In accordance with §68, the operator must complete an approved medical education course, obtain a comprehensive medical examination, and certify in writing that the operator has no disqualifying medical condition that would cause them to operate an aircraft in an unsafe manner. Additionally, in order to operate without a valid medical certificate, the following conditions must be met under §61.113(i):

- The operator must hold a valid driver's license issued within the United States,
- the aircraft is certified for six occupants or less, and has a maximum take-off weight of 6,000 pounds,
- the aircraft is operated with a maximum of five passengers on board,
- the aircraft is operated at 18,000 feet or below,
- the aircraft is operated within the U.S. unless authorized in a country outside U.S.,
- the aircraft does not exceed 250 knots, and
- the pilot logbook is in possession of the pilot.

Table 2.5 lists 14 CFR, Chapter I, Subchapter E regulations promulgated for classification and use of the national air space (NAS). Part 71, administered by FAA Order 7400.11A dated August 3, 2016, classifies the NAS into six categories with six distinct reporting points. While, §73 and §77 designate special use airspace and rules for safely using the navigable airspace. It was noted by the researcher that regulations for governing airspace were complex. As a result, the researcher sought and found further guidance published by the FAA within FAA Order 7400.11A, and FAA Handbook FAA-H-8083-254B H-80, which further explained and interpreted these regulations.

Table 2.5

Airspace (Aeronautics and Space, 2017)

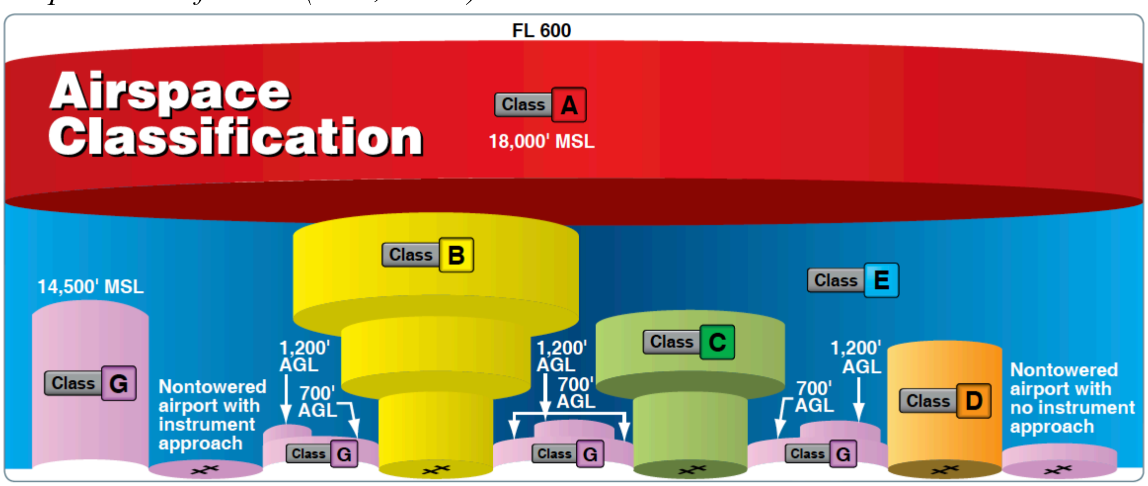
Part	Title
71	Designation of Class A, B, C, D, and E Airspace Areas; Air Traffic Service Routes; and Reporting Points
73	Special Use Airspace
77	Safe, Efficient Use, and Preservation of The Navigable Airspace

From Figure 2.1, the reporting points are defined in FAA Order 7400.11A, paragraph 1001, as physical geographic locations in which aircraft positions must be reported and applies to all directions of flight (FAA, 2016a). It is noted that these regulations and the supporting FAA administrative order exist for the purposes of air traffic control, to include prevention of mid-air collisions.

The six categories of air space delineated in §71 are Class A, B, C, D, E, and G. At the time of this research, the FAA did not publish a Class F airspace within the §71. Classification of these areas are illustrated in Figure 2.1, as reflected in Chapter 15 of FAA Handbook FAA-H-8083-254B titled, airspace.

Figure 2.1

Airspace Classification (FAA, 2016c)



Class A airspace, further detailed within FAA Order 7400.11A, paragraph 2000, is defined as the airspace from 18,000 feet mean sea level (MSL) to flight level (FL) 600, and it was noted by the researcher in review of this order that all aircraft operators must operate in accordance with instrument flight rules (IFR) and comply with 14 CFR Part 91.135 for general operating rules within Class A airspace (FAA, 2016c). Operations in accordance with §91.135 require specific aircraft communication and navigation equipment, as well as specific clearance and authorizations from ATC. The researcher identified Class A airspace to be most restrictive, with lessening of restrictions from Class B to G, with Class G airspace having the least restrictions. The associated FAA handbook and airspace chapter contains similar language in the definition of Class A airspace and states it includes the airspace extending 12 nautical miles (NM) from the coast of the 48 contiguous states, to include Alaska (FAA, 2016c).

Class B airspace is defined by subpart B, paragraph 3000, of the order. This airspace is dependent upon the location near specific major commercial airports (typically a defined radius around the airport) within specific major cities that are listed in the order, the distance from the surface of the ground, and ceiling limit of MSL height. Additionally, operations within these areas require minimum qualifications for the pilot, associated adherence to specific operating rules, ATC clearance and authorizations, as well as specific aircraft communication and navigation equipment in accordance with 14 CFR 91.131 general operating rules for Class B airspace (FAA, 2016c). It was identified by the researcher that operators are primarily responsible for determining the classification of airspace in which they operate and must adhere to specific operating requirements.

The associated FAA handbook and airspace chapter define Class B airspace to generally include the airspace existing from the surface of the ground to 10,000 feet MSL around (typically a defined radius around the airport) the nation’s busiest airports (FAA, 2016c).

Class C airspace is defined by subpart C, paragraph 4000, of FAA Order 7400.11A. These areas consist of cities/airports that are considered other-than-major commercial airports, also called primary airports, located in cities in Class C airspace. These cities are listed within the order and detailed in this section. Aircraft operators in Class C airspace are subject to the general operating rules under §91.130. Similar to Class B airspace, Class C airspace is also defined by the distance from the surface of the ground (typically a defined radius around the airport), and ceiling limit of MSL height. It was noted by the researcher that, although the order maintains a complete list of cities/primary airports located in Class C airspace, the list is too exhaustive and of no added benefit or value to list here in its entirety. Instead, the researcher presents the fact that it is incumbent upon any aircraft operator to know the specific airspace in which they intend to operate.

The associated FAA Handbook, FAA-H-8083-254B, further clarifies and defines Class C airspace in chapter 15 as the existing airspace from the surface of the ground to 4,000 feet MSL around affected airports (typically a five NM radius around the airport), which host an operational air traffic control tower that is serviced by ATC radar approach control, and has a specific number of IFR operations or passenger enplanements (FAA, 2016c). Additionally, operators must maintain two-way radio communications with ATC while operating in this airspace.

Class D airspace is defined by subpart D, paragraph 5000, of FAA Order 7400.11A. Operators of aircraft within this airspace are subject to the requirements of 14 CFR 91.129 and each area within this airspace contains at least one primary airport as listed within the order. It was noted by the researcher that, although the order maintains a complete list of areas located in Class D airspace, the list is too exhaustive and of no added benefit or value to list here in its entirety. Instead, the researcher presents the fact that it is incumbent upon any aircraft operator to know the specific airspace in which they intend to operate.

The associated FAA Handbook, FAA-H-8083-254B, further clarifies and defines Class D airspace in chapter 15 as generally including the airspace from the surface of the ground to 2,500 feet MSL surrounding affected airports hosting an operational air traffic control tower. Additionally, operators must maintain two-way radio communications with ATC while operating in this airspace.

Class E airspace is defined by subpart E, paragraph 6000, of FAA Order 7400.11A as controlled airspace which is not classified as A, B, C, or D. Although it does not include airspace above 18,000 feet MSL, it exists from the surface of the ground, or specified minimum altitude, to the adjacent controlled airspace. It was noted by the researcher that, although the order maintains a complete list of areas located in Class E airspace, the list is too exhaustive and of no added benefit or value to list here in its entirety. Instead, the researcher presents the fact that it is incumbent upon any aircraft operator to know the specific airspace in which they intend to operate.

The associated FAA (2016c) Handbook, FAA-H-8083-254B, further clarifies and defines Class E airspace in chapter 15 as the controlled airspace that is not classified as A, B, C, or D airspace and additionally describes it as a large amount of the airspace over the United States and includes the airspace below 14,500 feet MSL. Variations exist, however. The handbook also reveals FAA policy that depicts Class E airspace to begin at 14,500 feet MSL where no Class E base is defined and includes airspace that is 1,200 feet above ground level (AGL), which incidentally exists within most areas of the U.S. For the purposes of this paragraph, AGL is defined by the handbook as the vertical distance of an aircraft above the terrain that it extends to 17,999 feet and also the airspace above FL600. Flight level, or FL, is defined as flight above 18,000 feet. FL 600 is defined at 60,000 feet (FAA, 2016c).

Class G airspace is defined by FAA Order 7400.11A as the uncontrolled airspace that has not been classified as A, B, C, D, or E airspace. This airspace extends from the surface of the ground to Class E airspace. This airspace is not controlled by ATC and pilots must adhere to visual flight rules (VFR).

Table 2.6 lists 14 CFR, Chapter I, Subchapter F regulations promulgated for general air traffic and operating rules. Although the subchapter includes special rules for the security control of air traffic under §99, ultralight vehicles under §103, and parachute operations under §105, this section will more appropriately address §91, 93, 95, 97, and 101 as highlighted in Table 2.6. Because of the total volume of regulations contained within this subchapter, this section will highlight the subparts as they pertain to manned aircraft.

Table 2.6

Air Traffic and General Operating Rules (Aeronautics and Space, 2017)

Part	Title
91	General Operating and Flight Rules
93	Special Air Traffic Rules
95	IFR Altitudes
97	Standard Instrument Procedures
99	Security Control of Air Traffic
101	Moored Balloons, Kites, Amateur Rockets, Unmanned Free Balloons, and Certain Model Aircraft
103	Ultralight Vehicles
105	Parachute Operations

14 CFR Part 91 generally prescribes regulations promulgated for the operation of aircraft in the U.S., including the water extending three nautical miles from its coast. It applies to the person operating an aircraft and each person on board an aircraft. As it relates to this research, §91 does not apply to unmanned aircraft governed and operated in accordance with §107, except for those requirements listed in §§107.13, 107.27, 107.47,

107.57, and 107.59. These regulations will be addressed in small unmanned aircraft regulations section of this chapter.

Subparts under §91 address general aircraft operating requirements that define aircraft airworthiness, pilot in command (PIC) responsibilities, careless and reckless aircraft operations, rules prohibiting the use of drugs and alcohol, and rules that prohibit operators from transporting illicit drugs. It lists basic flight rules, containing both visual and instrument flight rules. It also lists basic aircraft equipment requirements; special types of flight operations; aircraft maintenance, preventive maintenance and alterations; requirements for foreign operators of U.S. registered aircraft outside the U.S.; procedures for regulatory waivers; and, requirements for fractional ownership of aircraft, or ownership of aircraft by more than one entity.

14 CFR Parts 93, 95, and 97 generally prescribe regulations promulgated for special air traffic, altitude standards, and instrument flight rule (IFR) altitudes. Special air traffic rules under §93 detail specific rules, definitions, descriptions of flight areas, operating procedures, types of operations (aircraft or rotorcraft), communication procedures, reservation and allocation of landing and take-off slots at high density airports, minimum altitudes, clearance procedures, special rules for commercial operations, filing of flight plans, visual flight rules, and instrument flight rules for special air traffic areas.

14 CFR Part 95 prescribes regulations for aircraft operating under IFR in air traffic routes controlled by ATC. These areas also include certain mountainous areas of the U.S. to include the states of Alaska and Hawaii, and the territory of Puerto Rico. Part 97 prescribes regulations for obstacle departure procedures and weather minimums applicable

to takeoffs under IFR at civil airports; and, standard instrument approach procedures and weather minimums applicable to landing IFR at civil airports.

14 CFR Part 101 prescribes regulations promulgated for operating moored balloons, kites, amateur rockets, unmanned free balloons, and model aircraft. Because this regulation is similar to the small unmanned aircraft regulations listed in §107, each type of aircraft defined in the applicability section of §101.1 will be detailed here, and the remaining regulations within §101 will be briefly examined in the subsequent paragraphs of this sections.

- A moored balloon is a device that is moored, or anchored by attachment, to the ground or an object, and is at least six feet in diameter, or has at least a 115-cubic foot gas capacity. 14 CFR Part 1.1 defines a balloon as a lighter-than-air aircraft, not driven by an engine, but instead sustains flight by use of gas or heater to maintain buoyancy.
- A kite is device intended to be flown with a similar rope-like, or string-like, attachment and weighs a maximum of five pounds. 14 CFR Part 1.1 defines a kite merely as a paper, cloth, metal or other material covered framework, which is flown at the end of a rope or cable.
- An amateur rocket is any amateur rocket, except those types used for aerial display such as aerial fireworks. 14 CFR Part 1.1 maintains a more thorough definition, and §101.1 provides reference to it. It further defines an amateur rocket as an unmanned rocket propelled by a motor or motors having a total impulse of no more than 889,600 Newton-seconds (combined), which can fly no higher than 150 kilometers from the ground.

- An unmanned free balloon is defined as a balloon that is not moored and carries a payload package of the required regulatory size and weight limitations and is suspended by a rope-like device from the balloon.
- A model aircraft is defined as an aircraft that meets §101.41 and is capable of sustained flight. Additionally, it is capable of being flown by the operator under visual line of sight conditions, being flown for the purposes of recreation or hobby, and not commercial purposes. Further definition listed within §101.41 generally limits the weight of a model aircraft to 55 pounds, requires the aircraft to be operated in accordance with community or nationally recognized organizational and operational standards, so as not to interfere with manned aircraft within the airspace, and requires the operator to notify an airport operator and ATC tower when the aircraft is operated within five miles from an airport.

Exceptions to these definitions apply, detailed in §101.7, stating that no one may operate any of the types of aircraft in a manner that is hazardous, which could harm other persons or property. Similarly, no one may drop objects from these types of aircraft if the potential exists for harm to other persons or property.

Further detailing these regulations throughout §101, the researcher identified that certain restrictions exist disallowing operators from operating these aircraft within prohibited and restricted areas, limiting aircraft altitude without ATC authorization dependent upon the type of aircraft, and requiring specific equipment and marking requirements dependent upon the type of aircraft.

Table 2.7 lists 14 CFR, Chapter I, Subchapter G regulations promulgated for aircraft operations by commercial air carriers and operators holding out for compensation or hire. The researcher found these regulations to be quite extensive in regulating safe operations of commercial passenger transportation, cargo operations, and other types of commercial aircraft operations. The regulations detail applicability of each part to the type of commercial operation, define terminologies used in each of these parts, establish requirements for flight duty times and rest periods for flight crew under certain types of commercial operations, and establish requirements for drug and alcohol testing of airmen.

These parts also establish certification and operating requirements of air carriers and commercial operators, certification and operating requirements for owner/operators of large aircraft that have a 20 or more seating capacity, foreign air carrier operating requirements, rotorcraft operating requirements involving external-load lifting and carrying operations, operating requirements for small commercial on-demand and commuter operations, commercial air tours, agricultural operations, and certification of airports for operations under these parts. This section will detail these regulations as it applies to the topics of this dissertation, the main research questions, and the data collection method used to interview research subjects.

Table 2.7

Air Carriers and Operators for Compensation or Hire (Aeronautics and Space, 2017)

Part	Title
110	General Requirements
117	Flight and Duty Limitations and Rest Requirements: Flight crew Members
119	Certification: Air Carriers and Commercial Operators
120	Drug and Alcohol Testing Program
121	Operating Requirements: Domestic, Flag, and Supplemental Operations
125	Certification and Operations: Airplanes Having a Seating Capacity of 20 or More Passengers or a Maximum Payload Capacity of 6,000 Pounds or More; and Rules Governing Persons on Board Such Aircraft
129	Operations: Foreign Air Carriers and Foreign Operators of U.S.-Registered Aircraft Engaged in Common Carriage
133	Rotorcraft External-Load Operations
135	Operating Requirements: Commuter and On Demand Operations and Rules Governing Persons on Board Such Aircraft
136	Commercial Air Tours and National Parks Air Tour Management
137	Agricultural Aircraft Operations
139	Certification of Airports

14 CFR Part 110 lists definitions of key terms and abbreviations for commercial aircraft operations used interchangeably across any of the parts listed within Subchapter G. It is key for the purposes of this dissertation to note that §110.1 specifically defines an unmanned aircraft as being operated without direct intervention from a person inside the aircraft.

14 CFR Part 117 contains regulations that establish requirements for a flight crew's flight and duty limitations, flight crew rest periods, and are applicable to conducting commercial passenger transportation under §121. The regulation also requires §121 operators to establish and maintain a fatigue education and awareness training program. And, requires these operators, if not meeting these minimum requirements, to obtain approval from the FAA to prevent fatigue related accidents and incidents.

It is noted by the researcher that Title 49 CFR Part 830.1 defines an aircraft accident as an occurrence associated with the operation of an aircraft which takes place between the time any person boards the aircraft with the intention of flight and all such persons have disembarked, and in which any person suffers death or serious injury, or in which the aircraft receives substantial damage (Notification and Reporting of Aircraft Accidents General Applicability, 2015). The definition also includes unmanned aircraft accidents, and the regulation further defines an incident as an occurrence other than an aircraft accident.

14 CFR Part 119 contains regulations promulgated for the certification of air carriers and commercial operators under §121, §125 and §135. The regulations establish requirements for approved operations specifications, or operational approvals by the FAA, a safety management system meeting §5 requirements, maintaining a principle base of operations, aircraft leasing arrangements, deviation requirements, minimum management personnel positions and descriptions, as well as minimum qualification requirements for management personnel. This part is not applicable to unmanned aircraft operations under §107.

14 CFR Part 120 contains regulations promulgated for the administration of drug and alcohol testing of pilots operating aircraft under §119, and air traffic controllers. This part also prescribes penalties prohibiting the use of drugs and alcohol by such pilots and air traffic controllers, as well as refusal to submit to drug and alcohol testing by these airmen, as well as airmen certificated under §63 and §65. Additionally, the part prescribes requirements for drug and alcohol testing programs administered by employers of each of the applicable airmen under this part.

The following regulations under Subpart G were noted to be specific to regulating the safety of commercial passenger transport operations of 9 or less passengers and those operations in excess of 9 passengers, as well as transporting air cargo.

- 14 CFR Part 121 Operating Requirements: Domestic, Flag, and Supplemental Operations
- 14 CFR Part 129 Operations: Foreign Air Carriers and Foreign Operators of U.S.-Registered Aircraft Engaged in Common Carriage
- 14 CFR Part 135 Operating Requirements: Commuter and On Demand Operations and Rules Governing Persons on Board Such Aircraft

These regulations prescribe rules for the certification to operate, and the FAA's approval of operational routes. Additionally, the regulations prescribe rules for establishing a quality and operations manual system for safely operating and maintaining control of operations and maintenance of aircraft, which require specific manual contents. Aircraft requirements, to include minimum aircraft instrument and equipment items, safety items, maintenance procedures, preventive maintenance procedures, alterations procedures, overhaul schedules, life limited component replacement schedules, airworthiness return to service requirements, and aircraft operating limitations are detailed within the regulation.

Similar to aircraft requirements, the regulations also detail airmen and crewmember certification, minimum crew numbers, crew member training and qualifications, flight and duty time limitations, and rest times. These regulations also detail required records and records retention requirements for all aircraft maintenance, aircrew flight records and training, loading, dispatch records, flight releases, airworthiness releases for maintenance actions, as well as FAA operating approvals and authorizations, and certification records.

The following regulations under Subpart G prescribe requirements for the safety of manned aircraft operations that involve specialty use of smaller aircraft and rotorcraft in certain types of operations. These regulations establish operating rules and require certain certification requirements in order to conduct approved aircraft operations; require specific pilot qualification, certificate, rating, and training requirements; aircraft airworthiness and maintenance requirements; and, with the exception of operations under §136, preclude the transportation of passengers. It was noted by the researcher that unless otherwise noted by these regulations to establish more restrictive operating requirements, minimum requirements under §91, general operating and flight rules, still applies.

- 14 CFR Part 133 Rotorcraft External-Load Operations
- 14 CFR Part 136 Commercial Air Tours and National Parks Air Tour Management
- 14 CFR Part 137 Agricultural Aircraft Operations

14 CFR Part 139 prescribes regulations for the certification of airports, applicable to airports serving scheduled passenger-carrying air carriers with a seating capacity of 9 or more passengers, as well as unscheduled passenger-carrying operations with a seating capacity of 31 or more passengers. In addition to the certification requirements, these regulations also prescribe rules for safe airport operations that covers facilities, equipment, navigational aids, personnel, inspection, records, and records retention. The regulation also details requirements for developing and maintaining a current airport certification manual, which must contain specific content items that includes a grid map of the airport layout, a description of the aircraft movement areas, procedure to avoid interruption or failure of facilities and navigational aids supporting aircraft when maintenance on facilities and

navigational aids are being conducted, procedures for maintaining improved and unimproved surfaces, procedures for maintaining airport marking and signage, as well as the airport emergency plans and procedures.

Table 2.8 lists 14 CFR, Chapter I, Subchapter H regulations promulgated for certifying and regulating pilot schools and training centers, as well as aviation maintenance schools and aircraft maintenance repair stations.

Table 2.8

Schools and Other Certificated Agencies (Aeronautics and Space, 2017)

Part	Title
141	Pilots Schools
142	Training Centers
145	Repair Stations
147	Aviation Maintenance Technician Schools

14 CFR Part 141 prescribes regulations for pilot schools, which formally train pilots. These regulations detail issuance of pilot school certificates by the FAA, and issuance of ratings for recreational, private, commercial, and air transport pilot courses, as well as instrument and aircraft type ratings. Additional ratings for flight and ground school instructor courses, and refresher courses in each category are also detailed. The regulation is specific in detailing requirements for the qualifications, experience, minimum flight hours, and certification requirements of airmen conducting training for the pilot school, as well as the required aircraft and airport facilities needed to conduct approved training. The regulation also details operating rules, records and record retention, and FAA approval of the pilot school course curriculum.

Similar to pilot schools, 14 CFR Part 142 lists regulations promulgated for the certification and operation of pilot training centers that conduct training in flight training devices, advanced flight training devices, and aircraft simulators as an alternate means of aircraft flight training under §§61, 63, 65, 91, 121, 125, 135, and 137. The regulation lists requirements, which are similar to §141, for airmen, facilities, training devices and equipment, operating rules, records and records retention, and course curriculum, in order to regulate the safety and quality of pilot training.

14 CFR Part 147 also contains requirements for formally training aircraft mechanics. This part lists similar requirements as §141 and §142 for FAA approval and certification to conduct training, maintaining adequate facilities and equipment for instruction, as well as teaching an approved curriculum to ensure the safety and quality of curriculum taught to aircraft maintenance technicians.

14 CFR Part 145 provides regulations for the safety and quality of maintenance conducted by certificated repair stations. These regulations for air agencies are applicable to repair stations that perform maintenance, preventive maintenance, major repairs and alterations on aircraft, engines, propellers, and components in accordance with §43, as well as in accordance with the maintenance and maintenance schedule requirements under §91, and §121 and §135 for maintenance conducted on commercial passenger aircraft.

These regulations prescribe rules for management personnel, supervisory positions, persons making airworthiness return to service determinations, quality and final inspections. Additionally, the regulations detail the quality and appropriateness of facilities, equipment and materials used in performing maintenance under these parts, as well as operating rules that include maintaining a current and FAA accepted repair station manual and quality control manual with the required content items for conducting operations, as well as a training program approved by the FAA.

With the exception of §153, Table 2.9 lists 14 CFR, Chapter I, Subchapter I regulations promulgated for administrative regulations for airports that were not considered by the researcher to directly impact aviation safety. These regulations, by title, are listed within Table 2.9.

Table 2.9

Airports (Aeronautics and Space, 2017)

Part	Title
150	Airport Noise Compatibility Planning
151	Federal Aid to Airports
152	Airport Aid Program
153	Airport Operations
155	Release of Airport Property from Surplus Disposal Restrictions
156	State Block Grant Pilot Program
157	Notice of Construction, Alteration, Activation, and Deactivation of Airports
158	Passenger Facility Charges
161	Notice and Approval of Airport Noise and Access Restrictions
169	Expenditure of Federal Funds for Nonmilitary Airports or Air Navigation Facilities Thereon

However, the researcher noted that §153 contained language directly requiring free and uninterrupted, or unrestricted, access to public-use airports by FAA inspectors on official business while bearing a current FAA inspector credential, otherwise known as an FAA Form 110A credential and badge. This access includes secured and restricted areas of the airport. The researcher notes the implications of these regulations are to grant FAA inspectors such access in order to inspect and surveil regulated aircraft operators, airmen and aircraft for compliance to applicable aviation safety regulations.

Table 2.10 lists 14 CFR, Chapter I, Subchapter J regulations promulgated under §170 for the establishment and discontinuance criteria for navigation aids operated and maintained by the United States, and non-federal navigation facilities under §171.

Table 2.10

Navigation Facilities (Aeronautics and Space, 2017)

Part	Title
170	Establishment and Discontinuance Criteria for Air Traffic Control Services and Navigational Facilities
171	Non-Federal Navigation Facilities

Regulations under §170.3 sets forth rules for the establishment of air traffic control towers (ATCT) after certain qualifications are met, which includes the requirement for the airport to be open to the public, whether public or privately owned. Additionally, the airport owners or authorities must guarantee that the airport will be open for a period of time to amortize the cost of establishing the ATCT, and land must be furnished to the FAA without cost to develop the ATCT. Discontinuance of FAA funded service to an ATCT, or the withdrawal of an ATCT from the airport as defined by §170.3, occurs when the ATCT operations and maintenance costs exceed the present value of the ATCT as detailed with §170.15.

14 CFR Part 171 prescribes rules for the request, minimum certification requirements, approval, installation, maintenance and operations, and performance requirements for very-high-frequency (VHF) omnidirectional range (VOR) facilities, non-directional radio beacon facilities, instrument landing system (ILS) facilities, simplified directional facilities, distance measuring equipment (DME), VHF marker beacon systems, and microwave landing systems (MLS).

Table 2.11 lists 14 CFR, Chapter I, Subchapter K regulations promulgated for administrative functions of the FAA. With the exception of §183, the researcher notes that these regulations do not appear to directly affect aviation safety. It was identified by the researcher that the FAA designates, or delegates, some of its responsibilities, in accordance with its authority and administrative rules under §183, to private persons who act as representatives of the FAA Administrator. The designees perform such FAA functions as examining, inspecting, and testing airmen and airmen applicants, and aircraft in order to issue applicable FAA certificates and certifications. These regulations specify minimum qualifications, testing, certification, privileges, and oversight of the following designees; aviation medical examiners, pilot examiners, technical personnel examiners, designated aircraft maintenance inspectors, designated engineering representatives, designated manufacturing representatives, and designated airworthiness representatives. These regulations also detail organizational designation authorizations for delegation to other than private persons to conduct designated functions on behalf of the FAA.

Table 2.11

Administrative Regulations (Aeronautics and Space, 2017)

Part	Title
183	Representatives of the Administrator
185	Testimony by Employees and Production of Records in Legal Proceedings, and Service of Legal Process and Pleadings
187	Fees
189	Use of Federal Aviation Administration Communication Systems
193	Protection of Voluntarily Submitted Information

Table 2.12 lists 14 CFR, Chapter I, Subchapter N regulations promulgated for aviation insurance. Though these regulations do not directly affect aviation safety, the researcher noted the regulations establish liability for hull losses, as well as injury and other property damages related to accidents and associated accident causes, which have resulted in regulations establishing the eligibility, basis, types, and types of coverages for such losses.

Table 2.12

War Risk Insurance (Aeronautics and Space, 2017)

Part	Title
198	Aviation Insurance

After conducting a thorough review of literature of Title 14 CFR, Chapter I, Subchapters A through N, aeronautics and space regulations, as detailed in Tables 2.1 through 2.12, the researcher found that extensive regulations were published by the FAA for the purposes of regulating the safe operation of aircraft, specifically manned aircraft for the purposes of transporting passengers and cargo. It is expected that certificated airmen and operators, from novice to expert, should have a thorough knowledge of these regulations, or the familiarity to research these regulations and apply them. However, it is expected that non-aviators may or may not have a similar level of knowledge of these regulations, or the familiarity to research and apply them.

Small Unmanned Aircraft Regulations

It was identified by the researcher during review of Title 14 CFR, Chapter I, Subchapters A through N, aeronautics and space regulations, that numerous aircraft, airmen, certification, and operations regulations were published at the time of this research. However, few regulatory parts were observed to be specifically written to regulate the operation of civil UAS, in comparison to manned civil aviation regulations.

As a result, the researcher sought to determine if existing UAS regulations addressed whether; UAS were as technically reliable and safe as manned aircraft; UAS were licensed the same as manned aircraft; UAS operators were licensed and trained the same as manned aircraft pilots; UAS were allowed to operate in the same airspace as manned aircraft; UAS mechanics were licensed the same as manned aircraft mechanics; and, if UAS were required to be maintained the same as manned aircraft.

Tables 2.13 and 2.14 detail Title 14 CFR, Chapter I, Subchapters C and F, aeronautics and space regulations that are specific to UAS, more respectively to small UAS, as adapted from the Government Printing Office’s electronic CFR website (Aeronautics and Space, 2017). However, prior to detailing these parts within Tables 2.13 and 2.14, the researcher notes that §91 generally prescribes regulations promulgated for the operation of manned aircraft in the U.S., including the water extending three nautical miles from its coast. It also applies to the person operating an aircraft and each person on board an aircraft. As it relates to this research, the researcher found that §91 does not apply to unmanned aircraft governed and operated in accordance with §107, except for those requirements listed in §§107.13, 107.27, 107.47, 107.57, and 107.59.

Table 2.13

Aircraft: UAS Specific (Aeronautics and Space, 2017)

Part	Title
48	Registration and Marking Requirements for Small Unmanned Aircraft

Table 2.14

Air Traffic and General Operating Rules: UAS Specific (Aeronautics and Space, 2017)

PART	TITLE
107	Small Unmanned Aircraft Systems

In Table 2.13, 14 CFR Part 48 Subpart A details the FAA’s general registration and marking requirements for small unmanned aircraft as defined by §1.1, as well as the definition listed within Chapter I of this dissertation. This regulation requires UAS operators to meet the registration and marking requirements of either §48, or alternatively meet the registration requirements of §47 and the marking requirements of §45 previously discussed in this chapter. For the purposes here, registration means the UAS operator submits the proper application for registration and aircraft registration number from the FAA. This regulation further requires small UAS registered within the U.S. and operated outside of the U.S. to meet the same alternative registration and marking requirements of §47 and §45.

Two sections within §48 list compliance dates in which hobbyist and commercial operators who operate small UAS must register and mark their small UAS. Specifically, §48.5 requires hobbyist who operate small UAS as model aircraft and have been doing so prior to December 21, 2015, must have complied with the registration and marking requirements of either §§47 or 48 by February 19, 2016. For all other hobbyist operators of small UAS, compliance became mandatory prior to operation once the regulation became effective and after February 19, 2016.

For other than hobbyist operators of small UAS, the regulation required authorized small UAS operators to comply with the §47 registration and marking requirements once the regulation became effective in December of 2015. However, beginning March 31, 2016, small UAS operators were afforded the option of complying with §48 instead of §47.

Certain requirements were observed in §48 for a person who operates a small UAS to be eligible for registration under this part. To be eligible registration, one of the following items must be met in accordance with §48.15. The UAS must be appropriately registered and marked with the registration number by its owner. Or, the UAS must weigh less than 0.55 pounds. Or, the UAS must be owned and operated by the U.S. Department of Defense. This part establishes rules for three types of operators; model aircraft operators, other than model aircraft operators, and small UAS operated by the U.S. Department of Defense.

To be eligible for registration under §48.20; the small UAS must not be registered in another country; it must be owned by a citizen or legal resident of the U.S., or a foreign company that is doing business and operating within the U.S.; or, is a UAS that is owned by the U.S., state or local government. Owners must also comply with registration by completing required application forms, and submission requirements, unless the owner is less than 13 years old. If the owner is less than 13 years old, §48.25 simply requires a person at least 13 years old to register the small UAS for the person under 13 years old. The researcher observed that the fees associated with registration were $5 per small UAS under §48.30.

Following the general registration and marking requirements of Subpart A to §48, Subpart B contained detailed instructions for certificates of registration for both model aircraft operators and other than model aircraft operators. This subpart lists detailed application requirements under §48.100, as well as requirements for maintaining current application information required by §48.100, which includes the name and physical address information of the registered owner, and the renewal requirements.

This subpart also includes the marking requirements previously mentioned within this section. Specifically, §48.205 lists the required display and location of the registration number issued by the FAA, which requires the owner to maintain the registration number in a legible condition, attach it to the aircraft in a method that ensures it remains attached while the aircraft is being operated, ensure the registration number is available for inspection and that it is visible and accessible without the use of a basic tool to access and view it should it be located inside a compartment.

Because §48 allows for alternative registration in accordance §47 and marking in accordance with §45, this paragraph will briefly contrast the two methods. The researcher found the registration methods, or the application and request for registration and associated registration number, to be similar between manned aircraft and small UAS. However, in contrast to the marking requirements for small UAS listed in §48.205, the marking requirements for aircraft under §45.11 were observed to be starkly different. This regulation not only addresses marking requirements for the registration number issued by the FAA, but also specific aircraft manufacturer information. Manufacturer marking will be covered first.

Specifically, §45.1 requires aircraft manufactured under certain sections of §21 to be marked with aircraft manufacturer information on a fireproof identification plate that contains the name of the manufacturer, its aircraft model number, its aircraft serial number, the FAA type certificate number if the aircraft was manufactured under a type certificate number, as well as its production number. The regulation also requires the fireproof plate to be secured in a way that it would not likely become unreadable, be removed or destroyed during normal operation of the aircraft, or become illegible or removed as a result of an accident and any associated accident forces or fire. The regulation also requires this fireproof plate to be located and securely attached to the exterior surface of the fuselage of the aircraft at or near its tail section as defined in the regulation.

Slight differences for the required information on, and location of, the data plate for manned free balloons, aircraft manufactured prior to March 7, 1988, powered parachutes and weight-shift-control aircraft are listed within §45 due to aircraft design differences and criteria.

14 CFR Part 45 Subpart C also specifies regulations for nationality and registration marks. The researcher observed this part to be different than the registration and marking requirements under §48.205. Under §45.21 general requirements, aircraft operators are prohibited from flying aircraft without legible nationality and registration marks that are permanently affixed to the aircraft in colored contrast to their background.

In contrast to §48 marking requirements for small UAS previously mentioned, §§45.23, 45.25, 45.27, and 45.29 establish the requirements for manned aircraft that an operator must display the aircraft registration number in the following manner:

- With a capital letter "N" preceding the registration number issued by the FAA. This configuration is also referred to as the N-number.
- For limited, restricted, light-sport, experimental, or provisionally certificated aircraft, a special capital letter must follow the N-number, and the word limited, restricted, light-sport, experimental, or provisional must be displayed near the cockpit in two to six-inch letters.
- On fixed-wing aircraft, the N-number must be located horizontally on both sides of the fuselage between the wing's trailing edge and the horizontal stabilizer's leading edge, or horizontally on the vertical tail surfaces. N-numbers may also be located horizontally on engine nacelles when the nacelles are located where N-numbers are supposed to be located on fuselage surfaces.
- On rotorcraft, the N-number must be located horizontally on both surfaces of the cabin, fuselage, boom, or tail section of the craft.

- On airships, or blimps, the N-number must be located horizontally on the right horizontal stabilizer's upper surface, and on the left horizontal stabilizer under surface, with the top of the N-number aligned parallel with the leading edge of the stabilizers.
- On balloons, N-numbers must be located on each side of the balloon's envelope, at its maximum horizontal circumference for spherical balloons, and its maximum cross section for non-spherical balloons.
- On weight-shift-control aircraft and powered parachutes, N-numbers must be located on opposite locations of the aircraft fuselage.
- The height of N-number lettering on fixed-wing aircraft must be 12-inches or taller, except for aircraft manufactured before January 1, 1983 which may have two-inch lettering until the aircraft are repainted or the N-numbers are changed or replaced.
- The height of N-number lettering on gliders must be three inches or taller.
- The height of N-number lettering on certain experimental aircraft certificated under §21.191 may be three-inches or taller, when the aircraft has a maximum airspeed that does not exceed 180 knots.
- The height of N-number lettering on airships and balloons, as listed above, must be three-inches or taller.
- The height of N-number lettering on rotorcraft must be 12-inches or taller, except rotorcraft manufactured before December 31, 1983 may have smaller lettering in accordance with §45.29(b)(3) until the rotorcraft is repainted or the N-numbers are changed or replaced.

- The width of N-number letters must be two-thirds as wide as the letter's height. There are exceptions for the number 1, and the letters M and W. The number 1 must be one-sixth as wide as the number's height and the letters "M" and "W" may be as wide as the letter's height.

In comparison, registration and identification requirements for small UAS are less stringent than for manned aircraft, in part due to their size. Overall, the researcher interprets §48 to be promulgated for the safety of the NAS through the registration and identification of small UAS by minimally holding these operators accountable, with traceability to the owner in the event of an unsafe operation or accident. It is noted that, in addition to §107 small UAS operators, even hobbyists are required to comply with registration and identification regulations, and are required to pay a registration fee.

In Table 2.14, 14 CFR Part 107 details the FAA's air traffic and general operating rules for small unmanned aircraft systems. Within Subpart A, general requirements are specified that determine applicability of the regulation, definitions, penalties for falsification of records or application for certificates, demonstration of compliance to §107 regulatory requirements, and accident reporting.

This regulation applies to civil UAS operated in the U.S., but does not apply to commercial air carrier operations, a model aircraft subject to §101 previously addressed in this dissertation, or operations conducted in accordance with an FAA approved exemption. The researcher notes that an operator may elect to comply with §101 model aircraft regulations instead of §107 small UAS regulations if the following conditions are met under §101.41 and §101.43. The aircraft must be operated recreationally under visual line of sight conditions and not for commercial purposes. The aircraft must weigh no more than

55 pounds unless it is designed and tested in accordance with a community-based organization's set of safety standards. The aircraft must be operated in accordance a community-based organization's nationally recognized and administered set of operating standards. The aircraft must not be an endangerment to the NAS, and must avoid other manned aircraft. And, when operated within five miles from an airport, the operator must notify the airport and the applicable ATC tower or center. To administer §107, the FAA incorporated key definitions.

- A control station, which is an aircraft subsystem device used by the operator to control the small UAS's flight path.
- A small unmanned aircraft, which is an unmanned aircraft that weighs less than 55 pounds at take-off.
- An unmanned aircraft, which is an aircraft operated without pilot intervention from within or on the aircraft.
- A visual observer, which is a person who assists the remote pilot operating the unmanned aircraft to see and avoid other aircraft in the NAS.

Small UAS operators must also report accidents, meeting certain criteria, within 10 calendar days. Events meeting reporting criteria are; any serious injury or loss of consciousness to a person; or, any damage in excess of $500 to property with a value greater than $500, other than damage to the small UAS.

Within 14 CFR Part 107, Subpart B operating rules, §107.12 specifies requirements for a remote pilot certificate and small UAS rating. To operate a small UAS, these regulations require a person to hold a remote pilot certificate with a small UAS rating, be supervised by a person holding a remote pilot certificate with a small UAS rating and having the ability to take control of the small UAS, or hold a temporary small UAS certificate as required by §107.65.

The regulation also specifies registration, airworthiness, and medical requirements. Operators must comply with and keep a copy of the registration certificate with the UAS as required by §91.203(a)(2). Prior to flight, the operator must inspect the small UAS and ensure it remains in safe condition for flight as required by §107.15 and stop operations in the event the UAS operation becomes unsafe. And, the regulation restricts a remote pilot, visual observer, or other participants from operating a small UAS if he or she has a medical condition that would not allow safe operation of the UAS.

Under §107.19, the regulation requires designation of a remote pilot in command (PIC) either before or during the small UAS flight operation. Similar to a PIC of a manned aircraft, the remote PIC of a UAS has the same responsibility and final authority over the flight operation, and must analyze the operation and ensure continued safe operations to prevent damage or harm to people and property in accordance with applicable aviation safety regulations.

In the event of an in-flight emergency, small UAS operators may deviate from any regulation as necessary to deal with the emergency in accordance with §107.21. Following the event causing the operator to deviate from regulations under §107.21, the remote PIC must, upon request, send a written report to the FAA detailing the event.

The regulation also specifies rules governing hazardous operations, the use of alcohol and drugs, conducting operations at night, visual line of sight, and use of visual observers. Under §107.23, operators must not operate in a careless or reckless manner, similar to §91 requirements for manned aircraft, so as not to endanger life and property.

UAS operators may not drop objects from the aircraft that would create a hazard to life and property.

Additional, safety restrictions are published for the safe operation of small UAS. In accordance with §107.25, generally, remote pilots may not operate a small UAS from inside a moving aerial, land or water vehicle. Exceptions in the regulation do allow operators to remotely operate a small UAS from a moving water or land vehicle, so long as it is not operated for commercial purposes, and is not operated above densely populated areas. Under §107.27, the FAA precludes small UAS operators from operating UAS while under the influence of drugs or alcohol, as well as transporting illegal drugs and narcotics.

Certain operational safety regulations were observed to be published for the safe operation of small UAS. Under §107.29, operators are prohibited from flying at night or during the hours of twilight. With the exception, they may be operated during hours of twilight if they are equipped with anti-collision lights meeting the visibility requirement of 3 statute miles. Additionally, §107.31 requires operators to adhere to visual line of sight rules. The remote PIC, visual observer, and operator must only use corrective lenses to correct vision in order to see the small UAS during flight.

For visual observers, if they are used, §107.33 requires the remote PIC and visual observer to maintain direct communication at all times during operations and for the visual observer to maintain visual contact with the small UAS at all times in accordance with the visual line of sight rules specified in §107.31, and visually assess the airspace for air traffic and reposition the small UAS to prevent mid-air collisions with other aircraft. Additionally, in accordance with §107.35 operators may not operate more than one aircraft at a time. Additionally, operators must adhere to the rules for right-of-way in the NAS in accordance with §107.37 yielding right the of way to all other aircraft, ensuring not to cross into its flight path in order to prevent mid-air collisions. Also, the small UAS may not be operated above people unless they are a part of the aircraft operation, or they are reasonably protected from being struck by the aircraft if they are not participating in operating the aircraft.

Similarly, small UAS may not be operated by carrying hazardous materials aboard the aircraft and are prohibited from being operated in airspace classified as B, C, and D; and, E airspace for airports without authorization from ATC, and may not be operated in such a way that would cause a hazard to take-off, landing and approach traffic patterns.

Regulations in §107.45 through §107.49 also prohibit small UAS from being operated in areas designated as prohibited or restricted, such as military operations areas, or areas restricted during large public events such as major sporting events, without prior FAA or controlling agency approval. A preflight evaluation and assessment of operating conditions of both the aircraft and surrounding airspace must be performed by the remote pilot prior to flight that includes assessment of weather, airspace, human bystanders, property and other hazards.

Aside from these operational conditions, certain operating limitations are required for small UAS and remote pilots. In accordance with §107.51, remote pilots must adhere to the following operating limitations

- Never exceed a speed of 87 knots.
- Never exceed an altitude of 400 feet AGL outside of a structure.
- Maintain a 3-statute mile visibility of the small UAS, and a minimum distance of 500 feet below and 2,000 feet horizontally from clouds.

14 CFR Part 107 Subpart C specifies requirements for the certification of and are applicable to remote pilots seeking a small UAS rating. Similar to regulations for pilots of manned aircraft, the subpart specifies denial or suspension of a remote pilot certificate with a small UAS rating for drug and alcohol offenses. For operating aircraft under the influence of drugs or alcohol specified in §91.17 or §91.19, the penalty is either denial of a remote pilot application, or suspension/revocation of a currently issued certificate as deemed necessary by the FAA. The subpart also specifies denial of a remote pilot application if convicted of an illegal drug/narcotic offense for up to one year from the date of final conviction, or suspension/revocation as deemed necessary by the FAA against a currently issued remote pilot certificate.

Refusal to submit to alcohol testing by law enforcement, or to provide the test results to the FAA as required by §107.59, results in similar penalties; denial of an application for a remote pilot certificate up to one year from the date of the documented refusal, or suspension/revocation of a currently issued remote pilot certificate as deemed necessary by the FAA.

To be eligible to receive a remote pilot certificate with a small UAS rating, the applicant must meet the minimum eligibility requirements, similar to pilots of manned aircraft. A remote pilot applicant, under §107.61, must be at least sixteen years old and:

- Read, speak, write, and understand the English language.
- Be physically and mentally fit to safely operate the small UAS, and
- Demonstrate a basic airman knowledge of aeronautics by passing an initial test as required by §107.73, which will be addressed in further detail within this section. If the applicant holds a current pilot certificate issued under

§61, the applicant only has to complete an initial training course meeting the subject area requirements of §107.74, in lieu of a basic knowledge test. However, student pilots under §61 must demonstrate basic knowledge of aeronautics by passing an initial test as required by §107.73.

Part 107 also requires the person to maintain recency of experience in order to operate a small UAS. Within the preceding twenty-four months, a small UAS operator must, in accordance with §107.65, pass the initial small UAS knowledge test or recurrent test, or pass either an initial or recurrent training course specified above if they currently hold a §61 pilot certificate.

The researcher also identified specific requirements for knowledge testing within §107.67 through §107.73. Knowledge test requirements within these regulations specify general requirements for proof of eligibility and testing, noting that the minimum passing score needed to pass airmen remote pilot examinations is determined by the Administrator within the associated FAA Airmen Test Guide, which states that the minimum passing score is 70% (FAA, 2017b).

To ensure operational safety, §107.73 and §107.64 prescribe knowledge areas required for initial and recurrent remote pilot airmen knowledge tests and training courses, which include knowledge of applicable aviation safety regulations, airspace and airport operations, weather, small UAS performance and loading, emergency procedures, crew resource management and communications, use of drugs and alcohol, decision-making, and airworthiness requirements.

It was noted that several regulatory exclusions exist for a hobbyist, or model aircraft operators. The concept of a model aircraft operator, classification requirements, and operating standards were observed to be addressed in FAA (2016b) Advisory Circular (AC) 91-57A, *Model Aircraft Operating Standards*. In paragraph 6(c) of AC 91-57A, to be classified as a model aircraft operator, or hobbyist, the aircraft must only be flown for recreational purposes, must not weigh more than 55 pounds unless certified by a community-based organization (CBO), must be operated in accordance with industry or community-based operational and safety standards, must not pose a safety hazard, must avoid other aircraft, and must not be flown within 5 miles from an airport without notifying the airport prior to operating the small UAS.

Additionally, the AC precludes model aircraft operators from flying UAS in areas with an active temporary flight restriction, permanent flight restriction, or areas designated as prohibited, where published in Notice to Airmen (NOTAMS) by the FAA. The AC also notes that the publication merely provides a means of compliance to safety regulations and public law, and does not replace such publications. Ultimately, model aircraft operators are responsible for complying with applicable regulation and law, and may face civil penalties from the FAA for posing safety hazards to other aircraft and for non-compliance to applicable regulations and laws.

In final review of regulations promulgated for the safe operation of small UAS, the researcher identified extensive rules in place to regulate safe operation of small UAS that are operated in accordance with these regulations; specifically, for commercial purposes. However, it was noted that the regulatory exclusions apply to UAS operated for recreation or hobby purposes, which pose a certain level of risk to other regulated aircraft that are operated within the NAS. In general, by publication of Advisory Circular 91-57C, the FAA has allowed the model aircraft industry to regulate itself with limited FAA restrictions through publication of CBO standards, or industry published standards for operation and safety of model, recreational, or hobbyist aircraft.

Additionally, it is expected that certificated remote pilots, from novice to expert, should have a thorough knowledge of these regulations, or the familiarity to research these regulations and apply them. However, it is expected that non-aviators, and model aircraft operators may or may not have a similar level of knowledge of these regulations, or the familiarity to research and apply them.

Large Unmanned Aircraft Regulations

At the time of this research, the researcher found no regulations promulgated specifically for large UAS by the FAA within 14 CFR aeronautics and space regulations. It is interpreted, unless operated for recreational purposes, that any large UAS flown within the United States must be operated in accordance with manned aircraft regulations. Or, the operator must seek a waiver or exemption from regulations that cannot be complied with, such as rules for right-of-way to see and avoid other aircraft required by §91.113 and small UAS regulations requiring remote pilots to adhere to the rules for right-of-way in the NAS in accordance with §107.37 to prevent mid-air collisions.

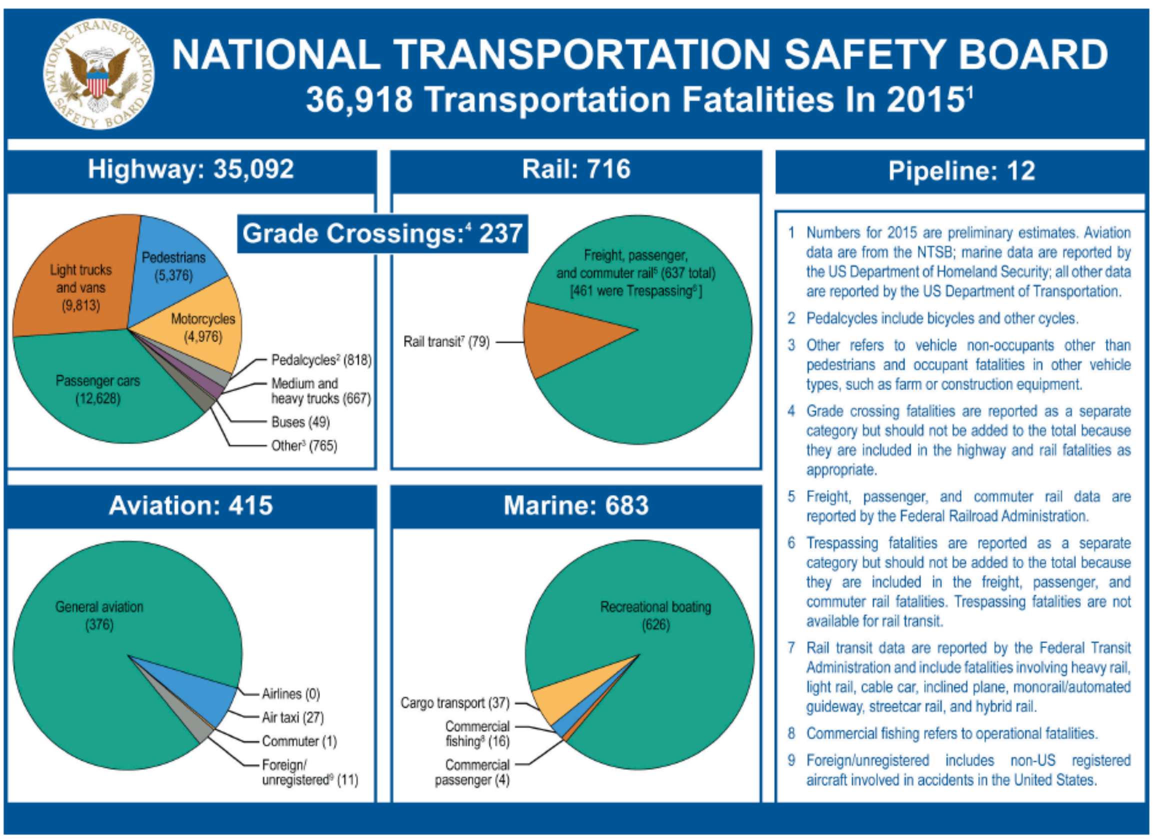
In general, by publication of Advisory Circular 91-57C, the FAA has allowed the model aircraft industry to regulate itself through publication of CBO standards, or industry published standards for operation and safety of model, recreational, or hobbyist aircraft, with limited FAA restrictions. Specifically, the FAA has designated a weight limit for small UAS at 55 pounds, and have allowed model aircraft operators to operate model aircraft in excess of 55 when certified and design approved by a CBO. It is interpreted by the researcher that model-aircraft can be operated in excess of 55 pounds if approved by a CBO, and operate the UAS in accordance with AC 91-57C.

Manned Aircraft Accident Data and Statistics

The researcher sought to identify current aircraft accident data and related statistics for manned aircraft in order to better understand the resultant data and implications of this study. As identified in the National Transportation Safety Board's (NTSB, 2015b) publication of all 2015 transportation fatalities listed in Figure 2.2, fatalities in aircraft accidents were significantly lower than other modes of transportation.

Figure 2.2

Transportation Fatalities in 2015 (NTSB, 2015b)



In review of the data in Figure 2.2, it was noted by the researcher that there were less fatalities in aviation accidents than in highway, rail or marine modes of transportation in the United States during 2015. Within aviation related accidents, the researcher identified that there were nearly 10 times more fatalities in general aviation accidents, versus aircraft operated for commercial purposes or foreign/non-US registered aircraft. Out of the 415 aircraft related fatalities, 376 occurred in general aviation and only 39 occurred in all other categories, including commercial aviation, during 2015. Compared to 2014, there was an overall decrease in the total number of aircraft accident related fatalities from 454 to 415, an overall decrease in the number of general aviation related fatalities from 424 to 376, while there was an overall increase in the number of fatalities in all other modes of aviation related accidents from 30 to 39, that includes commercial aviation (NTSB, n.d.-b).

The researcher adapted data contained in Tables 2.15 through 2.18 from the NTSB's (2015c) 2015 preliminary aviation statistics available from the aviation statistics section of its website. The data contained within Tables 2.15 through 2.17 denotes §§121, 135, and general aviation accident and fatal accident data comparative to available operational flight hour and departure data. Whereas, Table 2.18 details statistical accident rates for each of these types of aviation operations per 100,000 flight hours and departures, where the data is recorded and available for NTSB analysis and publication.

In reviewing the data contained within Tables 2.15 through 2.18, the researcher notes that the NTSB indicated that all related information was preliminary, with published flight hour and departure data reliant upon data being estimated and published by the FAA (NTSB, 2015c).

The NTSB noted that the FAA compiles and determines §135 on-demand and general aviation flight hour and departure data to be estimated based upon operator submission of applicable activity summary surveys. Because the results of these surveys were not published until the year following the survey, applicable NTSB statistics reliant upon this data were deemed preliminary until it analyzed available FAA data and published its summary of annual statistics. It is also noted by the researcher that data reflecting §135 on-demand and general aviation departure information is missing in these tables because the data was unavailable to the NTSB for analysis and publication (NTSB, 2015c).

Table 2.15

2015 Part 121 Accident Data (NTSB, 2015c)

14 CFR Part 121 Air Carriers	Accidents		Fatalities			
	All	Fatal	Total	Aboard	Flight Hours	Departures
Scheduled	27	0	0	0	17,435,000	8,859,000
Nonscheduled	1	0	0	0	385,000	119,000

Table 2.16

2015 Part 135 Accident Data (NTSB, 2015c)

14 CFR Part 135 Air Carriers	Accidents		Fatalities			
	All	Fatal	Total	Aboard	Flight Hours	Departures
Commuter	5	1	1	1	343,000	603,000
On-Demand	38	7	27	27	3,566,000	-

Table 2.17

2015 General Aviation Accident Data (NTSB, 2015c)

	Accidents		Fatalities			
	All	Fatal	Total	Aboard	Flight Hours	Departures
General Aviation	1,209	229	376	373	20,576,000	-

Of significance, the researcher notes that Table 2.18 contrasts accident and fatal accident rates between §§121, 135 and general aviation. The table reflects these statistics based upon 100,000 flight hours and 100,000 departures, where the data is applicable and available to the NTSB for analysis and publication. Specifically, this table reflects 0.155/0.260 accidents per 100,000 flight hours for §121 scheduled/nonscheduled air carrier operations respectively, and zero fatal accidents; 1.458/1.07 accidents and 0.292/0.20 fatal accidents per 100,000 flight hours for §135 commuter/on-demand air carrier operations respectively; and, 5.85 accidents and 1.09 fatal accidents per 100,000 flight hours for general aviation operations.

Table 2.18

2015 Flight Hour and Departure Accident Statistics (NTSB, 2015c)

	Accidents (per 100,000 flight hours)		Accidents (per 100,000 departures)	
14 CFR Part 121 Air Carriers	All	Fatal	All	Fatal
Scheduled	0.155	0	0.305	0
Nonscheduled	0.260	0	0.840	0
14 CFR Part 135 Air Carriers				
Commuter	1.458	0.292	0.829	0.166
On-Demand	1.07	0.20	-	-
General Aviation	5.85	1.09	-	-

To provide a historical context and a comparable perspective to the accident data and statistics for 2015, the researcher also examined historical accident data published by the NTSB for the years spanning 2002 through 2014. The years 2012 through 2014 will be examined first, followed by the years preceding 2012. Tables 2.19 through 2.21 detail the total accidents, fatal accidents and fatalities for the calendar years 2014, 2013 and 2012 as adapted from the NTSB's accident data and statistics websites.

These tables reflect a sharp decrease in the total number of accidents in all modes of aviation from 1,537 accidents in 2012 to 1,291 accidents in 2014. For §121 aviation operations, the tables reflect a slight rise in the total number of accidents over the three-year period from 27 accidents in 2012 to 29 accidents in 2014. And, although a slight drop in the total number of accidents occurred in 2013 to 23 accidents, the only §121 fatal accidents that occurred during the three-year period occurred in 2013, in which there were two fatal accidents and nine fatalities.

For §135 operations, the tables reflect no change in the total number of accidents in 2014 versus 2012. However, a sharp rise was observed in the total number of accidents in 2013, in which 51 accidents occurred. The total fatal accidents and associated fatalities also showed an increase, with an increase in the total fatalities jumping from nine in 2012 to 20 in 2014. While, a resultant sharp rise to 30 fatalities was noted in 2013, which coincides with the rise that same year in total accidents and fatal accidents, in which 12 fatal accidents occurred.

For general aviation operations conducted under §91, each year reflected a drop in the total number of accidents, with a sharp drop noted between the years 2012 and 2014 in which there were 1,471 accidents in 2012 and 1,223 in 2014. A small reduction, the total accidents dropped from 1,224 in 2013 to 1,223 in 2014. While, the total fatalities dropped from 440 in 2012 to 390 in 2013, with a rise to 424 fatalities in 2014.

As comparison for each of the years spanning 2012 to 2015, the following total numbers of aviation related fatalities were observed in each of these years; 449 fatalities in 2012, 429 fatalities in 2013, 444 fatalities in 2014, and 415 fatalities in 2015. This data reflects an average of 434.25 fatalities per year and a decrease in the total number of fatalities in 2015 compared to 2012 by 34 fatalities.

Table 2.19

2014 Civil Aviation Accident Data (NTSB, 2016)

Mode of Civil Aviation	Accidents	Fatal Accidents	Fatalities
Part 121	29	0	0
Part 135	39	8	20
General Aviation	1,223	257	424
Total	1,291	265	444

Table 2.20

2013 Civil Aviation Accident Data (NTSB, 2015d)

Mode of Civil Aviation	Accidents	Fatal Accidents	Fatalities
Part 121	23	2	9
Part 135	51	12	30
General Aviation	1,224	222	390
Total	1,298	236	429

Table 2.21

2012 Civil Aviation Accident Data (NTSB, 2014b)

Mode of Civil Aviation	Accidents	Fatal Accidents	Fatalities
Part 121	27	0	0
Part 135	39	7	9
General Aviation	1,471	273	440
Total	1,537	280	449

In its 2014 publication following a review of aviation accident data for the time period spanning 2002 to 2011, titled *Review of Civil Aviation Accident Calendar Year 2011,* the NTSB detailed aviation accident data and statistics (NTSB, 2014a). The abstract of the report noted that the study involved a review of accidents involving both §§121 and 135 as well as §91 general aviation aircraft accidents. In 2011, there were a total of 1,553 accidents. Of which, 282 were fatal accidents resulting in 489 fatalities. The researcher notes that the report also identified that 95% of the total aviation accidents, and 94% of the fatal aviation accidents, occurred in general aviation.

In its review of civil aviation accident data for calendar year 2011, the NTSB identified key historical data and statistics for §121 commercial aviation for the years spanning 2002 to 2011 (NTSB, 2014a). This report identified a four percent increase in the total number of flight hours flown during this time period, evidence of steady growth in §121 commercial aviation. It also established the §121 accident rate at 1.7 accidents per million flight hours flown, a sharp decrease of 27% for 2011 versus 2002. Similarly, it established the §121 accident rate at 3.2 accidents per million departures, a sharp decrease of 17% for 2011 versus 2002.

In its review of civil aviation accident data for calendar year 2011, the NTSB identified key historical data and statistics for §135 commuter operations for the years spanning 2002 to 2011 (NTSB, 2014a). This report identified a 19% increase in the total number of flight hours flown during this time period, evidence of significant growth in §135 commuter operations. It also identified that the number of §135 commuter operations accidents remained at or below seven accidents per year between 2002 and 2011. The report contained §135 commuter operations accident statistics in graph and chart format, in which it illustrated statistics that could not be easily identified in numerical detail and adequately presented within this dissertation. As a result, the researcher examined the accident data and statistics listed in the NTSB's 2015 preliminary accident statistics report, which was previously referenced in this dissertation.

The researcher identified the following §135 commuter operations accident statistics for the years spanning 2002 to 2011 as identified in the NTSB's (2015c) 2015 Preliminary Aviation Statistics report. In this segment of aviation from 2002 to 2011, a total of 3,034,718 flight hours were flown with the occurrence of 44 accidents, 2 fatal accidents, and 4 fatalities, with an average accident rate of 1.467 accidents per 100,000 flight hours and 0.064 fatal accidents per 100,000 flight hours (NTSB, 2015c). The NTSB indicated that all flight hours were estimated.

The researcher also identified the following §135 on-demand accident statistics for the years spanning 2002 to 2011 as identified in the NTSB (2015c) 2015 Preliminary Aviation Statistics report. In this segment of aviation from 2002 to 2011, a total of 29,885,000 flight hours were flown with the occurrence of 562 accidents, 138 fatal accidents, and 362 fatalities, with an average accident rate of 1.73 accidents per 100,000 flight hours and 0.41 fatal accidents per 100,000 flight hours (NTSB, 2015c). The NTSB indicated that all flight hours were estimated, and flight hour data and accident rate statistics for 2011 were unavailable due to FAA recalibration efforts.

In its review of civil aviation accident data for calendar year 2011, the NTSB identified key historical data and statistics for general aviation operations under §91 for the years spanning 2002 to 2011. It defined general aviation §91 operations as other than §§121, 135 and 139 and consisting of such operations as powered parachutes, other wide ranges of personal flying categories, and some specific types of commercial operations not regulated by §121, 135 or 139, such as §61 flight instruction and §137 aerial application operations.

In the report, the NTSB noted that during 2011, general aviation accounted for 92% of all civil aviation fatalities in the US, which accounted for 95% of all aircraft accidents and 94% of all fatal aircraft accidents (NTSB, 2014a). Additionally, the NTSB noted that personal flying accounted for 68% of the general aviation accidents in 2011, which involved a wide range of flying activities in various types of airframes. From 2002 to 2010, there was also a 27% increase in the total number of personal flight hours, a 24% increase in the personal flying accident rate, and a 10% increase in the personal flying fatal accident rate.

The researcher notes that the NTSB report contained accident statistics for general aviation operations conducted under §91 in graph and chart format, which illustrated statistics that could not be easily identified in numerical detail and adequately presented in this dissertation. As a result, the researcher examined the accident data and statistics listed in the NTSB's 2015 preliminary accident statistics report, which was previously referenced in this dissertation.

The researcher identified the following §91 aircraft accident statistics for the years spanning 2002 to 2011 as identified in the NTSB (2015c) 2015 Preliminary Aviation Statistics report. In this segment of aviation from 2002 to 2011, a total of 212,736,000 flight hours were flown with the occurrence of 15,883 accidents, 3,021 fatal accidents, and 5,429 fatalities, with an average accident rate of 6.77 accidents per 100,000 flight hours and 1.29 fatal accidents per 100,000 flight hours (NTSB, 2015c). The NTSB indicated that all flight hours were estimated, and flight hour data and accident rate statistics for 2011 were unavailable due to recalibration efforts by the FAA.

Upon review of relevant literature related to aircraft accident statistics, the researcher sought to compare the aircraft accident rates with motor vehicle accident rates by reviewing a relevant article and related government published information. In comparison to automotive accident rates, aviation is a significantly safer mode of transportation (Locsin, n.d.). A USA Today article by Locsin (n.d.) addresses the safety of air travel versus car travel and details 2008 National Highway Traffic Safety Administration (NHTSA) statistics that identify a motor vehicle accident rate of 1.27 fatalities per 100 million miles versus a 2008 NTSB statistic for aviation of nearly zero accidents per one million miles. The article further cites a study completed by the National Safety Council (NSC), which identified the odds of being killed in a motor vehicle accident at 1 in 98 for a person’s lifetime, versus 1 in 7,178 in aviation for a person’s lifetime.

The researcher examined recently published information for the source of these statistics and found the article to be relatively accurate, given a change in data over time. The researcher validated the USA Today article by reviewing a 2017 publication of the NSC’s odds of being killed data referenced in the USA Today article that cited 2008 NSC odds of being killed data. In its publication, adjusted for a nine-year change in data, the odds of being killed in a motor vehicle crash in 2017 were set at 1 in 114 for a person’s lifetime, and the odds of being killed in an aviation accident were set at 1 in 9,821 for a person’s lifetime (National Safety Council [NSC], 2017). Similarly, adjusted for a seven-year change in data, NHTSA published a 2015 motor vehicle fatality rate of 1.12 per 100 million miles, a rise from 1.08 per 100 million miles in 2014 (National Highway Traffic

Safety Administration [NHTSA], 2016).

Interestingly, the researcher notes that the NSC published the odds of being killed in a motor vehicle accident to be greater than being killed in a falling accident (1 in 127), an assault by a firearm (1 in 370), a motorcycle accident (1 in 985), an unintentional drowning (1 in 1,188), and generally, even an unintentional firearm discharge (1 in 6,905); statistically interesting given the political attention given to prevent some of these ways of being killed (NHTSA, 2016). The NSC acknowledges that the odds of being killed are relative to and affected by a person’s lifestyle, and environmental exposures.

Of final review of the relevant literature within this section, the researcher notes a study published by the FAA examining the percentage of operational human factor causes in all general aviation fatal aircraft accidents from 1990 to 2000, in which there were a total of 3,256 fatal accidents and 11,180 non-fatal accidents during the 11-year period (Wiegmann et al., 2005, p. 8). The researchers, Wiegmann et al. (2005), found that approximately 80% of both fatal and non-fatal general aviation accidents were caused by errors in pilot skill-based human factors (p. 8).

Similarly, an article published in Boeing magazine described Boeing’s Maintenance Error Decision Aid (MEDA) that it provides to the industry for use to investigate and prevent maintenance and inspection errors in its commercial aircraft and related products that are used worldwide (Rankin, 2007). Boeing cites a safety report published in 2003 by the International Air Transportation Association (IATA) that notes a study of 93 aircraft accidents in which 26% were determined to be caused by maintenance error (Rankin, 2007). The IATA study supports research that Boeing conducted which found that 80% of all aircraft accidents in today’s era of aviation are caused by human factors in operation, maintenance, air traffic control and manufacturing versus 1903 when 80% of aircraft accidents were caused by aircraft and equipment failure and 20% were caused by human factors (Rankin, 2007).

Unmanned Aircraft Accident/Incident Data and Statistics

The researcher sought to identify current aircraft accident data and related accident statistics for civil unmanned aircraft in order to better understand the resultant data and implications of this study. The researcher acknowledges that regulations were only published for small UAS at the time of this research. Additionally, the researcher acknowledges that the FAA authorized UAS operations under certificates of waiver or authorization (COA) to operators prior to and after publication of the small UAS regulation (FAA, 2017a).

However, in review of accident data publically available on the NTSB's website, it was identified that civil UAS accident rates and statistics were not available at the time of this research. Additionally, search criteria for categories of aircraft within the NTSB aviation accident database did not include unmanned aircraft as a searchable category under categories of aircraft, leaving researchers to rely fully upon the keyword search option to retrieve accidents with unmanned related terminology or the lack of such unmanned related terminology (NTSB, n.d.-a).

Of further observation during this review of relevant literature, the researcher identified that the NTSB did not track and publish flight hour data for UAS, similar to general and commercial aviation, in which to derive a UAS accident rate or statistic for any civil UAS (small or large) during the time of this research. Furthermore, without meaningful statistical accident rate information, it became apparent that it was realistically unknown if UAS were any more or less safe than the other modes of aviation that have published aircraft accident statistics. This lends itself to the researcher's recommendation for the government to track this data, determine an applicable accident rate, and conduct further research into the comparison of UAS accident rates versus other modes of aviation in order to determine if UAS are any more or less safe than other modes of aviation.

As a result of the lack of published UAS accident statistics, and to better understand the resultant data and implications of this study, the researcher examined the aviation accident and synopsis database on the NTSB's website to determine if any aircraft accidents involved unmanned aircraft or were recorded as an unmanned aircraft related accident (NTSB, n.d.-a). To do this, the researcher conducted a keyword search using six common terms related to unmanned aircraft between the dates January 1, 2002 to September 26, 2017. The common terms searched were drone, UAS, unmanned, UAV, remote pilot, and remote control, which yielded the following results.

1. A keyword search using the term "drone" retrieved zero accident reports.
2. A keyword search using the term "UAS" retrieved six accident reports:
    - On January 27, 2014, aircraft accident number DCA14CA043 was assigned to a public unmanned General Atomics MQ-9 aircraft. The aircraft accident was caused by a generator electrical failure, resulting in a controlled ditching. No injuries occurred.
    - On July 26, 2013, aircraft accident number DCA13CA172 was assigned to a public unmanned NASA Ames Research Center Sierra aircraft. The aircraft accident was caused by an engine failure under

weather conditions conducive to carburetor icing. No injuries occurred.

- On May 10, 2013, aircraft accident number DCA13CA088 was assigned to a public unmanned General Atomics MQ-9 aircraft. The aircraft accident was caused by the remote pilot's improper landing flare. No injuries occurred.
- On February 19, 2009, aircraft accident number DCA09FA028 was assigned to a public unmanned General Atomics MQ-9 aircraft. The aircraft accident was caused by the remote pilot's improper flare on landing under a tail wind. No injuries occurred.
- On November 6, 2008, aircraft accident number DCA09FA009 was assigned to a public unmanned General Atomics MQ-9 aircraft. The aircraft accident was caused by the remote pilot's improper flare during landing. No injuries occurred.
- On April 25, 2006, aircraft accident number CHI06MA121 was assigned to a public unmanned General Atomics Predator B aircraft. The aircraft accident was caused by the remote pilot's failure to follow the established checklist resulting in engine fuel starvation, as well as the lack of a flight instructor in the Ground Control Station to manage all of the aircrew. No injuries occurred.

3. A keyword search using the term "unmanned" retrieved seven accident reports, of which five were duplicated from the previous "UAS" keyword search results. The non-duplicated accidents are noted here:

- On June 6, 2016, aircraft accident number DCA16CA197 was assigned to unmanned Facebook UK LTD Aquila aircraft. The aircraft accident was caused by a wing structural failure due to wind gusts causing the aircraft to exceed airspeed limitations and the autopilot's capabilities to maintain constant airspeed within the aircraft's operating limitations. No injuries occurred.
- On May 1, 2015, aircraft accident number DCA15CA117 was assigned to unmanned Titan Aerospace Holdings Inc. Solara 50 aircraft. The aircraft accident was caused by wing structural failure due to the aircraft exceeding aircraft airspeed operating limitations. No injuries occurred.

4. A keyword search using the term "UAV" retrieved one accident report, of which it was duplicated from the previous "unmanned" keyword search results. The duplicated accident will not be noted here.
5. A keyword search using the term "remote pilot" retrieved zero accident reports.
6. A keyword search using the term "remote control" retrieved zero accident reports.

Because the NTSB did not publish UAS accident statistics available to the public at the time of this research, the researcher sought to identify UAS incident data published by the FAA. The researcher found limited information in report format spanning the time period between November 13, 2014 to August 20, 2015, in which the FAA report indicated there were 764 UAS incidents in the United States (FAA, 2015). The report indicated no injuries in any of the 764 incidents, and consisted of such incidents as either pilot or public sightings of UAS in the NAS, or near other aircraft in the NAS (FAA, 2015).

Aircraft Accident Causes

Upon reviewing published aircraft accident data and statistics, the researcher sought to identify common themes in the causes of aircraft accidents to better understand the resultant data and implications of this study. Several sources of information were reviewed in order to capture a broad perspective on accident causes. The sources reviewed were; the book titled, *Accident Investigation Manual* published in 1948 by the Northwestern University Traffic Institute; the book titled, *Aircraft Accident Investigation* written in 2006 by Wood and Sweginnis; the book titled, *Aircraft Accident Reconstruction and Litigation* written in 2011 by McCormick and Papadakis; and the report titled, *Statistical Summary of Commercial Jet Airplane Accidents of Worldwide Operations from 1959 to 2016* published in 2017 by Boeing Commercial Airplanes.

First, the researcher identified that the science of accident investigation precedes the modern era of aviation safety of today, which is extensively regulated for safety and accident prevention by the FAA as identified within previous sections of this chapter. In its book published in 1948, titled the *Accident Investigation Manual*, the Northwestern University Traffic Institute details procedures for highway traffic accident investigation, determination of causal factors, and final report construction and publication. It was noted that the book cited literary sources in accident investigation photography techniques dating back to as early as 1930 from the U.S. War Department (*Accident Investigation Manual*, 1948, p. 166). The researcher also notes that photography is still a basic tool in modern aircraft accident investigation today (Wood & Sweginnis, 2006, p. 43).

Additionally, the *Accident Investigation Manual* (1948) identifies a basic principle and philosophy of investigation. The philosophy that accidents are not accidents. Instead, they are occurrences that are caused by several factors and because of that, they can be reduced (*Accident Investigation Manual*, 1948, p. 9). They can be reduced, in part, because it identifies that accidents are caused by circumstances it represents as human error, such as reckless driving, speeding, drunk driving, and disobeying traffic signs (*Accident Investigation Manual*, 1948, p. 9). The book also delves into what can be perceived as a modern systems theory of accident investigation to determine probable cause. It was interpreted that system means all inputs, or lack of inputs, to the accident sequence.

The book describes the circumstances surrounding an accident to be multi-causal (*Accident Investigation Manual*, 1948). It illustrates this concept with a scenario in which a man leaves a bar at night, he is drunk, he fails to use the vehicle headlights, he is speeding to get to his destination, it is misting rain and the street is wet, a pedestrian dressed in dark clothes enters his driving path, he had not maintained his vehicle brakes properly prior to the accident, his car skids and it cannot stop when he or she applies the brakes, and he hits and kills the pedestrian (*Accident Investigation Manual*, 1948, p. 10). The notion of such circumstantial accident prevention holds that no single input to the accident sequence caused the accident. Even the pedestrian was causal to the accident. Under this notion, if one contributing factor had been eliminated from the accident sequence, the accident might not have occurred. In this scenario, the human is at the center of every input to the resultant accident.

With this notion, however, the researcher identified one fundamental difference between the book's system theory on accident prevention and the systems theory on accident prevention of today. The Northwestern University Traffic Institute states that accident investigation is the foundation of accident prevention, with educating the public on safety, engineering, and enforcement being important approaches to safety and accident prevention (*Accident Investigation Manual*, 1948, p. 16). However, as identified in the aviation safety regulations of today, specifically the promulgation of 14 CFR Part 5 requirements for §121 operators to develop and maintain a safety management system, it appears that the system philosophy of today to prevent accidents has shifted to one with a foundation in safety policy, safety risk management, safety assurance and safety promotion. The researcher notes these principles are similar to what the book determines to be important approaches to accident prevention, but not foundational in concept as the book noted; safety education, engineering, and enforcement were merely important approaches to accident prevention. In review of this literature, the researcher identified four categories of accident causes; the man, the machine, the environment, and the system in which the accident occurred.

Secondly, the researcher examined a modern era aircraft accident investigation book, titled *Aircraft Accident Investigation*, written in 2006. The authors of this book also detailed the notion that accidents are not the result of a single cause, rather multiple causes, in what was termed a system of aggravating causes (Wood & Sweginnis, 2006, p. 9). The book details technical procedures for investigating aircraft accidents in all areas of the system in which the accident occurred, which includes the pilot in properly operating the aircraft, the manufacturer in properly designing and manufacturing the aircraft, the mechanic in properly maintaining the aircraft, as well as the aircraft systems that include its propulsion, structural, electrical, hydraulic, instrumentation, landing gear, primary and secondary flight control, pneumatic, fuel, and other miscellaneous systems. The book also details techniques and procedures specifically for investigating environmental and human factor related aircraft accidents.

In the area of environmental, the book details procedures for investigating airfield, air traffic control, and weather inputs to the accident sequence (Wood & Sweginnis, 2006, pp. 171-174). In the area of human factors, the book details procedures for determining pilot and mechanic qualifications and experience, which begins with the most basic of investigation techniques; determining if the pilot or mechanic were certificated by the FAA, which would be initial evidence that the pilot or mechanic were initially qualified to either fly or maintain the aircraft (Wood & Sweginnis, 2006, pp. 165-169). The book also contains a separate chapter on human factors that details the aero-medical examiner's role in determining the health and physical condition of the pilot, and identifying if drug or alcohol use may have contributed to the accident (Wood & Sweginnis, 2006, pp. 183-185). In review of this literature, the researcher identified four categories of accident causes; the man, the machine, the environment, and the system in which the accident occurred.

A review of the third book yielded similar results as it did for previous books on accident investigation causes. Accidents causes can be placed into four categories; the man, the machine, the environment, and the system in which the accident occurred. In the book titled, *Aircraft Accident Reconstruction and Litigation*, the authors have compiled a guide for attorneys and experts to reconstruct accident scenarios and litigate aircraft accident related legal cases, describing an aircraft as a complex system that operates within a larger system, in which the environment, air traffic control, human error in operating and maintaining the aircraft, or an aircraft malfunction can be causal to an accident (McCormick & Papadakis, 2011, p. 3). The book examines aircraft systems, air traffic control and weather environment, human error, and human factors. Specifically, it contains a chapter that clearly identifies accident causes in two basic categories; human errors and aircraft system failures (McCormick & Papadakis, 2011, pp. 113-121). Under the human error category, the book also clearly ties human error in judgement to nearly every aspect of environmental and system causes of an accident sequence.

For example, if weather were a factor in an aircraft accident, the book makes the argument that the pilot should not have flown, or that he or she may have received faulty air traffic control or weather reporting information, all human factor causes (McCormick & Papadakis, 2011, p. 113). Similarly, the book makes the argument that the manufacturer or maintainer may be at fault for failed aircraft components due to such human factors as faulty design, maintenance, inspection, or development of maintenance and inspection procedures and scheduling intervals.

Lastly, the researcher also identified information published by an aircraft manufacturer, which cited accident statistics and causes of commercial jet aircraft accidents from 1959 to 2016 based upon data and statistics adapted from other government published sources. The Boeing Commercial Airplanes (2017) company published its report, titled *Statistical Summary of Commercial Jet Airplane Accidents of Worldwide Operations from 1959 to 2016*, that discussed and primarily illustrated accident summaries in graph and chart format by types of operation, severity of injury to persons and damage to property, and statistical accident rate information for commercial jet aircraft based on data and accident rate information published by the NTSB.

Because accident data and statistical information was previously discussed within this dissertation, the report's statistical information will not be addressed here as it would duplicate information previously identified. However, related to this section of the dissertation, the researcher notes that the Boeing Commercial Aircraft company published information within its report from the International Civil Aviation Organization (ICAO) Commercial Aviation Safety and Common Taxonomy Team. Boeing notes this team is made up government, industry, manufacturers, commercial operators, and pilot associations from around the world and is chartered to establish common language and definition taxonomies for the industry to use in accident and incident database and reporting systems.

This team is also focused on categorizing accident occurrences from 2007 to 2016 into principle categories to identify common causes, so the industry can focus accident prevention efforts on targeted causes (Boeing Commercial Airplanes, 2017). The report identified the following principle categories; abnormal runway contact, controlled flight into terrain, fire and smoke not related to impact, loss of control in-flight, midair and near midair collisions, ground handling, runway excursions and incursions, aircraft system and component failures and malfunctions, unknown, other, and undershoot or overshoot of the runway (Boeing Commercial Airplanes, 2017). In review of the principle categories within this literature, the researcher identified four categories of accident causes; the man, the machine, the environment, and the system in which the accident occurred.

Unmanned Aircraft Human Factors

The researcher notes that the aircraft accident causes listed in the previous section for manned aircraft did not directly and specifically address unmanned aircraft. Although, the machine, the environment and the system in which an accident occurs can be similarly causal to an unmanned aircraft accident. However, the human factors associated with the pilot, or man, who operates the unmanned aircraft remotely are unique to remotely operating an unmanned aircraft.

As a result, the researcher sought to identify the human factors related to unmanned aircraft in order to better understand the resultant research data and implications of this study by examining relevant government and academic research. The government research reports included; a study summarizing UAS accident and incident data that focused on human factors; a study on UAS human factors in accidents involving flight-control malfunctions; and, a study detailing sensory information for unmanned aircraft operators. The researcher also reviewed academic research that examined the visual acuity, or ability, of a pilot of a manned aircraft to detect small unmanned aircraft.

First, the researcher examined the government research study completed by the Federal Aviation Administration's Civil Aerospace Medical Institute (CAMI) titled, *A Summary of Unmanned Aircraft Accident/Incident Data: Human Factors Implications* (Williams, 2004). This research study examined unmanned aircraft accident data from the United States Department of Defense. Specifically, the U.S. Army, Navy and Air Force. The author noted that military reports and data were limited and some provided insufficient information in some instances (Williams, 2004, p. 4).

The study examined accident data for the Global Hawk, Hunter, Pioneer, Predator, and Shadow UAS, citing human factors as causal for a varying 21% to 68% of the accidents across all aircraft platforms, which identified that many of the identified accidents could have been prevented by better analysis of the human system interfaces and procedures (Williams, 2004, p. 1). The study also noted that electromechanical system failure was the most prevalent cause, whereas aircraft system failure was attributed to 33% to 67% of the accidents across all aircraft platforms (Williams, 2004, p. 5). The report identified the following human factors related to the UAS accidents.

- Aircrew coordination
- Alerts and alarms
- Display design
- External pilot landing error
- External pilot takeoff error
- Pilot-in-command issues
- Procedural error
- Weather related

The report notes that where an operational error was caused by the design of the aircraft or procedures to operate it, those too were considered human factor causes. For instance, the report noted that the Hunter and Pioneer UAS had known design issues making the aircraft difficult to fly by external means, resulting in aircraft control issues. Similarly, where human system interfaces attributed to the accident, those too were considered human error. Often times, the author of the research report notes that the designers and developers of the aircraft were not primarily aircraft manufacturers, leading to systems interfaces that were not designed similar to manned aircraft. Only the Predator UAS had system interfaces that were similar to manned aircraft as noted by the author.

Second, the researcher examined the government research study completed by the

Federal Aviation Administration's CAMI titled, *Human Factors Implications of Unmanned Aircraft Accidents: Flight-Control Problems* (Williams, 2006). This research report identified the human factors associated with three common UAS flight control issues. These human factors were identified as;

- External Pilot difficulties with UAS controls.
- External Pilot difficulties with transfer of control.
- Design problems with flight control automation.

The author of the report explains that external pilot difficulties with UAS controls are due to an inconsistent mapping of the UAS controller to aircraft flight control movement, and subsequent aircraft response (Williams, 2006, p. 2). Further explained, the researcher notes basic monitoring of small UAS flight attitude, altitude, heading and position by visual line of sight with a hand held remote controller, similar to those used hobbyist, can be problematic when the aircraft changes direction. Such as, when the aircraft changes direction from flying away from the operator to flying towards the operator. An inconsistent mapping, in this instance, does not account for the change in direction, relative to the operator's perspective (Williams, 2006, p. 2). The author of the report suggested to eliminate the external pilot all together by fully automating small UAS, as a solution to this problem (Williams, 2006, p. 5).

The author of the report also explained the problems associated with the transfer of control from one remote pilot to another. The author noted the occurrence of military UAS accidents involving transfer of control, in which, the receiving remote operators were unaware of such factors as inoperable systems, or incorrectly configured switches and controls, ultimately leading to the accident (Williams, 2006, p. 3). And, the report suggested, as a solution, for UAS designers to design control displays with standard critical flight control system information that is readily available to transferring and receiving operators, and to standardize transfer procedures for matching flight control system information between receiving and sending stations as solutions to eliminate the problem of transfer of control (Williams, 2006, p. 5).

The author of the report also explained the problems associated with flight control automation. The author's focus of problems with flight control automation were with the inability of automation systems to predict and couple every problem encountered with correct solutions, while maintaining adequate system information for the remote pilot to notice flight control anomalies and take appropriate corrective actions in a timely manner to prevent accidents (Williams, 2006, p. 4). The author suggested two solutions to this problem; design better system information interfaces for remote pilots to identify and properly react to flight control anomalies when flight control automation has failed to maintain controlled flight. And, adequately design flight control automation systems with appropriate responses to flight control problems, admittedly a challenging engineering task according to the author (Williams, 2006, pp. 5-6).

Third, the researcher examined the government research study completed by the Federal Aviation Administration's CAMI titled, *Documentation of Sensory Information in the Operation of Unmanned Aircraft Systems* (Williams, 2008). The research report examines the sensory information not available to remote pilots of UAS and how the lack of this sensory information has led to UAS accidents (Williams, 2008, p. 1). The report also examines the human senses as they are applicable to manned aircraft, in order to give a perspective of the hazards that the lack of sensory information presents to unmanned aircraft.

Five of the human sensory capabilities, or senses, aid a pilot in flying a manned aircraft. Smell provides the pilot the indication of smoke, fire and other dangerous abnormalities that require immediate emergency action procedures. And, sight allows the pilot to visually see outside the aircraft to detect and avoid other aircraft and remain in visual meteorological conditions (VMC) if he or she is not properly rated for flying in instrument conditions, as well as other hazards such as ice accumulation on wing surfaces. Sight also aids in other pilot functions, such as visually scanning the instrument panel inside the cockpit for visual cues on the health and performance of the aircraft.

Hearing allows the pilot to detect abnormal engine performance, such as changes in propeller and engine revolutions per minute (RPM), as well as engine ignition system misfires and knocking. Hearing also aids the pilot in detecting audible warning horns and sirens located inside the aircraft that warn the pilot of abnormal aircraft conditions and performance such as stalls and air traffic collision avoidance warnings.

The sense of touch, also called the haptic or tactile sense, aids the pilot to detect changes in the sense of feel of aircraft flight controls, engine and airframe performance. Specifically, the author of the report notes proprioceptive and kinesthetic information that primarily aids the pilot to fly the aircraft. Where, "proprioception is the sensing of changes in the muscles and tendons of the body" (Williams, 2008, p. 4), "kinesthetic information is information regarding body movement, as perceived by the muscles, tendons, and joints of the body" (p. 4). The sense of changes in gravitational, directional and acceleration forces are crucial to maintaining control of the aircraft by reacting to the changes with the appropriate flight control inputs. However, the associated vestibular information can result in spatial disorientation, which will be addressed next.

The vestibular system is located within a person's inner ear, and its function is to maintain the body's equilibrium (Antunano, n.d.). However, vestibular illusions can result in spatial disorientation, which account for 5-10% of the accidents in general aviation (Williams, 2008, p. 5). Such accidents are caused by not maintaining aircraft control resulting in what the author of the report called; "the graveyard spin, graveyard spiral and Coriolis illusion" (Williams, 2008, p. 6). For the pilot, the proprioceptive and kinesthetic inputs to the senses can be received as immediate and noticeable changes that are felt immediately in yoke and rudder pedals movements, as well changes in gravitational and acceleration forces felt by the body (Williams, 2008, p. 4).

However, a vestibular illusion can result in a symptom called the leans that is caused by the pilot not sensing gradual and prolonged changes of approximately 2 degrees per second in gravitational, rotational, directional and acceleration forces of the aircraft indicating the aircraft is not flying straight and level or maintaining proper heading (Williams, 2008, p. 5). The author notes that such illusions occur when there is a lack of visual references relative to the horizon, which leads the pilot to perceiving that the aircraft is straight and level when it is not.

The author identified the sensory inputs for pilots of manned aircraft. However, the author notes that vision is the primary sensory information for remote pilots of UAS because they primarily rely on aircraft system health information through electronic displays (Williams, 2008, p. 1). For manned aircraft pilots, the available sensory information allows for better sense and detection of hazards outside the aircraft, as well as inside the cockpit in the form of anomalies in aircraft performance, and system warnings and instrumentation. With less sensory information available, remote pilots are at a disadvantage to detect and diagnose system malfunctions, which has led to 15% to 20% of the UAS accidents analyzed by the author (Williams, 2008, p. 20).

Last, the researcher reviewed the academic research study titled, *Seeing the Threat: Pilot Visual Detection of Small Unmanned Aircraft Systems in Visual Meteorological Conditions*, which examined the visual acuity, or ability, of manned aircraft pilots to detect small UAS (Loffi, Wallace, Jacob, & Dunlap, 2016). The researcher chose to review this academic research study because it aligned with the aspect of identifying unique human factors related to UAS. Specifically, it aligned with the unique human factor of manned aircraft pilots being able to visually detect UAS in the NAS and avoid mid-air collisions, which leads to publicity about UAS safety and ultimately affects the public perception of UAS safety. Which, is the topic of this dissertation. The purpose of Loffi, Wallace, Jacob, and Dunlap's (2016) academic research study was to identify if a general aviation pilot's visual acuity, or ability, was an adequate means of detecting small UAS while operating under VMC (p. 1).

The researcher recalls from the review of relevant literature, in the unmanned aircraft accident/incident data and statistics section of this chapter, that between November 13, 2014 and August 20, 2015, the FAA reported there were 764 UAS incidents in the United States of pilot or public reported sightings of UAS being operated near manned aircraft in the NAS, posing a mid-air collision hazard (FAA, 2015). This equates to approximately 85 reported incidents per month nationwide during the nine-month time period. Loffi et al.'s (2016) academic research study noted similar data identifying that "between November 2014 and January 2016, the FAA recorded 1,346 pilot sightings and near-misses of UAS platforms—nearly 100 per month" during the 14-month period (p. 1). The academic research study also detailed other UAS encounter studies that analyzed 921 near miss incidents between UAS and manned aircraft. Which revealed, 58.8% occurred near airports, 90.2% occurred 400 feet above ground level and higher, 21.2% occurred within 50 feet or less of aircraft to UAS separation, and 8.6% resulted in the manned aircraft pilot avoiding the UAS to prevent a mid-air collision (Loffi et al., 2016, p. 2).

In posing their research questions, the researchers further identified the hazard of midair collisions, related to integrating UAS into the NAS, being due to the lack of an aircraft electronic system to detect UAS. Leaving the safety of the NAS reliant upon the pilot's visual ability of detection and avoidance, whose reliability is unknown (Loffi et al., 2016, p. 1). Loffi et al. (2016) posed the following research questions in their academic research study (p. 7):

1. What is the mean distance in which an aware pilot can reliably visually detect a converging sUAS platform under visual meteorological conditions?
2. Is there a substantial difference in detectability of fixed-wing vs quadcopter UAS platforms?
3. Is there variability between a pilot's perceived visual distance from a UAS and their actual distance?
4. Based on the FAA's model for Aircraft Identification & Reaction Time, would pilots have adequate time to evade a UAS collision?

To answer these research questions, the research methods utilized a small manned aircraft operated by research subject pilots. The pilots were asked by the researchers to visually detect a small UAS within the airspace in or around the aircraft's flight path while operating under VMC, and were also required to estimate the distance the small UAS was from the pilot's manned aircraft (Loffi et al., 2016, pp. 7-8). A small quadcopter UAS with 3.24 square feet of visible surface area and a small fixed-wing UAS with 5.27 square feet of visible surface area were also used for the study (Loffi et al., 2016, p. 12).

The researchers established six scenarios for the pilots to detect a small UAS during their flight; 1) a scenario in which no small UAS was located in the surrounding airspace, 2) a scenario in which a hovering quadcopter was located on the left side of the aircraft, 3) a scenario in which a hovering quadcopter was located on the right side of the aircraft, 4) a scenario in which a quadcopter would be transitioning from the left to the right side of the aircraft, 5) a scenario in which a quadcopter would be transitioning from the right to left side of the aircraft, and 6) a scenario in which a fixed-wing UAS would be circling ahead of the aircraft's flight path (Loffi et al., 2016, p. 8). A total of 20 flights were conducted for a total of 13 flight hours with 119 experimental scenarios completed as identified in this paragraph (Loffi et al., 2016, p. 11).

In presenting the results of the study and detectability of the small UAS, Loffi et al. (2016) noted that the pilots were capable of detecting the small UAS during 40.3% of the total 119 scenarios; in further detail, during 36.8% of the quadcopter scenarios and 87% of the fixed-wing scenarios (p. 11). When estimating the distance from the small UAS, the pilots generally overestimated their distance from the smaller quadcopter UAS and underestimated their distance from the larger fixed-wing UAS when the researchers compared pilot estimates to the actual distance based on GPS coordinates for each aircraft (Loffi et al., 2016, p. 17). The researchers provided answers to each of the four research questions at the conclusion of the study.

The researchers answered the first question posed during the research study, “What is the mean distance in which an aware pilot can reliably visually detect a converging sUAS platform under visual meteorological conditions?” (Loffi et al., 2016, p. 7). The researchers’ results identified that the smaller quadcopter UAS was more difficult to detect than the larger fixed-wing UAS at distances beyond 0.10 statute miles and the detection rates within 0.10 statute miles varied between 26.3% and 57.9% detectability (Loffi et al., 2016, p. 19). Compared to the smaller quadcopter UAS, Loffi et al. (2016) noted that the larger fixed-wing UAS was significantly easier to detect, with an 84.2% detectability rate within 0.493 statute miles (p. 19). However, the overall results of the study were inconclusive to fully answer this research question.

The researchers answered the second question posed during the research study, “Is there a substantial difference in detectability of fixed-wing vs quadcopter UAS platforms?” (Loffi et al., 2016, p. 7). The researchers addressed the differences in detectability between the smaller quadcopter UAS and the larger fixed-wing UAS. It was identified that the fixed-wing UAS had a detection distance that was 500% greater than the smaller quadcopter UAS and was likely due to the larger visible surface area as previously addressed in this section of the dissertation (Loffi et al., 2016, p. 22).

The researchers answered the third question posed during the research study, “Is there variability between a pilot’s perceived visual distance from a UAS and their actual distance?” (Loffi et al., 2016, p. 7). As previously stated in this section of the dissertation, when estimating the distance from the small UAS, the pilots generally overestimated their distance from the smaller quadcopter UAS and underestimated their distance from the larger fixed-wing UAS when the researchers compared pilot estimates to the actual distances based on GPS coordinates (Loffi et al., 2016, p. 17). The researchers noted this in the conclusion section of the study and indicated it to be a significant finding because small UAS, with smaller visible surface areas, represent the majority of small UAS used for commercial and hobbyist purposes (Loffi et al., 2016, p. 22).

The researchers answered the fourth question posed during the research study, “Based on the FAA’s model for Aircraft Identification & Reaction Time, would pilots have adequate time to evade a UAS collision?” (Loffi et al., 2016, p. 7). The researchers noted that “pilots require at least 12.5 seconds to detect, process, and perform required evasive maneuvers to avoid an airborne collision threat” (Loffi et al., 2016, p. 22). As previously identified in this section, the researchers’ results identified that the smaller quadcopter UAS was more difficult to detect than the larger fixed-wing UAS at distances beyond 0.10 statute miles and the detection rates within 0.10 statute miles varied between 26.3% and 57.9% detectability (Loffi et al., 2016, p. 19).

Compared to the smaller quadcopter UAS, Loffi et al. (2016) noted that the larger fixed-wing UAS was significantly easier to detect, with an 84.2% detectability rate within 0.493 statute miles (p. 19). Based on the detectability range of 0.10 statute miles for smaller quadcopter UAS, and 0.493 statute miles for larger fixed-wing UAS, the researchers determined that the pilot of a manned aircraft would unlikely have time to detect and respond to a collision threat from the smaller quadcopter UAS versus the larger fixed-wing UAS if traveling at the same relative airspeed of 100 knots, whereas the pilot would require 3.12 seconds to respond to the smaller UAS versus 15.42 seconds for the larger UAS (Loffi et al., 2016, pp. 22-23).

Public Trust in Automation

The stated purpose of this research was to qualitatively study the public's trust and knowledge of UAS safety through data collection by interviewing research subjects. Previous sections of this chapter examined the topics of aviation safety that aligned with purpose of gaining an understanding of the research subjects' level of knowledge about aviation safety.

The purpose of this section is to better understand the resultant research data and implications of this study by examining relevant academic research as it aligns with the research question that sought to determine the factors that affect the research subjects' trust in UAS safety. As a result, the researcher reviewed the following relevant literature; an academic research study of public perceptions of UAS; an academic research study of factors that influence the public to fly as passengers in UAS; an academic research study of cultural differences in public perceptions about aircraft auto-pilot systems; and, an academic paper on public fear of UAS published in an industry journal.

The first review of relevant literature that will be examined is a quantitative academic research study titled, *Public Perceptions of Unmanned Aerial Vehicles* (Tam, 2011). Tam (2011) identified that the purpose of the research was to quantitatively examine the perceptions the public has about UAS used for transporting people and cargo in commercial operations, with a key research focus to identify if there were any Pearson correlations between the public's familiarity of UAS and perceptions they had about UAS safety (p. 12).

Tam's (2011) research methodology consisted of using a data collection instrument in the form of a questionnaire disseminated to 170 and voluntarily completed by 158 male and female faculty members of a university and an international organization for aviation industry professionals who were over the age of 18 years old, had knowledge of aviation travel and represented the air traveling consumers' demographics (pp. 8-9).

The results of Tam's (2011) research are illustrated in Figures 2.3 and 2.4. The researcher of this dissertation notes that Figure 2.3 relates to questions as they pertain to Tam's research subjects' support of UAS passenger transportation and Figure 2.4 relates to questions as they pertain to the research subjects' support of UAS cargo transportation. The researcher of this dissertation also notes that the same questions were asked in each category of transportation, as noted in Figures 2.3 and 2.4.

Figure 2.3

Support of Unmanned Passenger Transportation (Tam, 2011, p. 10)

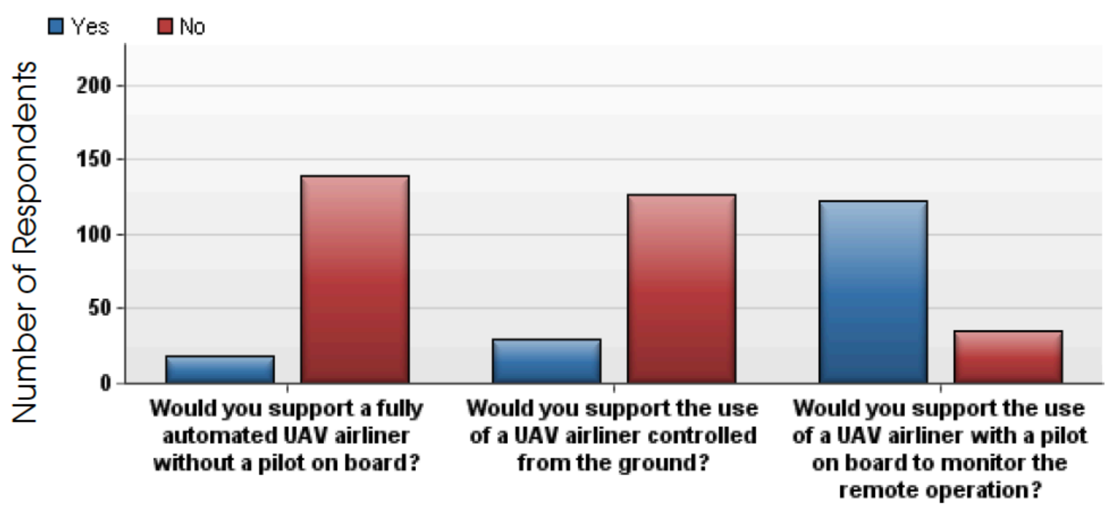
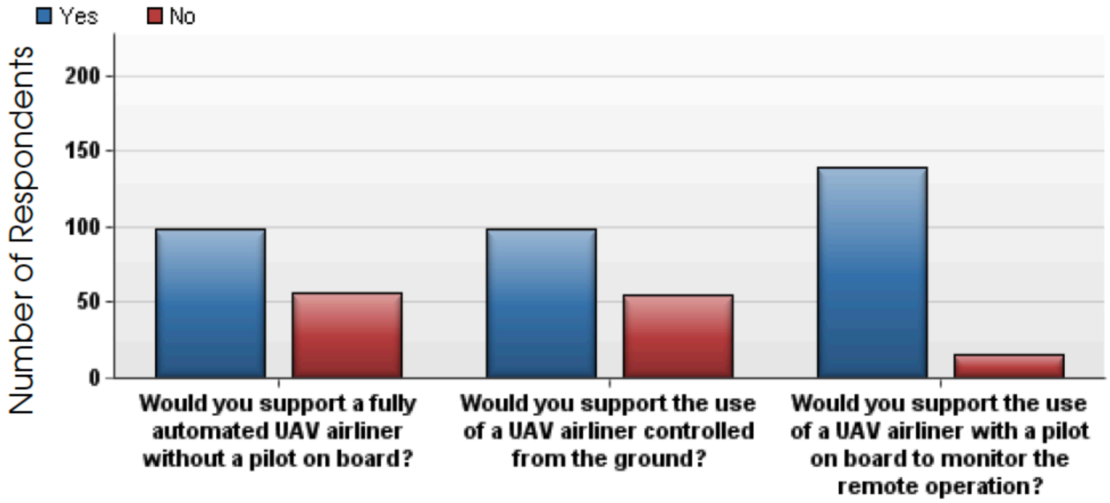


Figure 2.4

Support of Unmanned Cargo Transportation (Tam, 2011, p. 11)



Tam (2011) described the demographic make-up of the research subjects as; 60% were male and 40% were female; 53% were between the ages of 50 to 64 years old; 29% were between the ages of 35 to 49 years old; 12% were between the ages of 25 to 34 years old; 4% were over the age 65 years old; and, 2% were between the ages of 18 to 24 years old (p. 9). Additionally, Tam (2011) identified that 98% of the research subjects indicated that they flew at least once a year (p. 9), yet the research subjects' average familiarity of UAS was "little to moderate knowledge" and only five of the 158 research subjects indicated they were experts in the field of UAS (p. 11).

Figures 2.3 and 2.4 explained, Figure 2.3 shows that a majority of Tam's (2011) research subjects did not support UAS for passenger travel unless a pilot was on board to monitor the operation of the UAS. However, Figure 2.4 shows the opposite was true for the research subjects' support of UAS used in cargo operations without a pilot onboard, but they had even greater support of UAS for cargo operations if a pilot were onboard to monitor the operations of the UAS. Tam also calculated the Pearson Correlation R2 value to determine if any correlation existed between a research subject's gender and their familiarity with UAS, which yielded the result that a R2 value of 0.21 for male research subjects "weakly suggested" that males had more familiarity with UAS than female research subjects; and similarly, there was no correlation between a research subject's gender and age, versus their willingness, or likelihood, to fly as a passenger in a UAS (Tam, 2011, pp. 13-14). Overall, Tam (2011) cited that resultant Pearson Correlation calculations completed during the study for all research subjects indicated "no significant correlation" between their familiarity and willingness or likeliness to fly as passengers in UAS (p. 12).

The research subjects expressed concerns about the absence of a pilot onboard a UAS and the fidelity of automated UAS systems. The specific concerns identified were; the absence of a pilot to react to emergency situations and either take control of the UAS, or mitigate the situation and redirect the automated UAS operations (Tam, 2011, p. 14). Tam (2011) also noted that besides a pilot physically being onboard the aircraft to mitigate emergency situations, including security incidents and threats, the subjects also indicated the need for redundant fail-safe redundant systems that have been proven as safe as manned aircraft systems (pp. 13-14).

In summary, Tam (2011) recommended that a pilot physically be onboard to mitigate emergency situations in order to increase the willingness and likelihood of passengers to fly on the UAS because 77% of the research subjects supported flying on a UAS under these conditions, while 90% of the research subjects supported UAS cargo operations under these conditions (p. 15).

The second review of relevant literature that will be examined is a quantitative academic research study of factors that affect passenger decisions to fly on unmanned aircraft titled, *Analysis of Factors that may be Essential in the Decision to Fly on Fully Automated Passenger Airliners* (Vance, 2014). The purpose of Vance's (2014) research was to identify the "trust, safety and cost" factors that affect passenger decisions to fly on fully automated unmanned aircraft (p. 8).

Vance (2014) utilized a Bayesian statistical reference and Design of Experiments method, or fractional factorial survey, to quantitatively analyze outside historical research data against new research data captured during the study by utilizing the fractional factorial survey to determine the sample population's statistical willingness to fly as passengers on unmanned aircraft (p. 160). Utilizing a web-based survey, the demographic make-up of research subjects consisted of men and women over the age of 18 years-old who had experience flying as passengers on commercial aircraft (Vance, 2014, p. 48). However, Vance (2014) acknowledged that the diversity of the research subjects did not match U.S. population census data or represent the general public because; there were disproportionately more research subjects in the 49 to 67-year-old age group than the other age groups; 520 out of the 1,506 research subjects worked in the aviation field, while 316 out of the 520 were pilots; and, 568 out of the 1,506 research subjects worked in the science, mathematical, and engineering professions (pp. 162-163).

The results of Vance's (2014) study revealed three "statistically significant" variables with the potential to influence the research subjects' decisions to fly as passengers on unmanned aircraft, which were; displayed service provider characteristics; automation sophistication; and, system response to interruptions (p. 164). Described as having the most influence on a research subject's decision to fly as passengers on an unmanned aircraft, displayed service provider characteristics is defined as the trust that research subjects had in the “moral integrity, technical competence and fiduciary responsibility” (Vance, 2014, p. 164) of an airline operating as an unmanned airliner.

Described as having the second most significant influence on a research subject’s decision to fly as a passenger on an unmanned aircraft, automation sophistication is defined as the “quality and reliability” (Vance, 2014, p. 39) of the UA’s automated systems to operate and continue to operate safely and predictability. Described as having the third most significant influence on a research subject’s decision to fly as a passenger on an unmanned aircraft, Vance (2014) defines system response to interruptions as the UA’s system’s ability to respond to such interruptions as; unexpected system errors, malfunctions and mechanical failures; adverse weather phenomenon; and, criminal actions that includes “rogue air traffic system participants and terrorists” (p. 34) activities.

Vance’s (2014) research also revealed qualitative comments that are applicable to the results of this research study. Vance (2014) indicated that 1800 open-ended comments were received from the research subjects and were organized in descending order beginning with most frequently observed of the six most common themes; human pilot presence on the aircraft; endorsement by the aviation community of the reliability of the automated system; safety and security measures to prevent cyber-attacks and threats; sophistication of automation technology to replication human pilot capabilities; mistrust of government oversight and policy; and rejection of automation of unmanned aircraft systems (pp. 172-176)

The third review of relevant literature that will be examined is a quantitative academic research study titled, *Passengers from India and the United States Have Differential Opinions about Autonomous Auto-Pilots for Commercial Flights* (Rice et al., 2014). The purpose of the research study was to investigate and compare American and Indian research subjects' comfort and trust levels, as well as their willingness to accept autonomous aircraft systems and remotely controlled aircraft (Rice et al., 2014, p. 6). The researchers hypothesized that 1) the research subjects would have greater negative perceptions about automated and remotely controlled aircraft versus completely manned aircraft, that 2) Indian research subjects would more readily accept completely automated and remotely controlled aircraft than American research subjects (Rice et al., 2014, p. 6), and 3) the research subjects would have greater negative perceptions when their own children were affected than when colleagues were affected (Rice et al., 2014, p. 8)

The researchers used an online survey instrument to interview 201 research subjects that consisted of 104 subjects from the United States, 51 males and 53 females with an average age of 31.01 years old, and 97 subjects from India, 64 males and 33 females with an average age of 31.34 years old (Rice et al., 2014, p. 4). The researchers' survey instrument contained a Likert scale to measure the research subjects' level of comfort and trust of automation within the range of categories from "Extremely Uncomfortable, Distrust, and Unwilling" to "Extremely Comfortable, Trust, and Willing" (Rice et al., 2014, pp. 4-5).

This study also defined the differences between a collectivist culture versus an individualistic culture, which aligned with and supported the research and reasoning behind the research hypotheses. Rice et al. (2014) identified that the Indian culture is a collectivist culture, which tend to be more interdependent in perspective of the self by having a greater concern for others, which influences decision making when it affects others (p. 2). The concept of collectivism influences trust in the Indian culture; so much so, that individuals tend to have blind trust in a particular situation when it is expected, known or anticipated that the collective culture has trust in the situation (Rice et al., 2014, p. 2). It was understood from review of this literature that these types of cultures have greater concern for the community-based interests than their own individualistic self-interests. According to the literature, the opposite is true for individualistic culture, such as the United States culture. It was understood from reading this study that individualistic cultures have greater tendencies to hold higher regard for self-interests than community-based interests, which influences trust and decision making. Rice et al. (2014) also referenced a collectivist and individualistic cultural index with a range of one to 100, one being the least individualistic and 100 being the most individualistic; India scored a 48, which was identified to be moderately collectivist; while, the United States scored a 91, which was identified to be highly individualistic (p. 2). Interestingly Guatemala scored a six, otherwise identified to be highly collectivist (Rice et al., 2014, p. 2).

The results of their research identified that, overall, the research subjects from both countries were more comfortable, more trusting and willing to accept a human pilot versus automated aircraft systems, while the research subjects from the United States had more positive perspectives about human pilots, but more negative perspectives about autopilot systems and remotely controlled aircraft when compared to research subjects from India (Rice et al., 2014, p. 5). Similarly, both United States and Indian cultures had more negative perspectives when a particular situation included their own children (Rice et al., 2014, p. 6).

The researchers also found that the collectivist culture influenced the Indian research subjects' level of acceptance and trust of automation more than the United States research subjects, which is a glimpse into the cultural differences that support the researchers' hypothesis that Indian research subjects would more readily accept completely automated and remotely controlled aircraft (Rice et al., 2014, p. 9).

The fourth review of relevant literature that will be examined is an academic paper published in the Journal of Law Enforcement titled, *the Fear of Drones: Privacy and Unmanned Aircraft* (Friedenzohn & Mirot, 2013). The academic paper examined research and literature surrounding UAS and drone terminology as it relates to the topic of the law-abiding public's privacy and legal concerns in law enforcement's use of unmanned aircraft for the purpose of aerial photography to capture data during monitoring of a criminal's illegal activity (Friedenzohn & Mirot, 2013, p. 1). At the center topic of the paper were the public's concerns about the serious implications to the rights of law abiding citizens to be free from unreasonable search and seizure by law enforcement in its aerial monitoring of unlawful activities by suspected criminals, thus creating public fear of government applications of unmanned aircraft technologies. The concern is based on the use of the term drone, versus UAS, because of the stigma associated with the term drone.

Friedenzohn and Mirot (2013) assessed an Associated Press' (AP) poll of public opinions about privacy and law enforcement's use of drone technology for surveillance (p. 2). In its 2012 poll, the AP found that 35% of those polled had privacy concerns over law enforcement's use of drones, 24% were somewhat concerned with privacy, while 36% had no concerns for privacy (Friedenzohn & Mirot, 2013, p. 2). In their assessment of the same AP poll, Friedenzohn and Mirot (2013) noted that it contained inconsistencies in its data collection and was thus misleading in its overall results because of inconsistencies in applying terminologies in the survey questions (p. 2).

The AP poll data reflected that 48% of those polled were in support of law enforcement's use of UAS while 36% were not in support of law enforcement's use of UAS (Friedenzohn & Mirot, 2013, p. 2). However, Friedenzohn and Mirot (2013) noted that the AP poll inconsistently applied drone terminology across the survey questions, specifically using it in privacy concern questions while using UAS terminology instead of drone terminology in questions regarding support of using UAS for law enforcement purposes, which they deemed counterproductive to empirical research because it potentially created research subject biases due to the negative stigma associated with drone terminology (p. 2).

Friedenzohn and Mirot (2013) note that even though the US Constitution contains language detailing the public's right to the freedom from unreasonable search and seizure, and that there is also legal precedence established by case law that supports the US Constitution's language prohibiting law enforcement's unreasonable search and seizure of property without warrants based on probable cause (p. 5), a certain fear of drones taking aerial pictures without a warrant exists that causes a hysteria in the public when the term drone is used (p. 1). Similarly, this same fear has existed when aircraft have been flown over private property to observe illegal activity without a search warrant, but was later upheld by case law that established precedence.

Such case law establishing legal precedence to conduct aerial surveillance without a search warrant, later upheld by the US Supreme Court, includes California v. Ciraolo in 1986 when law enforcement used a helicopter to fly above a house whose occupants were suspected of growing marijuana behind a tall fence that blocked direct view of the plants from the ground (Friedenzohn & Mirot, 2013, p. 6). With the helicopter being flown lawfully in accordance with aviation safety regulations, law enforcement was able to conduct aerial surveillance without a search warrant to capture aerial photos of the marijuana plants being grown behind the tall fence, thus leading to law enforcement obtaining a search warrant to enter the property, seize 73 marijuana plants, conduct an arrest and convict the grower (Friedenzohn & Mirot, 2013, p. 6).

Regardless of whether drones are flown legally or illegally by law enforcement in accordance with aviation safety regulations, the paper depicts the use of drones with negative descriptive drone terminology as being primarily and covertly used in ominous military applications and constantly publicized as such in the media, thus influencing a negative public perception of drones. However, it also depicts the use of unmanned aircraft technology with positive descriptive UAS terminology, thus influencing positive public perception. Interesting insights into the influence that publicity has over public perception of drones and unmanned aircraft, the topic of the paper leads to the next topic within this dissertation; unmanned aircraft publicity.

Unmanned Aircraft Publicity

As addressed in the previous section of this dissertation, public perception of UAS and drones can be influenced by safety, reliability and security. Because of this, negative media publicity about UAS and drones was examined and detailed in this section of the dissertation for the researcher to gain a perspective about the influences it may have in the following categories; safety, reliability, and security. At the time of this study and beyond, the researcher acknowledges that countless internet media articles were available to the research subjects and the researcher from mainstream news websites, non-mainstream news websites, and independent news websites.

As a result of the volume of information available, the researcher randomly selected articles about safety, reliability, and security from these types of sources to render a perspective on influential media that was and is available for review by the public. Although a limited number of sources were reviewed, the researcher believes that conducting a limited review satisfactorily establishes the needed perspective for the researcher that; negative media about the safety, reliability and security of UAS and drones does exist, it exists in amounts too numerous to count, and it is available to the public. Thus, reviewing countless negative media articles would provide little overall added value to this study and would require an extensive amount of time. The first category that will be examined is safety.

Publicity was shown to target the perceived safety threats that UAS pose to the public, and other aircraft operators in the NAS, as an accident waiting in some instances to mere unauthorized sightings in others. This paints a broad picture for the public that UAS are more dangerous than government accident statistics actually reveal. The researcher recalls that the unmanned aircraft accident statistics previously addressed in this dissertation revealed a lack of government data to not only compare accident rates of UAS to manned aircraft, but to also establish a known accident rate for UAS in which to base comparisons in the first place. Yet, articles published by the media paint a negative image without source data comparison of accident statistics to objectively determine if UAS and drones are any more or less safe than manned aircraft. Similarly, negative media makes safety determinations without proper classification and categorization as an accident, incident or occurrence, such as what the Guardian published in 2015 when it painted a picture that unauthorized drone sightings in the first eight months of 2015 had risen from 238 during the entire year of 2014 to 650 by August 2015 ("US Plans," 2015).

While these numbers were published by the Guardian, the researcher recalls that no known civil UAS or drones operated by civil operators were classified as being involved in an aircraft accident or fatal accident during the time period previously addressed in this dissertation according to the NTSB aircraft accident database. However, a few public or government UAS accidents were recorded with no associated fatalities. It is recalled by the researcher that incident statistics previously identified in this dissertation revealed sightings of unauthorized UAS and drone operations, but none were classified as being involved accidents or caused accidents either, so it is not clear if unauthorized operations actually pose as high a safety risk as it is perceived in media articles such as the one published by the Guardian. In fact, one could argue that with no life onboard the unauthorized operation of a UAS, the operation of manned aircraft could actually pose a greater risk to life than an unmanned aircraft or drone.

Other media reports reflect UAS and drone sales to be outpacing manned aircraft sales at an alarming and prolific rate, suggesting that the government cannot handle the level of additional safety risk imposed on the NAS by the sheer number of additional UAS. One article identified that the sales volume of UAS and drones by consumers in 2014 was 200,000 per month worldwide at nearly $720 million in reported sales, while the sales numbers were predicted to double in 2015 and reach nearly $4.5 billion by 2020 (Barry & Calix, 2015). While the implications of such information leaves readers the implied message that the government will be task saturated in regulating the safety of UAS, current statistics do not reveal the risk to be as high as the media perceives it to be, possibly influencing bias in public opinion about the safety of UAS without consideration for risk-based decision making founded in data and data comparison.

Another method of sensationalizing UAS and drone safety was found to be through endorsement. One such internet article identified a bona fide aircraft accident investigator, Australian Senator Barry O'Sullivan, who openly warned the public that large numbers of fatalities could be expected to occur before drones were appropriately regulated due to the surge in the number of UAS and drones that entered and began being operated in the airspace with manned aircraft (Mizen, 2017).

Mizen (2017) cited that, based on O'Sullivan's credentials of investigating aircraft accidents for 20 years, drones posed a catastrophic mid-air collision hazard, yet the author did not provide correlative studies between bird strikes and drone or UAS strikes to show that drones or small UAS were any more or less of a catastrophic safety hazard and resultant risk than birds were to manned aircraft in the NAS. The researcher considered the lack of full and accurate reporting to be nothing more than sensationalism and not objective and empirical analysis by the author.

The researcher also notes another internet article about the safety of UAS, or drones, which indicates to the reader that a "tragic accident" involving a midair collision between a drone and a commercial aircraft was imminent because of the prolific number of drones being operated hazardously (Thomas, 2016). Thomas (2016) reported that there were 23 near misses in the United Kingdom between April and October during 2015, posing a serious risk. Thomas also went on to write that globally, drone operators are "routinely ignoring" common operating limitations of flying no higher than 400 feet AGL and no closer than five miles from an airport. Additionally, Thomas cited cases in which drones were sighted within 50 feet of manned aircraft by the pilot of a manned aircraft. However, the author did not reference relevant literature, as previously addressed within this dissertation, detailing limitations of pilot visual acuity to identify small UAS or drones at altitude, while operating at approach airspeeds, thus decreasing the credibility of the report empirically. However, the article did appear as sensationalism to the reader.

The next type of negative media publicity that will be examined is on the topic of UAS or drone reliability. Again, the researcher found countless articles on this topic. First, the researcher identified a negative article about the reliability of the U.S. military's Gray Eagle, an Army UAS similar to the Air Force Predator that was plagued with system reliability and system failures. Beckhusen (2012) reported that the U.S. Army purchased 164 Gray Eagles in its UAS program beginning in 2011 and scheduled through 2022 at a cost of "hundreds of millions of dollars". Yet, despite the poor reliability of all of the aircraft's systems, the Army continued the program after numerous system failures that resulted in aircraft accidents (Beckhusen, 2012). Of significance, Beckhusen (2012) reported the U.S. Army continued the program, despite an average system failure rate of one system failure for every 25 flight hours when the originally expected failure rate was one system failure every 100 flight hours.

The researcher also identified a second article about the reliability of military UAS or drones. Whitlock (2016) wrote that a "mysterious surge" (para. 2) in U.S. Air Force mishaps involving the Reaper drone occurred in 2015. The Reaper, used for combat operations by the Air Force to target enemy and terrorist threats in the Middle East, suffered electrical system failures causing the loss of aircraft power resulting in accidents, or what the author described as "sudden electrical failures that have caused the 2 ½ -ton drone to lose power and drop from the sky" (Whitlock, 2016, para. 3).

The author also sensationalized the secrecy surrounding the national security of classified accident reports as "shrouding the extent of the problem and keeping details" from the public, however the author noted he was able to obtain declassified accident reports under the Freedom of Information Act request for information from the U.S. government (Whitlock, 2016). Whitlock (2016) cited that 24 Reaper drones were involved in accidents during 2015, double the number from previous years, and a total of 237 Reaper accidents occurred between 2001 and 2015. The researcher highlights the fact that Whitlock reported that there were no fatalities in any of the Reaper accidents. This data appeared to be unbiased, empirical, transparent, well rounded and fact based, and correlated to UAS and drone accident data and statistics previously addressed within this dissertation.

The researcher also reviewed other articles related to the reliability of military UAS, besides the Reaper. One specific article provided the statistical information that not only compared the accident rates between UAS, but also compared those accidents rates against manned aircraft. Although the overall military UAS or drone accident rates fell from 62.06 accidents per 100,000 flight hours in 2001 to 5.13 accidents per 100,000 flight hours in 2011, the overall UAS accident rate was still higher than rates for manned aircraft such as the 3.89 accident rate for the F-16 (Hansen, Zeller, & Austin, 2017). Hansen, Zeller, and Austin (2017) also noted that the unmanned Global Hawk aircraft had a 15.16 accident rate that was nearly three times the accident rate than the manned U-2 spy aircraft that flew similar reconnaissance missions.

The researcher also identified an internet article detailing the reliability of small

UAS or drones that are operated for recreational or hobbyist purposes. Teschler (2016) wrote about the poor reliability of gas engines, specifically the engine's carburetor, as the factor limiting hobbyist UAS or drones to 200 hours of reliable flight time. And, the author went on to state that the cause of these limitations was the result of smaller parts and vacuum orifices that were both harder to adjust and clean, and were more sensitive when subjected to vibrations that affect engine/carburetor tuning (Teschler, 2016).

The last area of negative media and publicity about UAS and drones is security. Security meaning UAS can be used specifically for criminal purposes and also meaning the physical or virtual vulnerabilities of UAS systems to malicious hackers who can take control of the UAS in flight. Of greatest credibility, the researcher identified government published information about the threats that UAS pose to the public, specifically UAS used for criminal purposes.

The researcher found that the U.S. Department of Homeland Security (DHS) published on its website that UAS or drones are used for legitimate purposes, such as commercially, hobby and recreation, firefighting and law enforcement, and research (Department of Homeland Security [DHS], 2017). However, it also acknowledged its concern that these devices can be used by terrorists and other criminals to conduct such malicious and criminal activity as illegal spying, carrying weapons or dangerous payloads such as explosives or chemicals used to attack the public or government, as well as simple public disruption and harassment of people, property, and government and law enforcement agencies (DHS, 2017).

Similarly, the researcher found other sources of information about the security threats that UAS and drones pose to the public. Crawford (2016) wrote that terrorists organizations such as Islamic State of Iraq and ash-Sham (ISIS) are researching new ways to use drones to deliver weapons of mass destruction and mass casualties, such as chemical and biological weapons, and even nuclear weapons. The article also credited ISIS with a successful attack on Kurdish military using a drone carrying explosives to kill and injure soldiers (Crawford, 2016). Although the attack occurred in the Middle East, the implication of the article for the researcher was that the technology can be used by organized criminals and terrorist groups, and lone individuals domestically here in the United States.

The second area of security that will be addressed is the physical or virtual vulnerabilities of UAS systems to malicious hackers who can take control of UAS in flight. Sperry (2012), in a CNN article, wrote that “it wouldn't take much effort to hijack a drone over U.S. airspace and use it to commit a crime or act of terrorism.” The author went on to identify that global positioning system (GPS) technology currently exists in off-the-shelf format that can be used to electronically hijack a sophisticated and expensive UAS, but specifically noted small drones are even more vulnerable to malicious attack due to unencrypted software and GPS navigation information (Sperry, 2012). Sperry also wrote that as drones proliferate in numbers, the natural progression of their use will result more, and more, into such illegal activity as spying on homes, backyards and areas typically meant to be private, and the government must regulate their manufacture and use due to the privacy issue they create. And, because of sophisticated camera and small UAS technology, drones that are available to the public are exceptional tools for invading privacy (Forrest, 2015).

The researcher also identified articles detailing the criminally nefarious use of drones to carry illegal drugs across the border of Mexico into U.S. by drug cartels, as well as gangs using drones to deliver illegal drugs and contraband into prisons (Barry & Calix, 2015).

The New York Times also published a similar article on the security threat that drones pose to the public. In 2016, it stated that the "FAA is not equipped to regulate another big drone-related issue: privacy" (New York Times Editorial Board, 2016). In the article, it cited a 2014 survey in which 63 percent of the population was concerned that drones would cause harm in the NAS. The concerns being, threats to privacy and other airplanes.

The last two articles about UAS and drone security reviewed by the researcher were the most sensational, soliciting public fear and accusations of Chinese espionage against the U.S. government and its citizens, supporting the DHS's acknowledgment of its concern for drone security as published on its website. The first, an independent and non-mainstream internet source, Cawley's (2015) article titled the "5 Unstoppable Drone Security Threats You Should be Aware of" was a solicitation for public fear of drones and the potential threat to pose to the public and government.

The author identified five realistic threats that drones pose to security; 1) drones with cameras, 2) drones with weapons, 3) drones with the capability of hacking computer systems, 4) private drones that operated behind secure law enforcement and firefighting boundaries, 5) drones operated by terrorists and criminals. The author placed blame for these threats primarily on the accessibility of this technology by the manufacturers and on the government by the lack of oversight and regulations. The researcher found each of these threats plausible and realistic in nature, given the ingenuity of humankind to enhance base technology and make it better, or more sinister, than its originally intended purpose.

The last article by Rivett-Carnac (2016) about Chinese espionage against the U.S. government and its citizens was examined by the researcher. The researcher recalls the DHS's acknowledgment of its concern for drone security as published on its website, which this article relates to, and the researcher also considered a solicitation for public fear of UAS and drones. DJI, the Chinese manufacturer of DJI Phantom, and also considered the world's largest drone manufacturer, was reported by Bloomberg to be handing over data collected by its drones at the request of the Chinese government (Rivett-Carnac, 2016). The data includes GPS location information, video and still imagery, and related flight data, as well as owner information. The article did not define the scope of customers affected by the government request, or whether it included U.S. customers of the DJI products. The researcher recalls from previously discussed review of relevant literature in this dissertation the privacy implications that drones pose to the public at the hands of the government collection of information without proper warrant. The implications of this article, if true, represent a significant threat to civil liberties of U.S. citizens to be free from unreasonable search and seizure.

Dunning-Kruger Effect

As previously identified in this dissertation, the researcher questioned if the Dunning-Kruger Effect could influence public perceptions of aviation safety, which suggests that people think more highly of their cognitive decision-making abilities even when they have limited knowledge in which to make a competent decision (Kruger & Dunning, 1999, p. 1121). As a result, the researcher reviewed the study by Kruger and Dunning (1999) published in the Journal of Personality and Social Psychology titled, *Unskilled and Unaware of It: How Difficulties in Recognizing One's Own Incompetence Lead to Inflated Self-Assessments* (p. 1121).

Kruger and Dunning (1999) maintained the belief and assumption that under-skilled people overestimate and maintain higher opinions about their skills and abilities than do skilled people in a particular knowledge area, suffering the ability to realize the incompetence brought about by the lack knowledge or skill (p. 1121). The result is an incorrect assumption of competence. The authors conducted four studies to examine the effects of this predicted phenomenon, finding that the incompetent person experiences two negative results from overestimated assumptions about their skills or knowledge level; 1) they experience errors in judgement, choice, and skills, and 2) they lose the opportunity to learn from their errors because they do not realize the errors due to their incompetence (Kruger & Dunning, 1999, p. 1121).

The research pair explained this phenomenon with the relatable example of being competent to read, write, and detect grammatically correct sentences. The premise being that, in order to detect errors in grammatically incorrect sentences, one must be competent in reading and writing grammatically correct sentences in the first place. Kruger and Dunning (1999) also termed this an "imperfect self-assessment" (p. 1122). In that, an average person sees themselves as above average, when in fact they are either average or less than average, but fail to recognize it, which leads the incompetent to believe and overestimate that they are performing well (Kruger & Dunning, 1999, p. 1122).

Kruger and Dunning (1999) focused their research and predictions on these competence and metacognitive skills, which are the foundational knowledge and subsequent experiences one has about one's personal cognitive abilities. The authors predicted these to be lacking in the incompetent person, which is a required skill for correctly assessing one's own abilities (Kruger & Dunning, 1999, p. 1122). In reviewing the study, the researcher identified Kruger and Dunning's (1999) four predictions based on their beliefs and assumptions about the metacognitive abilities of incompetent people (p. 1122):

1. People who are incompetent will overestimate their own cognitive abilities more than those who are competent.
2. People who are incompetent will be less likely than people who are competent to recognize competence in themselves and others.
3. People who are incompetent will be less likely than people who are competent to learn from assessing the performance of other people, in order to assign a correct assessment of self-performance.
4. People who are incompetent can become competent by being taught about their errors, which provides them with the needed metacognitive skills to properly assess self-performance.

The research pair conducted four research studies to test these predictions. The first was a study of humor, the second was a study of logic, the third was a study of grammar and the English language, and the fourth was a follow-on study of logic. In each study, Kruger and Dunning (1999) required the research subjects to assess their own competence, their estimation of their competence was tested, and in each study the research pair predicted that the research subjects would overestimate their competence, but be unaware of poor competence (p. 1123).

The first study, of humor, examined the research subjects' ability to assess their skills at estimating the reaction of other people to jokes, by assessing a series of written jokes and determining if the jokes were either funny or not funny. The study included professional comedians to assess if the jokes were funny, or not. Then, the research subjects' assessments of jokes were compared to the assessments of the professional comedians.

In their predictions, Kruger and Dunning (1999) predicted that the research subjects would overestimate their ability to recognize jokes that would be funny to other people and they would not realize their incompetence (p. 1123). The results of the study revealed that the research subjects actually over-estimated their competence at recognizing funny jokes to be in the 66th percentile, whereas their actual performance was in the 12th percentile, which reflected a severe overestimation of competence (Kruger & Dunning, 1999, p. 1124). In summary of the results of the first study, Kruger and Dunning (1999) affirmed prediction one, and of greatest importance, identified that the incompetent research subjects were "utterly unaware of their incompetence", thus affirming prediction two (p. 1124).

The second study, of logic, Kruger and Dunning (1999) focused on two objectives; 1) validating the result of the first study, and 2) comparing the perceptions of the research subjects (p. 1124). The first objective, to validate the first study, focused on intellectual competence rather than social competence as in the first study. Focusing on intellectual competence and logic skills allowed the research pair to compare the competence of the research subjects based on their actual logic skills, verses perceived social ability. The research pair concluded that the first study of humor had research limitations because what was funny could be perceived as subjective. Focusing on logic, however, allowed the research pair to subject the research subjects to questions with definitive correct and incorrect responses (Kruger & Dunning, 1999, p. 1124). Thus, Kruger and Dunning subjected the second group of research subjects to questions based on legal school admission test questions that contained definitive right and wrong responses.

The second research objective, to compare the perceptions of the research subjects, allowed the research pair to comparatively measure the second group of research subject's ability to compare their competence against the competence of other research subjects in the same group. Effectively, it established their perception of who was right, then compared their responses to the reality of who was actually right and wrong. This objective aligned with prediction three.

As in the first study, the second group of research subjects over-estimated their competence to be in the 66th percentile, when their actual performance fell in the 12th percentile. The results also revealed the incompetent research subjects' inability to properly assess the competence of other research subjects. In summary of the results of the second study, Kruger and Dunning (1999); 1) met the first objective by validating the results of the first study, affirming predictions one and two, and 2) met the second objective to measure the research subjects' ability to assess the competence of others, thus affirming prediction three (p.1125).

The third study, of grammar and English language skills, required the research subjects to complete a self-assessment measuring their predicted competence in the standards and rules for their written use of the English language. Additionally, the subjects were also required to rate their competence to recognize the competence of other research subjects by examining their written use of the English language to determine if they followed established standards and rules for language use. This allowed the research pair to establish competence in the use of language, and the ability to recognize the correct or incorrect use of language skills of other people. Additionally, the research pair were able to assess the ability of the research subjects' ability to identify their own incompetence.

In summary of their research, the research pair found the study to validate the results of the first two studies. In that, Kruger and Dunning (1999) observed the bottom quartile subjects to similarly overestimate their competence and demonstrate significant deficiencies in metacognitive skills to not only identify incompetence in their own abilities, but others as well, thus affirming predictions one and two (p. 1127). Additionally, the research study also affirmed the third predication in that, the incompetent research subjects failed to recognize their own incompetence and believed their performance was above average (Kruger & Dunning, 1999, p. 1127).

The fourth study, a follow-on study of logic ability, used a fourth group of research subjects, with the overall objective to "manipulate competence" in an effort to determine if the subject's metacognitive skills could be improved, thus aligning with prediction four (Kruger & Dunning, 1999, p. 1128). Kruger and Dunning (1999) administered a logic test with problem solving and association tasks to the research subjects, required them to assess their own competence level in problem solving and association, then immediately trained half of the research subjects on problem solving and association, and lastly required all of the research subjects to grade their responses as either correct or incorrect (p. 1128).

In summary of their research, Kruger and Dunning (1999) found that training the incompetent research subjects in problem solving and association made them more competent at recognizing their own incompetence, and also increased their self-performance and overall competence in problem solving and association, thus affirming prediction four (p. 1129). Overall, the research pair were able to affirm each of their four research predictions.

In conclusion, the researcher of this dissertation notes the purpose of this research was to qualitatively study the public's trust and knowledge of UAS safety. Additionally, the researcher sought to determine whether the research subjects would be willing to fly as passengers in UAS, and if publicity of the UAS industry, its development and integration into the NAS have influenced their perception of UAS safety, which could affect their decision to travel as passengers in UAS. The researcher also examined data to identify if any observable Dunning-Kruger Effect existed that would suggest if any of the subjects believed they had more knowledge about the factors that affect UAS safety than what they knew about those factors when deciding whether they would fly as passengers in UAS.

To obtain a better understanding of these topics in order to conduct a thorough analysis of data obtained, as well as to obtain a thorough understanding of the level of knowledge of aviation safety that the research subjects have, this chapter detailed the researcher's review of relevant literature as it related to the purpose of this study. As such, the researcher aligned the topics of this review of literature chapter with the topics contained within the data collection instrument detailed within the methodology chapter of this dissertation. Specifically, this chapter detailed; manned aviation regulations, small unmanned aircraft regulations, large unmanned aircraft regulations, aircraft accident statistics, aircraft accident causes, unmanned aircraft human factors, public trust in automation, unmanned aircraft publicity, and the Dunning-Kruger effect.

CHAPTER III

METHODOLOGY

The researcher submitted the required Oklahoma State University (OSU) Institutional Review Board (IRB) application, obtained approval from the IRB to complete this research study, and collected data from August 3 to October 10, 2016. Reference Appendix A for IRB approval. This chapter details the research methodology used by the researcher during this study. Specifically, it details the sampling population, the subject selection methodology, subject recruitment, the data collection method, the data collection instrument, and ethical considerations.

Sampling Population

Qualitative data collection is dependent upon what Creswell (2012) describes as purposeful sampling of a population by intentionally selecting research subjects in order to learn about the central concepts, themes or phenomenon of the study (p. 206). The researcher utilized Creswell's purposeful sample method by identifying a typical sample of the public who 1) did not have a technical background in manned or unmanned aviation, but was aware of the concepts of manned and unmanned aircraft and may or may not have flown in manned aircraft, and 2) did have a technical background in manned or unmanned aviation.

Subject Selection Methodology

The researcher utilized the purposeful typical sampling method to identify the initial number of research subjects, and then utilized what Creswell (2012) defines as a snowball sampling method, in which the initial research subjects recommended other people who fit the purposeful typical sampling profile identified by the researcher. In these methods, Creswell (2012) defines an adequate number of subjects for purposeful sampling as a range from one to 40 (p. 209). Creswell (2012) also states that it is acceptable to stop data collection if further data collection reveals saturation, defined as the point where the researcher determines that no new information will be obtained by additional data collection (p. 433).

The typical sample method used by the researcher was planned to identify the first one to 10 subjects, and the snowball sample method was planned to be used to identify the remaining number of subjects utilizing the interview questions in the data collection method and data collection instrument sections of this chapter. However, the actual number of purposeful and snowball subject sample sizes differed from the original plan due to the willingness of purposeful sample subjects to recommend snowball sample recruit contacts, and the willingness of snowball sample recruit contacts to participate in the study. As a result, the inverse of the original plan occurred and a greater number of purposeful sample subjects participated versus the number of snowball sample subjects. The research subject demographics, and procedures used to recruit research subjects are detailed within the next section of this chapter.

Subject Recruitment

The researcher attained saturation of data, and stopped further recruitment at a total of 25 subjects who willfully participated in this study. The researcher utilized the purposeful typical sampling method to identify 22 research subjects, by identifying the subjects from personal and professional contacts who were directly known by the researcher to fit the purposeful typical sample profile. The snowball sampling method resulted in identifying three research subjects. Reference Table 3.1 following the next paragraph for research subject selection totals.

The researcher recruited subjects by emailing a subject recruitment letter, Appendix B, and informed consent document, Appendix C, prior to each subject's participation in the study. The researcher received an informed consent document signed by each research subject prior to conducting an interview and collecting data. Reference the appendix section for these documents. Table 3.2 lists the observed demographics of the research subjects who participated in this study.

Table 3.1

Research Subject Selection

Purposeful Sample	Snowball Sample	Total Research Subjects
22	3	25

Table 3.2

Research Subject Demographics

Sex	Age Ranges			
	18-35	36-50	Over 50	Total
Male	0	11	4	15
Female	2	3	5	10

During subject recruitment, the researcher failed to receive responses from 11 recruit contacts. As a result, these recruit contacts were not interviewed. Reference Table 3.3 for non-interviewed recruit contact totals. A total of 6 purposeful sample recruit contacts and a total of 5 snowball sample recruit contacts failed to respond to the requests to be interviewed by the researcher. Reference Tables 3.4 and 3.5 for the demographics of non-interviewed purposeful and snowball sample recruit contacts.

Table 3.3

Non-Interviewed Recruit Contacts

Purposeful Sample	Snowball Sample	Total Recruit Contacts
6	5	11

Table 3.4

Non-Interviewed Purposeful Sample Recruit Contacts

Sex	Age Ranges			
	18-35	36-50	Over 50	Total
MALE	0	0	1	1
FEMALE	0	3	2	5

Table 3.5

Non-Interviewed Snowball Sample Recruit Contacts

Sex	Age Ranges Unknown
Male	5
Female	0

Data Collection Method

Creswell (2012) describes the process for collecting, analyzing and interpreting qualitative data to include; 1) collecting data by recording interviews, 2) preparing recorded data from interviews by transcribing it into meaningful written text, 3) reviewing the transcribed data to identify central themes and categories, and 4) coding the central themes and categories for analysis and interpretation detailed in the final dissertation report (p. 237). The researcher utilized this process for data collection.

The researcher conducted telephone interviews, which ranged from an approximate half-hour to an hour-and-a-half, with each typical and snowball sample subject until saturation of data occurred. Interviews were conducted by telephone from the researcher's home office and audio from each interview was recorded. The researcher also developed and used an IRB approved interview guide. The guide was used to ask each subject the same open-ended and closed-ended interview questions.

Because of the qualitative design of this study, both open-ended and closed-end questioning generated further follow-on questions from the researcher and the research subjects in order to gain further clarification of either the research subjects' responses to the questions, or to clarify the questions for the research subjects. These follow-on questions generated a data rich environment for the researcher to complete this study, which will be detailed in the analysis and findings chapter of this dissertation. Reference Appendix D for the interview guide and Appendix A for the IRB approval letter.

The data collection interview questions were designed and used to determine the following; if the subjects trusted UAS safety; if the subjects had a knowledge of factors that affected UAS safety; if the subjects believed any other factors affected their trust of UAS safety; if the subjects believed that UAS publicity affected their trust of UAS safety; and overall, if the subjects were willing to fly as passengers in UAS. The results are detailed within the analysis and findings chapter of this dissertation.

Data collection methods used to identify the research subjects' knowledge of UAS safety focused on specific factors the researcher knows affect UAS safety based on the researcher's technical experience and professional education in the field of aviation safety; which are, FAA regulations, certification, and oversight of manned and unmanned aircraft, operations, and airworthiness.

Within the analysis and findings chapter of this dissertation, the researcher details the results of the process that Creswell (2012) describes for collecting, analyzing and interpreting qualitative data. Following the collection of data, the researcher prepared the recorded data from interviews by transcribing it into meaningful written text, reviewed the transcribed data to identify central themes and categories, and coded the central themes and categories for analysis and interpretation detailed in the final dissertation report. The following sections within this chapter identify the data collection instrument used during this study, and ethical considerations and measures taken to preserve the validity of data and integrity of the research process.

Data Collection Instrument

The researcher used a two-part data collection instrument and asked each research subject to respond to each interview question and statement. The duration of each interview session ranged from an approximate half-hour to an hour-and-a-half in length. Only one interview session was used to complete the interview process for each subject.

First Part: Open-Ended Interview Questions and Statements

1. Please describe your background, experience and education in aviation. [Ask if the male or female research subject to further describe their age as between (1) 18-35; (2) 36-50; and (3) over 50]
2. Can you describe your level of trust in manned aircraft safety?
3. Can you describe your level of trust in unmanned aircraft safety?
4. What factors affect your trust of unmanned aircraft?
5. What factors affect your trust of manned aircraft?
6. Can you describe your knowledge of factors that affect unmanned aircraft safety?
7. Can you describe your knowledge of factors that affect manned aircraft safety?
8. Can you describe what has been publicized about UAS by the government and media, and how this publicity has affected your opinions about UAS?

Second Part: Follow-on Closed-Ended Questions

1. Are you an aircraft pilot or mechanic?
2. Do you, or anyone you know operate UAS?
3. How often do you fly as a passenger in a commercially manned aircraft?
4. Are UAS regulated and overseen for safety the same as manned aircraft?
5. Are UAS considered to be as technically reliable and safe as manned aircraft?
6. Are UAS licensed the same as manned aircraft?
7. Are UAS operators licensed and trained the same as manned aircraft pilots?
8. Are UAS allowed to operate in the same airspace as manned aircraft?
9. Are UAS mechanics licensed the same as manned aircraft mechanics?

10. Are UAS required to be maintained the same as manned aircraft?
11. Would you volunteer to be the first person to fly in an unmanned aircraft?
12. If proven safe and reliable, would you fly as a passenger in an unmanned aircraft?
13. Would you recommend another person who may be suitable for this study?

Ethical Considerations

Pursuant to OSU IRB procedures, and in order to prevent harm to the research subjects, data collected during this study was not, and will not be made a part of any record that can be linked to any of the research subjects, and none of the subjects were misled or deceived in any way to further this research study. The sampling population did not include members of any special population as defined by the OSU IRB policy, and no subjects were under the age of 18.

At no time during this research study were any of the research subjects exposed to stress or risks that were greater than what the research subjects would normally encounter during their normal and daily physical or psychological activities. Similarly, because biological sampling was not conducted, physical conditioning and/or issuance of any life sustaining food, water and drugs necessitating medical clearance was not required. At no time during this research study were the research subjects exposed to offensive, threatening, or degrading material, nor were they offered inducements to participate in this study that could be perceived as compensation to participate.

To meet IRB intervention, environment, and subject manipulation requirements, the researcher utilized the approve IRB informed consent document to notify the research subjects of confidentiality and risks associated with participation in the qualitative question and answer interview process. Reference the appendix section for these documents approved by the IRB. At no time during this research study did the researcher manipulate the subjects or the environment, and no exposure-outcome research was performed in this qualitative study.

The 23 purposeful sample research subjects who participated in this study were known to the researcher, while the three snowball subjects who participated were not known by the researcher. In order to protect the identity and well-being of each research subject, the researcher has stored and will keep all informed consent documents and audio recorded responses to interview questions for the following specified time period.

Before recording, transcribing, coding and categorizing of data, the name of each research subject was replaced with a research subject number and each associated research subject number corresponds to the associated research subject's responses to their interview questions. Audio recordings did not contain personally identifiable information, and instead contained the research subject number instead of any subject names or personally identifiable information. Similarly, subject names do not correspond to responses to any interview questions.

All informed consent documents, audio recordings and transcripts are and will be kept secure in the researcher's residence, locked in a fire proof safe for a period of three years. After three years, the information will be destroyed. Informed consent documents have not, and will not be made available to anyone other than the researcher and the Dissertation Committee Chair. During the records retention time period, research subject numbers and the associated transcribed written text will be made available for review by the Oklahoma State University, the Dissertation Committee, and outside researchers seeking to validate research results.

To maintain credibility and validity of the research methods and data, the researcher commissioned the services of a third party to transcribe interview audio data into meaningful written text for researcher coding and categorizing of data into central themes. The audio files sent to the transcriptionist did not contain any personally identifiable information, and instead contained the research subject number associated with the audio files.

CHAPTER IV

ANALYSIS AND FINDINGS

Introduction

The purpose of this research was to qualitatively study the public's trust and knowledge of UAS safety through data collection by interviewing research subjects. The researcher sought to determine whether the research subjects would be willing to fly as passengers in UAS, and if publicity of the UAS industry, its development and integration into the NAS have influenced their perception of UAS safety. The researcher also examined data to identify if any observable Dunning-Kruger Effect existed that would suggest if any of the subjects believed they had more knowledge about the factors that affect UAS safety than what they knew when deciding whether to fly as passengers in UAS.

To gain a greater understanding of these topics and conduct a more thorough analysis of the research data, the researcher conducted a review of relevant literature as it relates to the purpose of this study. As such, the researcher aligned the topics of the review of literature chapter with the topics contained within the data collection instrument detailed within the methodology chapter. Specifically, the review of literature contained topics in manned aviation regulations, small unmanned aircraft regulations, large unmanned aircraft regulations, aircraft accident statistics, aircraft accident causes, unmanned aircraft human factors, public trust in automation, unmanned aircraft publicity, and the Dunning-Kruger effect.

This section of the dissertation details the analysis of the data that was collected during research interviews utilizing the data collection instrument. Specifically, the chapter details the demographics of the research subjects, analyzes the results of the data collection instrument, and discusses research findings related to common themes of the research. The demographics of the research subjects will be analyzed first.

Demographics

As detailed in the methodology chapter of this dissertation, the researcher recruited 25 research subjects that consisted of 22 purposeful sample subjects and three snowball sample subjects. Tables 4.1 and Table 4.2 lists the sample types, and observed age and sex demographics of the research subjects who participated in this study. This demographic data was captured during the first open-ended interview question/statement of the first part of the data collection instrument, which asked the male and female subjects to further describe their age as either 18-35, 36-50, or over 50. Further education and experience demographics of the research subjects are detailed in the next section of this chapter, which analyzes the results of the data collection instrument.

Table 4.1

Research Subject Selection

Purposeful Sample	Snowball Sample	Total Research Subjects
22	3	25

Table 4.2

Research Subject Demographics

Sex	Age Ranges			
	18-35	36-50	Over 50	Total
Male	0	11	4	15
Female	2	3	5	10

Data Collection Instrument Analysis

The data collection instrument consisted of two parts. The first part contained eight open-ended interview questions and statements. The second part contained 13 follow-on closed-ended questions. This section details and analyzes the results of each research question, within each part, of the data collection instrument.

The researcher notes that qualitative descriptive language is used throughout this section to consistently and qualitatively describe the number of research subjects in each of the two research subject categories that were observed in question number one of the first part of the data collection instrument; the 12 subjects without a background, experience and education in aviation; and, the 13 subjects with a background, experience and education in aviation. These qualitative descriptions are referenced within Table 4.3. The first part of the data collection instrument, the open-ended interview questions, will be examined first.

Table 4.3

Descriptors of Research Subject Quantity

Descriptor	Without Background in Aviation	With Background in Aviation
Some	2 to 3 out of 12	2 to 4 out of 13
Few	4 out of 12	5 out of 13
Less than half	5 out of 12	6 out of 13
Half / Slightly more than half	6 out of 12	7 out of 13
Majority	7 out of 12	8 out of 13
Most	8 to 10 out of 12	9 to 11 out of 13
Nearly All	11 out of 12	12 out of 13

First Part: Open-Ended Interview Questions and Statements

1. Please describe your background, experience and education in aviation.

This question asked the research subjects to describe their background, experience and education in aviation. The responses for background and experience in aviation were categorized in the following common themes; 1) yes, the research subject had a background and experience in aviation; or 2) no, the research subject did not have a background and experience in aviation. These categorical themes were analyzed throughout each question of the data collection instrument.

Based on the research subjects' qualitative responses, their responses were further categorized as either having an identified background or experience in aviation as a pilot, mechanic, or other capacity. Other was identified as someone having a background or experience in aviation as either a flight attendant, an airline ticketing and loading agent, air traffic controller, or someone who provided administrative support in aircraft accident investigations.

Responses to education were also categorized into common themes. The responses were categorized as none, academic, and/or technical. Academic was identified as either college undergraduate, or college graduate degrees in aviation subject matter. Technical was identified as training in aviation vocational subject matter. The research data reflected the following information.

It was observed that 12 of the research subjects indicated they had no background, experience, or education in aviation.

- Seven (7 out of 12) research subjects were observed to be male (six between the ages of 36-50 and one who was over 50).
- Five (5 out of 12) subjects were observed to be female (two between the ages of 18-35, two between the ages of 36-50, and one who was over 50).
- None (0 out of 12) indicated they were a pilot or a mechanic.

It was observed that 13 of the research subjects indicated they had a background and experience in aviation, which will be examined here. Some subjects also indicated they had aviation education, which will be examined after this section.

- Eight (8 out of 13) of the research subjects were observed to be male (five between the ages of 36-50, and three who were over the age of 50).
    - Of the eight male research subjects, three indicated they had a background and experience in both piloting manned aircraft and in aviation maintenance (one had experience operating large unmanned aircraft and one had experience operating a small UAS).
    - Of these eight male research subjects, five indicated they only had experience in aviation maintenance.
- Five (5 out of 13) subjects were observed to be female (one between the ages of 36-50 and four who were over the age of 50).

    - Of the five female subjects, one was a commercial aircraft flight attendant, one was an airline ticket and loading agent, one was an air traffic controller, one was a commercial pilot, and one provided administrative support in airmen toxicology investigations of aircraft accidents.

As previously noted, the responses to education were also categorized into common themes. But, 12 out of 25 research subjects indicated they had no education in aviation. The research data for the remaining 13 research subjects reflected the following information.

Out of the 13 research subjects who indicated they had a background and experience in aviation:

- Twelve (12 out of 13) of the research subjects indicated having technical and/or academic education in aviation subject matter
    - All (12 out of 12) indicated they had aviation technical education.
    - Four (4 out of 12) indicated they also had additional undergraduate and graduate college academic degrees in aviation related subject matter.
- One (1 out of 13) subject, the airline ticket and loading agent, indicated having neither.

It is noted that all 25 research subjects indicated they had previously flown as passengers in a commercial aircraft, while some had flown as passengers in small non-commercial aircraft.

2. Can you describe your level of trust in manned aircraft safety?

This question asked the research subjects to describe their level of trust in manned aircraft safety and generated qualitative responses from most of the research subjects. This question also led to follow-on questions for the researcher to clarify the question for the research subjects, or for the research subjects to clarify their responses for the researcher. Specifically, clarification centered around whether manned aircraft meant large or small manned aircraft.

Most of the subjects who had a background and experience in aviation had a general awareness of the distinction between large aircraft used in commercial aviation and small aircraft used in general aviation. As a result, these subjects either asked the researcher to clarify if the question referred to large or small aircraft, or they clarified the question themselves and made the distinction in their responses. Some of the research subjects who did not have a background and experience in aviation asked the researcher to clarify the question. For the remaining subjects, they made no distinction between large and small, so the researcher asked the subjects to clarify their responses.

As previously noted in the analysis of this data collection instrument, 12 of the research subjects indicated they had no background, experience, or education in aviation subject matter. While, 13 of the research subjects indicated they had a background, experience and/or education in aviation subject matter. For this question, the research data reflected the following information for large and small manned aircraft.

Large Manned Aircraft

Out of the 12 research subjects who indicated they had no background, experience, or education in aviation subject matter:

- Most (8 out of 12) of the research subjects indicated they had a high level of trust in large, or commercial, manned aircraft safety.
- A few (4 out of 12) subjects indicated they had a medium level of trust in large, or commercial, manned aircraft safety.

Out of the 13 research subjects who indicated they had a background, experience and/or education in aviation subject matter:

- Nearly all (12 out of 13) of the research subjects indicated they had high level of trust in large, or commercial, manned aircraft.
- One (1 out of 13) subject indicated a low level of trust.

Small Manned Aircraft

Out of the 12 research subjects who indicated they had no background, experience, or education in aviation subject matter:

- A few (4 out of 12) of the research subjects indicated they had a high level of trust in small, or general aviation, manned aircraft safety.
- Some (3 out of 12) subjects indicated they had a moderate level of trust in small, or general aviation, manned aircraft safety.
- Some (2 out of 12) indicated they had a low level of trust in small, or general aviation, manned aircraft safety.

- Some (3 out of 12) had no opinion about small manned aircraft safety due to lack of knowledge.

Out of the 13 research subjects who indicated they had a background, experience and/or education in aviation subject matter:

- Some (3 out of 13) of the research subjects indicated they had a high level of trust in small manned aircraft safety.
- One (1 out of 13) subject indicated a medium level of trust in small manned aircraft safety.
- Less than half (6 out of 13) indicated a low level of trust in small manned aircraft safety.
- Some (3 out of 13) had no opinion about small manned aircraft safety due to lack of knowledge.

This question also generated qualitative data that readily identified common themes around trust in manned aircraft safety. The common themes were; the man (the human component), the machine (the mechanical component), the environment (weather, other external non-manmade phenomenon, etc.), the system (ATC, training processes and procedure, airports, safety regulations, regulatory oversight, operator processes and procedures, etc.), and security (malicious acts, and those things affected by malicious acts, and the processes and procedures in place to reduce malicious acts). It is noted that these common themes align with the common themes identified within the review of literature chapter of this dissertation.

Though the research subjects expressed comments identifying these common themes, this question did not expressly solicit a response to identify common themes. As a result, the researcher did not draw distinct conclusions about any particular level of knowledge the subjects had or did not have based on their comments.

As previously noted in the analysis of this data collection instrument, 12 of the research subjects indicated they had no background, experience, or education in aviation subject matter. While, 13 of the research subjects indicated they had a background, experience and/or education in aviation subject matter. The research data reflected the following information around the common themes.

Common Themes

Out of the 12 research subjects who indicated they had no background, experience, or education in aviation subject matter:

- One (1 out of 12) of the research subjects identified two of the common themes in manned aircraft safety; the man and the machine.
- A majority (7 out of 12) of the subjects identified one; three identified the man and four identified the machine.
- A few (4 out of 12) did not provide a response as in depth as the other subjects, and did not identify any common themes as a result.

Out of the 13 research subjects who indicated they had a background, experience and/or education in aviation subject matter:

- One (1 out of 13) of the research subjects identified all five common themes in manned aircraft safety; the man, the machine, the environment, the system and security.

- One (1 out of 13) subject identified four; the man, the machine, the environment, and the system.
- Some (3 out of 13) identified three; the man, the machine and the system.
- A few (5 out of 13) identified two; the man and the machine.
- Some (2 out of 13) identified one; one subject identified the man and one subject identified the machine.
- One (1 out of 13) did not provide a response as in depth as the other subjects, and did not identify any common themes as a result.

3. Can you describe your level of trust in unmanned aircraft safety?

Similar to question two, question three asked the research subjects to describe their level of trust in unmanned aircraft safety, and generated qualitative responses from most of the research subjects. This question also led to follow-on questions for the researcher to clarify the question for the research subjects, or for the research subjects to clarify their responses for the researcher. Specifically, clarification centered around whether unmanned aircraft meant large or small unmanned aircraft. The only distinction made by the researcher in clarifying the difference between large and small was a comparison of a small unmanned aircraft to that of a hobbyist or small drone. Some research subjects equated large unmanned aircraft to be comparable to a large military unmanned aircraft and even the size of a large commercial aircraft capable of carrying passengers.

As previously noted in the analysis of this data collection instrument, 12 of the research subjects indicated they had no background, experience, or education in aviation subject matter. While, 13 of the research subjects indicated they had a background, experience and/or education in aviation subject matter. The research data reflected the following information around large and small UAS.

Large UAS

Out of the 12 research subjects who indicated they had no background, experience, or education in aviation subject matter:

- One (1 out of 12) of the research subjects indicated a high level of trust for large unmanned aircraft safety.
- One (1 out of 12) subject indicated a medium level of trust.
- Most (8 out of 12) indicated a low level of trust.
- Some (2 out of 12) indicated no level of trust.

Out of the 13 research subjects who indicated they had a background, experience and/or education in aviation subject matter:

- A few (5 out of 13) of the research subjects indicated they had a high level of trust for large unmanned aircraft safety.
- A few (5 out of 13) subjects indicated they had a medium level of trust.
- One (1 out of 13) indicated a low level of trust.
- Some (2 out of 13) indicated no level of trust.

Small UAS

Out of the 12 research subjects who indicated they had no background, experience, or education in aviation subject matter:

- One (1 out of 12) of the research subjects indicated a high level of trust in small unmanned aircraft safety.
- Less than half (5 out of 12) of the subjects indicated a medium level of trust.
- A few (4 out of 12) indicated a low level of trust.
- Some (2 out of 12) indicated no level of trust.

Out of the 13 research subjects who indicated they had a background, experience and/or education in aviation subject matter:

- One (1 out of 13) of the research subjects indicated a high level of trust in small unmanned aircraft safety.
- Some (4 out of 13) of the subjects indicated a medium level of trust.
- Some (4 out of 13) indicated a low level of trust.
- Some (4 out of 13) indicated no level of trust.

Question three also generated qualitative data that readily identified common themes as noted in question two. However, it was centered around trust in unmanned aircraft safety. The common themes were; the man, the machine, the environment, the system, and security. Though the research subjects expressed comments identifying these common themes as in question two, this question did not expressly solicit a response to identify the common themes. As a result, the researcher did not draw distinct conclusions about any particular level of knowledge the subjects had or did not have based on their comments.

As previously noted in the analysis of this data collection instrument, 12 of the research subjects indicated they had no background, experience, or education in aviation subject matter. While, 13 of the research subjects indicated they had a background, experience and/or education in aviation subject matter. The research data reflected the following information centered around these common themes.

Common Themes

Out of the 12 research subjects who indicated they had no background, experience, or education in aviation subject matter:

- Some (3 out of 12) of the research subjects identified two of the common themes in unmanned aircraft safety; the man and the machine.
- One (1 out of 12) subject identified one common theme; the man.
- Most (8 out of 12) did not provide a response as in depth as the other subjects, and did not identify any common themes as a result.

Out of the 13 research subjects who indicated they had a background, experience and/or education in aviation subject matter:

- Slightly more than half (7 out of 13) of the research subjects identified three common themes in unmanned aircraft safety; five identified the man, the machine and the system; one identified the man, the system, and security; and, one identified the machine, the system and security.
- Some (3 out of 13) of the subjects identified two common themes; the man and the system.
- Some (3 out of 13) did not provide a response as in depth as the other subjects, and did not identify any common themes as a result.

4. What factors affect your trust of unmanned aircraft?

Question four asked the research subjects to identify the factors that affect their trust of unmanned aircraft. The question generated qualitative data that readily identified common themes as noted in question two and three. Similar to question three, the responses centered around trust in unmanned aircraft. The common themes were; the man, the machine, the environment, the system, and security. Specifically, however, the question directly solicited for comments identifying general common themes of trust in unmanned aircraft regardless of their size, unlike questions two and three. As a result, the researcher was able to capture data to draw distinct conclusions about the general level of knowledge the subjects had or did not have about the factors that affect their trust in unmanned aircraft.

As previously noted in the analysis of this data collection instrument, 12 of the research subjects indicated they had no background, experience, or education in aviation subject matter. While, 13 of the research subjects indicated they had a background, experience and/or education in aviation subject matter. The research data reflected the following information.

Out of the 12 research subjects who indicated they had no background, experience, or education in aviation subject matter:

- Most (8 out of 12) of the research subjects identified two common themes as factors that affect their trust of unmanned aircraft; five identified the man and the machine; one identified the man and the system; one identified the machine and the system; and, one identified the machine and security.
- Some (3 out of 12) of the subjects identified one common theme; two identified the man and one identified the machine.

- One (1 out of 12) did not provide a response as in depth as the other subjects, and did not identify any common themes as a result.

Out of the 13 research subjects who indicated they had a background, experience and/or education in aviation subject matter:

- One (1 out of 13) of the research subjects identified four of the common themes as factors that affect their trust of unmanned aircraft; the man, the machine, the environment, and the system.
- Less than half (6 out of 13) of the subjects identified three common themes; the man, the machine and the system.
- Less than half (6 out of 13) identified two common themes; five identified the man and the machine, and one identified the man and the system.

5. What factors affect your trust of manned aircraft?

Question five asked the research subjects to identify the factors that affect their trust of manned aircraft. The question generated qualitative data that readily identified common themes as noted in question four. In contrast to question four, however, the responses centered around trust in manned aircraft. The common themes were; the man, the machine, the environment, the system, and security. Specifically, however, the question directly solicited for comments identifying general common themes of trust in manned aircraft regardless of their size, unlike questions two and three. As a result, the researcher was able to capture data to draw distinct conclusions about the general level of knowledge the subjects had or did not have about the factors that affect their trust in manned aircraft.

As previously noted in the analysis of this data collection instrument, 12 of the research subjects indicated they had no background, experience, or education in aviation subject matter. While, 13 of the research subjects indicated they had a background, experience and/or education in aviation subject matter. The research data reflected the following information.

Out of the 12 research subjects who indicated they had no background, experience, or education in aviation subject matter:

- Less than half (5 out of 12) of the research subjects identified three common themes as factors of trust in manned aircraft; two identified the man, the machine, and the system; two identified the man, the machine, and security; while, one identified the man, the environment, and security.
- Less than half (5 out of 12) of the subjects identified two common themes; one identified the man and the machine; one identified the man and the system; two identified the man and security; while, one identified the machine and the environment.
- A few (2 out of 12) identified one common theme; the machine.
- The researcher observed that one subject identified a factor within the system category of common themes, which is notable to highlight here. The subject indicated that the aesthetical appearance of a commercial aircraft, or its general appearance, was a factor in trusting that the aircraft was safe.

Out of the 13 research subjects who indicated they had a background, experience and/or education in aviation subject matter:

- Some (2 out of 13) of the research subjects identified five common themes as factors of trust in large manned aircraft; the man, the machine, the environment, the system, and security.
- Some (3 out of 13) of the subjects identified four common themes; one identified the man, the machine, the environment, and the system; two identified the man, the machine, the system and security.
- Slightly more than half (7 out of 13) identified three common themes; three identified the man, the machine, and the system; and four identified the man, the machine and security.
- One (1 out of 13) indicated one common theme as a trust factor in large manned aircraft.
- It was also observed by the researcher that eight (8 out of 13) subjects identified security as a common theme in trust of manned aircraft. In all instances regarding comments about security, the qualitative responses were in reference to 14 CFR Part 121 commercial aircraft operations.

6. Can you describe your knowledge of factors that affect unmanned aircraft safety?

Question six asked the subjects to describe their level of knowledge about the factors that affect unmanned aircraft safety. As identified in question four, these noted common themes were identified as the man, the machine, the environment, the system and security. Based on the number of common themes each research subject identified in their qualitative response to the question, the researcher assigned a qualitative descriptor to describe their perceived level of knowledge about unmanned aircraft safety. The research subjects were assigned the following descriptors of knowledge levels in Table 4.4 based on the number of common themes they identified in their qualitative response.

Table 4.4

Descriptors of common theme knowledge level

Descriptor	Definition
Novice	One common theme identified in qualitative response
Intermediate	Two common themes identified in qualitative response
Advanced	Three common themes identified in qualitative response
Expert	Four common themes identified in qualitative response
Superior	Five common themes identified in qualitative response

As previously noted in the analysis of this data collection instrument, 12 of the research subjects indicated they had no background, experience, or education in aviation subject matter. While, 13 of the research subjects indicated they had a background, experience and/or education in aviation subject matter. The research data reflected the following information.

Out of the 12 research subjects who indicated they had no background, experience, or education in aviation subject matter:

- Some (3 out of 12) of the research subjects identified one common theme and were assigned a level of Novice; two identified the man and one identified the system.
- Most (9 out of 12) of the subjects described no level of knowledge.

Out of the 13 research subjects who indicated they had a background, experience, or education in aviation subject matter:

- Some (2 out of 13) of the research subjects identified five of the common themes and were assigned a level of Superior; the man, the machine, the environment, the system and security.
- One subject (1 out of 13) of the subjects identified four common themes and was assigned a value of Expert; the man, the machine, the environment, and the system.
- Some (2 out of 13) identified three common themes and were assigned a level of Advanced; the man, the machine, and the system.
- Some (4 out of 13) identified two common themes and were assigned a level of Intermediate; two identified the man and the machine; one identified the machine and the system; and, one identified the man and system.
- One subject (1 out of 13) identified one common theme and was assigned a level of Novice; the man.
- Some (3 out of 13) of the subjects described no level of knowledge.

7. Can you describe your knowledge of factors that affect manned aircraft safety?

Question seven asked the subjects to describe their level of knowledge about the factors that affect manned aircraft safety. Similar to question 6, based on the number of common themes each research subject identified in their qualitative response to the question, the researcher assigned a qualitative descriptor from Table 4.4 to describe their perceived level of knowledge about manned aircraft safety.

As previously noted in the analysis of this data collection instrument, 12 of the research subjects indicated they had no background, experience, or education in aviation subject matter. While, 13 of the research subjects indicated they had a background, experience and/or education in aviation subject matter. The research data reflected the following information.

Out of the 12 research subjects who indicated they had no background, experience, or education in aviation subject matter:

- Some (2 out of 12) of the research subjects identified two of the common themes and were assigned a level of Intermediate. One identified the man and the machine, and one identified the machine and security.
- Less than half (5 out of 12) of the subjects identified one common theme and were assigned a level of Novice. Four identified the man and one identified the machine.
- Less than half (5 out of 12) of the subjects described no level of knowledge.

Out of the 13 research subjects who indicated they had a background, experience, or education in aviation subject matter:

- Some (3 out of 13) of the research subjects identified five common themes and were assigned a level of Superior; the man, the machine, the environment, the system and security.
- Some (2 out of 13) of the subjects identified four common themes and were assigned a level of Expert; the man, the machine, the environment and the system.
- Some (4 out of 13) identified three common themes and were assigned a level of Advanced; the man, the machine and the system.

- Some (3 out of 13) identified two common themes and were assigned a level of Intermediate; two identified the man and the machine, and one identified the machine and the system.
- One (1 out of 13) identified one common theme and was assigned a level of Novice; the man.

8. Can you describe what has been publicized about UAS by the government and media, and how this publicity has affected your opinions about UAS?

Question 8 asked the research subjects to describe publicity they have observed about UAS and how it has affected their opinions about UAS. The qualitative data was categorized into common themes previously identified within this section; the man, the machine, the environment, the system and security. Additionally, the researcher captured and categorized the qualitative data identifying how publicity has affected the research subjects' opinions about UAS. These were categorized as either "positive", "negative", or "neutral".

The researcher observed that two of 25 subjects were unaware of any government or media publicity about UAS and will not be further analyzed, while 11 out of the 25 subjects recalled specific publicity that affected their opinions, and the remaining 12 subjects had formed opinions about UAS based on a conglomerate of publicity without being able to fully articulate any specific publicity that affected their opinion.

The data captured in this question will first be analyzed based on the positive and negative effects that specific publicity has had on the research subjects' opinions, and the resultant common themes associated with the publicity. Then, the data will be analyzed based on the positive and negative effects that the conglomerate of publicity has had on the research subjects' opinions, and the resultant common themes associated with the publicity.

Positive and Negative Effects of Specific Publicity

The research data for those research subjects (11 out of 25) who indicated that specific publicity affected their opinions, which consisted of four subjects in the first category and seven subjects in the second category, reflected the following qualitative information.

As previously noted in the analysis of this data collection instrument, in the first category, 12 of the research subjects indicated they had no background, experience, or education in aviation subject matter. While in the second category, 13 of the research subjects indicated they had a background, experience and/or education in aviation subject matter.

In the first category, or the 12 research subjects who indicated they had no background, experience, or education in aviation subject matter, four (4 out of 12) indicated that specific publicity has had an effect on their opinions. These were categorized as "positive" and "negative".

- One (1 out of 12) research subject indicated specific publicity about Amazon's efficient use of drones that positively affected their opinion about increases in technology and efficiency for mail and package delivery, and was therefore categorized as "positive".
- Three (3 out of 12) subjects indicated specific publicity about the use of drones and UAS by the military and Amazon, which has created new

opportunities for malicious use in terrorism and spying. These subjects indicated that the publicity had a negative effect on their opinions, and were therefore categorized as “negative”.

In the second category, or the 13 research subjects who indicated they had a background, experience, or education in aviation subject matter, seven (7 out of 13) indicated specific publicity that has had an effect on their opinions. These were categorized as “positive”, “negative” and “neutral”.

- One (1 out of 13) research subject indicated specific publicity about the FAA’s new requirement for operators to register drones which positively affected the subject’s opinion about increases in drone safety, and was therefore categorized as “positive”.
- Three (3 out of 13) subjects indicated specific publicity that negatively affected their opinions, and was therefore categorized as “negative”. These were UAS and drone use by the military and Amazon, which has created new opportunities for malicious use in terrorism and spying. As well as, delayed publication of regulations by the FAA, which decreases safety by increasing hazards for mid-air collisions.
- Three (3 out of 13) subjects also indicated they observed similar publicity as in the previous paragraph, but it had a neutral effect on their opinions, and was therefore categorized as “neutral”. These were; publicities about UAS and drone use by the military and Amazon, which has created new opportunities for malicious use in terrorism and spying; and, delayed

publication of regulations by the FAA which decreases safety by increasing hazards for mid-air collisions.

Positive and Negative Effects of the Conglomerate of Publicity

The research data for those research subjects (12 out of 25) who indicated that the conglomerate of publicity affected their opinions, which consisted of six subjects each of the two categories, reflected the following qualitative information.

As previously noted in the analysis of this data collection instrument, in the first category, 12 of the research subjects indicated they had no background, experience, or education in aviation subject matter. While in the second category, 13 of the research subjects indicated they had a background, experience and/or education in aviation subject matter.

In the first category, or the 12 research subjects who indicated they had no background, experience, or education in aviation subject matter, six (6 out of 12) subjects indicated that a conglomerate of publicity negatively affected their opinions and were therefore categorized as "negative" in the following common themes.

- Two (2 out of 12) of the research subjects indicated that publicity about the man and security negatively affected their opinions.
- Two (2 out of 12) subjects indicated that publicity about the man negatively affected their opinions.
- One (1 out of 12) indicated publicity about the man negatively affected their opinions.

- One (1 out of 12) indicated that publicity about the system negatively affected their opinions.

In the second category, or the 13 research subjects who indicated they had a background, experience, or education in aviation subject matter, six (6 out of 13) subjects indicated that a conglomerate of publicity negatively affected their opinions and were therefore categorized as "negative" in the following common themes.

- One (1 out of 13) research subject indicated that publicity about the man, the machine, the system and security had negative effects on opinions.
- One (1 out of 13) subject indicated that publicity about the man, the machine and the system had negative effects on opinions.
- One (1 out of 13) indicated that publicity about the man, the machine and security had negative effects on opinions.
- One (1 out of 13) indicated that publicity about the system and security negatively affected their opinions.
- Two (2 out of 13) indicated publicity about the system had negatives effects on their opinions.

Thus far, this section detailed the first part of the data collection instrument, which consisted of eight open-ended interview questions and statements. The second part, the follow-on closed-end questions, will be examined next. As previously noted, the qualitative language used throughout this section to consistently and qualitatively describe the number of research subjects will follow the qualitative descriptions referenced within Table 4.3.

Second Part: Follow-on Closed-Ended Questions

1. Are you an aircraft pilot or mechanic?

Question one asked the research subjects if they were an aircraft pilot or mechanic in order to specifically align with the subjects' responses to question one of the first part of the data collection instrument. As previously noted in the analysis of this data collection instrument, 12 of the research subjects indicated they had no background, experience, or education in aviation subject matter. While, 13 of the research subjects indicated they had a background, experience and/or education in aviation subject matter. The research data reflects the following information.

Out of the 12 research subjects who indicated they had no background, experience, or education in aviation subject matter.

- None (0 out of 12) of the research subjects indicated they were a pilot or a mechanic.
- This data aligned with responses to question one of the first part of the data collection instrument.

Out of the 13 research subjects who indicated they had a background, experience, or education in aviation subject matter.

- Some (3 out of 13) of the research subjects indicated they were a pilot.
- A few (5 out of 13) subjects indicated they were a mechanic.
- One (1 out of 13) indicated they were both a pilot and mechanic.
- Some (4 out of 13) indicated they were neither.
- This data aligned with responses to question one of the first part of the data collection instrument.

2. Do you, or anyone you know operate UAS?

Question two asked the research subjects to identify if they, or anyone they knew, has operated a UAS. As previously noted in the analysis of this data collection instrument, 12 of the research subjects indicated they had no background, experience, or education in aviation subject matter. While, 13 of the research subjects indicated they had a background, experience and/or education in aviation subject matter. The research data reflects the following information.

Out of the 12 research subjects who indicated they had no background, experience, or education in aviation subject matter:

- Less than half (5 out of 12) of the research subjects indicated that they had not operated a UAS and neither had anyone they knew.
- A few (4 out of 12) of the subjects indicated that they knew someone who operated a small UAS or drone.
- Some (3 out of 12) indicated they, and someone they knew, operated a small UAS or drone.

Out of the 13 research subjects who indicated they had a background, experience, or education in aviation subject matter:

- Two (2 out of 13) of the research subjects indicated they had not operated a UAS and neither had anyone they knew.
- Less than half (6 out of 13) of the subjects indicated that they knew someone who operated a small UAS or drone.
- Two (2 out of 13) indicated that they had operated a small UAS or drone.

- Two (2 out of 13) indicated that they had operated both large and small UAS or drones, and knew someone who had operated both large and small UAS or drones.
- One (1 out of 13) indicated they had operated small UAS or drones, and knew someone who operated both large and small UAS or drones.

3. How often do you fly as a passenger in a commercially manned aircraft?

Question three asked the research subjects to identify how often they fly as passengers in a commercially manned aircraft to establish their amount of exposure to the air transportation system as passengers. This section uses qualitative language to consistently, and qualitatively, describe this frequency using the descriptive terms based on the commercial air travel frequency listed in Table 4.5.

Table 4.5

Descriptors of Air Travel Frequency

Frequent	Infrequent	Rarely	None
4 or more times per year	2 to 3 times per year	Has flown, but less than infrequently	Never

As previously noted in the analysis of this data collection instrument, 12 of the research subjects indicated they had no background, experience, or education in aviation subject matter. While, 13 of the research subjects indicated they had a background, experience and/or education in aviation subject matter. The research data reflects the following information.

Out of the 12 research subjects who indicated they had no background, experience, or education in aviation subject matter:

- Some (3 out of 12) of the research subjects indicated they flew as passengers in commercially manned aircraft on a frequent basis.
- Some (3 out of 12) of the subjects indicated they flew as passengers in commercially manned aircraft on an infrequent basis.
- Half (6 out of 12) indicated they rarely flew as passengers in commercially manned aircraft.

Out of the 13 research subjects who indicated they had a background, experience, or education in aviation subject matter:

- Less than half (6 out of 13) of the research subjects indicated they flew as passengers in commercially manned aircraft on a frequent basis.
- Some (4 out of 13) of the subjects indicated they flew as passengers in commercially manned aircraft on an infrequent basis.
- Some (3 out of 13) indicated they rarely flew as passengers in commercial manned aircraft.

The previous questions within this data collection instrument examined the research subjects' background, experience and education in aviation, their level of trust in both manned and unmanned aircraft safety, their general knowledge of factors that affect aviation safety, how UAS publicity has affected their opinions about UAS, as well as the frequency in which they are exposed to commercial air transportation by flying as passengers in commercially manned aircraft. Question four through 10 of the second part of this data collection instrument examined the research subjects' specific knowledge of technical requirements in comparison of the operation and maintenance of both manned and unmanned aircraft. Question four will be examined first.

4. Are UAS regulated and overseen for safety the same as manned aircraft?

Question four specifically asked the research subjects if UAS were regulated and overseen for safety the same as manned aircraft. Their responses were categorized as either "I don't know", "No", or "Yes". As previously noted in the analysis of this data collection instrument, 12 of the research subjects indicated they had no background, experience, or education in aviation subject matter. While, 13 of the research subjects indicated they had a background, experience and/or education in aviation subject matter. The research data reflects the following information.

Out of the 12 research subjects who indicated they had no background, experience, or education in aviation subject matter:

- Most (10 out of 12) of the research subjects indicated they did not know.
- Two (2 out of 12) of the subjects indicated no.

Out of the 13 research subjects who indicated they had a background, experience, or education in aviation subject matter:

- Some (4 out of 13) of the research subjects indicated they did not know.
- Less than half (6 out of 13) of the subjects indicated no.
- Two (2 out of 13) indicated yes.
- One (1 out of 13) indicated yes, they are regulated the same. But no, they are not overseen the same.

5. Are UAS considered to be as technically reliable and safe as manned aircraft?

Question five specifically asked the research subjects if UAS were as technically reliable and safe as manned aircraft. Their responses were categorized as either "I don't know", "No", or "Yes". As previously noted in the analysis of this data collection instrument, 12 of the research subjects indicated they had no background, experience, or education in aviation subject matter. While, 13 of the research subjects indicated they had a background, experience and/or education in aviation subject matter. The research data reflects the following information.

Out of the 12 research subjects who indicated they had no background, experience, or education in aviation subject matter:

- Half (6 out of 12) of research subjects indicated they did not know.
- A few (4 out of 12) of the subjects indicated no.
- Two (2 out of 12) indicated yes.

Out of the 13 research subjects who indicated they had a background, experience, or education in aviation subject matter:

- Two (2 out of 13) of the research subjects indicated they did not know.
- A majority (8 out of 13) of the subjects indicated no.
- Some (3 out of 13) indicated yes.

6. Are UAS licensed the same as manned aircraft?

Question six specifically asked the research subjects if UAS were licensed the same as manned aircraft. Their responses were categorized as either "I don't know", "No", or "Yes". As previously noted in the analysis of this data collection instrument, 12 of the research subjects indicated they had no background, experience, or education in aviation subject matter. While, 13 of the research subjects indicated they had a background, experience and/or education in aviation subject matter. The research data reflects the following information.

Out of the 12 research subjects who indicated they had no background, experience, or education in aviation subject matter:

- Most (9 out of 12) of the research subjects indicated they did not know.
- Some (3 out of 12) of the subjects indicated no.

Out of the 13 research subjects who indicated they had a background, experience, or education in aviation subject matter:

- Less than half (6 out of 13) of the research subjects indicated they did not know.
- Less than half (6 out of 13) of the subjects indicated no.
- One (1 out of 13) indicated yes.

7. Are UAS operators licensed and trained the same as manned aircraft pilots?

Question seven specifically asked the research subjects if UAS operators were licensed and trained the same as manned aircraft pilots. Their responses were categorized as either "I don't know", "No", or "Yes". As previously noted in the analysis of this data collection instrument, 12 of the research subjects indicated they had no background, experience, or education in aviation subject matter. While, 13 of the research subjects indicated they had a background, experience and/or education in aviation subject matter. The research data reflects the following information.

Out of the 12 research subjects who indicated they had no background, experience, or education in aviation subject matter:

- A majority (7 out of 12) of the research subjects indicated they did not know.
- Less than half (5 out of 12) of the subjects indicated no.

Out of the 13 research subjects who indicated they had a background, experience, or education in aviation subject matter:

- Most (9 out of 13) of the research subjects indicated they did not know.
- Two (2 out of 13) of the subjects indicated no.
- Two (2 out of 13) indicated yes, they are licensed the same. But no, they are not trained the same as manned aircraft pilots.

8. Are UAS allowed to operate in the same airspace as manned aircraft?

Question eight asked the subjects if UAS are allowed to operate in the same airspace as manned aircraft. Their responses were categorized as either “I don’t know”, “No”, or “Yes”. As previously noted in the analysis of this data collection instrument, 12 of the research subjects indicated they had no background, experience, or education in aviation subject matter. While, 13 of the research subjects indicated they had a background, experience and/or education in aviation subject matter. The research data reflects the following information.

Out of the 12 research subjects who indicated they had no background, experience, or education in aviation subject matter:

- A majority (7 out of 12) of the research subjects indicated they did not know.
- A few (4 out of 12) of the subjects indicated no.

- One (1 out of 12) indicated yes.

Out of the 13 research subjects who indicated they had a background, experience, or education in aviation subject matter:

- Some (4 out of 13) of the research subjects indicated they did not know.
- Less than half (6 out of 13) of the subjects indicated no.
- Some (3 out of 13) indicated yes.

9. Are UAS mechanics licensed the same as manned aircraft mechanics?

Question nine specifically asked the research subjects if UAS mechanics were licensed the same as manned aircraft mechanics. Their responses were categorized as either "I don't know", "No", or "Yes". As previously noted in the analysis of this data collection instrument, 12 of the research subjects indicated they had no background, experience, or education in aviation subject matter. While, 13 of the research subjects indicated they had a background, experience and/or education in aviation subject matter. The research data reflects the following information.

Out of the 12 research subjects who indicated they had no background, experience, or education in aviation subject matter:

- Most (10 out of 12) of the research subjects indicated they did not know.
- Two (2 out of 12) subjects indicated no.

Out of the 13 research subjects who indicated they had a background, experience, or education in aviation subject matter:

- Slightly more than half (7 out of 13) of the research subjects indicated they did not know.

- A few (5 out of 13) of the subjects indicated no.
- One (1 out of 13) indicated yes.

10. Are UAS required to be maintained the same as manned aircraft?

Question ten specifically asked the research subjects if UAS were required to be maintained the same as manned aircraft. Their responses were categorized as either “I don’t know”, “No”, or “Yes”. As previously noted in the analysis of this data collection instrument, 12 of the research subjects indicated they had no background, experience, or education in aviation subject matter. While, 13 of the research subjects indicated they had a background, experience and/or education in aviation subject matter. The research data reflects the following information.

Out of the 12 research subjects who indicated they had no background, experience, or education in aviation subject matter:

- Most (10 out of 12) of the research subjects indicated they did not know.
- Two (2 out of 12) of the subjects indicated no.

Out of the 13 research subjects who indicated they had a background, experience, or education in aviation subject matter:

- Slightly more than half (7 out of 13) of the research subjects indicated they did not know.
- A few (5 out of 13) of the subjects indicated no.
- One (1 out of 13) indicated yes.

11. Would you volunteer to be the first person to fly in an unmanned aircraft?

Question eleven specifically asked the research subjects if they would volunteer to be the first person to fly in an unmanned aircraft. The premise being, if the UAS were not yet proven safe and reliable, they would fly onboard the maiden voyage to test its safety before passengers and paying passengers could embark on an unmanned flight. Hence the use of the phrase "first person" instead of "first passenger". Their responses were categorized as either "Yes", "No", or "Maybe". As previously noted in the analysis of this data collection instrument, 12 of the research subjects indicated they had no background, experience, or education in aviation subject matter. While, 13 of the research subjects indicated they had a background, experience and/or education in aviation subject matter. The research data reflects the following information.

Out of the 12 research subjects who indicated they had no background, experience, or education in aviation subject matter:

- Two (2 out of 12) of the research subjects indicated yes.
- Most (8 out of 12) of the subjects indicated no.
- Two (2 out of 12) indicated maybe.

Out of the 13 research subjects who indicated they had a background, experience, or education in aviation subject matter:

- Two (2 out of 13) of the research subjects indicated yes.
- Slightly more than half (7 out of 13) of the subjects indicated no.
- Some (4 out of 13) indicated maybe.

12. If proven safe and reliable, would you fly as a passenger in an unmanned aircraft?

Question twelve specifically asked the research subjects if they would be willing to fly as a passenger in a UAS. The premise being, once proven a safe and reliable method of transportation, passengers and paying passengers would be allowed to fly in UAS. Their responses were categorized as either “Yes”, “No”, or “Maybe”. As previously noted in the analysis of this data collection instrument, 12 of the research subjects indicated they had no background, experience, or education in aviation subject matter. While, 13 of the research subjects indicated they had a background, experience and/or education in aviation subject matter. The research data reflects the following information.

Out of the 12 research subjects who indicated they had no background, experience, or education in aviation subject matter:

- A majority (7 out of 12) of the research subjects indicated yes.
- Less than half (5 out of 12) of the subjects indicated maybe.

Out of the 13 research subjects who indicated they had a background, experience, or education in aviation subject matter:

- Most (11 out of 13) of the research subjects indicated yes.
- Two (2 out of 13) of the subjects indicated maybe.

13. Would you recommend another person who may be suitable for this study?

As detailed in the methodology chapter of this dissertation, this question was used to solicit and generate potential candidates for snowball sample subjects from both purposeful sample and other snowball sample subjects. As previously noted in Table 4.1

of this chapter, this question only yielded three snowball sample subjects, which will not be analyzed further.

The next section of this chapter addresses the research findings captured from the data collection instrument and its analysis, as well as findings identified during the researcher's review of literature that was detailed in the review of literature chapter of this dissertation.

Research Findings

The previous sections of this analysis and findings chapter have detailed the demographics of the research subjects and analyzed the results of the data collection instrument. This section discusses ten findings related to the following four common themes identified during review of relevant literature, and from the researcher's analysis of the data collection instrument; 1) findings related to review of relevant literature; 2) exposure of the research subjects to the manned air traffic system; 3) factors that affect research subject trust in unmanned aviation safety; and, 4) the research subjects' perceived knowledge of factors that affect unmanned aviation safety.

Findings Related to Review of Relevant Literature

Following the review of relevant literature, the researcher identified three findings. The findings that were identified were; 1) inaccurate government data to accurately calculate a general aviation accident rate; 2) lack of government data to accurately calculate a civil UAS accident rate; and, 3) common themes for aircraft accident causes. Finding one will be examined first.

Finding 1

The first finding that was identified during the review of relevant literature was the FAA's method of collecting flight hour data that the NTSB uses to calculate general aviation accident rates. The researcher identified, within the manned aircraft accident data and statistics section of the review of literature chapter of this dissertation, that the FAA's methods do not accurately capture flight hour activity data for general aviation as it does for Parts 121 and 135 commercial air carriers. As a result, the data in which the NTSB estimates general aviation accident rates are calculated based on voluntary submission of flight hour activity summaries by operators, which can be reported late, not reported at all, or contain inaccurate flight hour data (NTSB, 2015c).

The activity summary, known as the General Aviation and Air Taxi Activity (GAATA) Survey, allows operators the opportunity to voluntarily complete and submit flight hour activity data to the United States Department of Transportation. According to its 2005 safety report, the NTSB identified that general aviation operators are not required to report this information as Part 121 and 135 commercial air carriers, however the NTSB still relies on this estimated information to calculate estimated aircraft accident statistics for reporting to the industry, the public and Congress (NTSB, 2005, p. iv).

Because this information is used for public policy, law and rule making by the government, the NTSB identified this as a deficiency and an area for improvement. In its 2005 safety report, the NTSB identified the FAA's inaccurate data collection and operator reporting methods, and recommended that the FAA develop a more accurate method of capturing flight hour data, require all operators to report the required flight hour data, and develop a method to verify the accuracy of data that is reported by general aviation operators (NTSB, 2005, p. 27).

The researcher notes the related impacts of this finding are an inaccurate assessment and comparison of accident rates within aviation and across multiple modes of transportation. Resultantly, it is ultimately unknown if general aviation is any more, or less, safe than other modes of transportation, to include modes within aviation. So, public policy, law and rule making dependent upon this data may be focused in the wrong area of transportation accident prevention. Additionally, inaccurate aircraft accident statistics can have a misleading effect on public perceptions of general aviation safety.

As detailed in the recommendations section of chapter five, the researcher recommends that the government track this data accurately instead of estimating it, determine the applicable accident rate, and conduct further research into the comparison of general aviation accident rates to other modes of aviation in order to determine if general aviation is any more or less safe, then focus policy and rule making appropriately. Finding two will be examined next.

Finding 2

The second finding that was identified during review of relevant literature was the lack of aircraft accident statistics for civil unmanned aircraft. The researcher identified, within the unmanned aircraft accident/incident data and statistics section of the review of literature chapter, that the FAA did not track and publish flight hour data for UAS, similar to estimated general aviation and actual commercial aviation flight hour data. As a result, the NTSB did not publish UAS accident statistics for civil UAS (small or large) at the time of this research.

The researcher examined UAS accidents data between January 1, 2002 and September 26, 2017 within the NTSB aviation accident database by conducting a keyword search using six common terms related to unmanned aircraft. The common terms were drone, UAS, unmanned, UAV, remote pilot, and remote control. A keyword search was conducted because the NTSB did not provide a search option for UAS as an aircraft category. The search yielded eight UAS accidents. Six of the accidents involved public-use aircraft and resulted in no fatalities or injuries. Two of the accidents involved civil-use aircraft that were granted approval by the FAA to operate under a waiver and exemption from regulations, and resulted in no injuries or fatalities.

Because the NTSB did not publish UAS accident statistics at the time of this research, and relatively few accidents were identified within the NTSB aviation accident database, the researcher examined incident data for UAS published by the FAA. Between November 13, 2014 and August 20, 2015, the FAA reported there were 764 UAS incidents in the United States (FAA, 2015). However, the FAA identified no injuries in any of these incidents that involved reported sightings of UAS operating in the NAS, or operating near other aircraft in the NAS (FAA, 2015).

Without accurate accident/incident statistics, it is realistically unknown if UAS are any more, or less, safe than other modes of transportation, to include modes within aviation. However, throughout the unmanned aircraft publicity section of the review of literature chapter, negative publicity was identified that depicted unmanned aircraft to be unsafe and to pose a hazardous threat to the safety of other aircraft within the NAS. Yet, at the time of the review of literature, no known injuries or fatalities were identified related to the operation of either a large or small civil unmanned aircraft, not including hobbyists. To a further point, given the current FAA incident statistics, it is also unknown if small UAS present any more of a mid-air collision hazard and subsequent safety risk to other aircraft within the NAS than birds.

The researcher notes the related impact of this finding is primarily the lack of a proper assessment and comparison of UAS accident rates against other modes of transportation, to include other modes within aviation. As a result, it is ultimately unknown if UAS are any more, or less, safe than other modes of transportation, to include modes within aviation. Because public policy, law and rule making are dependent upon such data, a latent impact is that the government may be focused in the wrong area of transportation accident prevention. This lack of empirical analysis by the government also leaves room for media speculation and negative publicity about UAS. Furthermore, negative publicity about UAS based on the lack of aircraft accident statistics may have a misleading effect on public perceptions of UAS safety.

As detailed in the recommendations section of chapter five, the researcher recommends that the government track this data, determine an applicable accident rate, and conduct further research into the comparison of UAS accident rates versus other modes of aviation in order to determine if UAS are any more or less safe. Another recommendation made by the researcher, is for the NTSB to develop a search option for UAS as an aircraft category within the aviation accident database to allow the public and academia to conduct an adequate search of aircraft accident database information. Finding three will be examined next.

Finding 3

The third finding that was identified during the researcher's review of relevant literature was the aspect of common themes related to aircraft accident causes. The review of literature revealed that aircraft accidents can be categorized into five common causal themes; the man or human element; the machine or aircraft and related components; the surrounding natural environment in which the aircraft is operated; the man-made system of rules, regulations, practices and procedures in which the aircraft and its operators and maintainers must abide by to ensure safe operations; and, the security or malicious activities that lead to an accident. These five common themes were identified within the aircraft accident causes and unmanned aircraft publicity sections of the review of literature chapter of this dissertation.

During review of accident causes, the researcher found that these concepts dated as far back as 1948 in the book published by the Northwestern University Traffic Institute, titled the *Accident Investigation Manual*. The *Accident Investigation Manual* (1948) identified four causal factors to highway accidents in its readings; the man, the machine, the environment, and the system in which the accident occurred.

Each of these four concepts were also found to be universally applicable to aviation as similarly identified in the following literature detailed within the aircraft accident causes section of the review of literature chapter; the book titled, *Aircraft Accident Investigation* written in 2006 by Wood and Sweginnis; the book titled, *Aircraft Accident Reconstruction and Litigation* written in 2011 by McCormick and Papadakis; and the report titled, *Statistical Summary of Commercial Jet Airplane Accidents* of Worldwide Operations from 1959 to 2016 published in 2017 by Boeing Commercial Airplanes.

Although these readings detailed the man, the machine, the environment and the system as common themes in accident causal factors, the topic of security arose as a common theme during review of unmanned aircraft publicity as detailed in the unmanned publicity section of the review of literature chapter.

Identified as an area of negative publicity about UAS that can negatively affect public opinion, security was identified as a legitimate threat and concern to air safety. Meaning, UAS can be used for malicious purposes and UAS also have physical and software vulnerabilities open to malicious hackers. Of greatest credibility within this section of the review of literature, the researcher identified information published by the U.S. Department of Homeland Security (DHS) about the threats that UAS pose to public safety. Specifically, when UAS are used for criminal purposes or when UAS system vulnerabilities are taken advantage of by hackers for malicious intent.

DHS specifically noted that UAS can be used by terrorists and other criminals to conduct such malicious and criminal activity as illegal spying, carrying weapons or dangerous payloads such as explosives or chemicals used to attack the public or government, as well as disrupting and harassing the public or law enforcement (DHS, 2017). As a result of this government published information identifying security as a threat to the public and aviation safety, the researcher elected not to simply place security as a mitigatable hazard into one of the other four common theme categories, and to not simply discount it as unpreventable and un-mitigatable. Instead, based on the credible information published by the DHS, the researcher elected to add it to the list of common themes of accident causes; the man, the machine, the environment, the system, and security.

A positive related impact, categorization of accident causes into common themes is critical to root cause analysis and accident prevention. Thus, it is a positive benefit to accident investigation, reconstruction, pattern identification and analysis. Similarly, identification of common themes had a positive related impact on this research because it allowed the researcher to analyze the level of knowledge that research subjects had about factors that affect aviation safety against a known industry standard for common themes in accident causes.

Findings Related to Exposure of the Research Subjects to the Manned Air Traffic System

Following data collection, the researcher identified two findings related to the research subjects' exposure to the manned air traffic system, identified in this section as findings four and five. These findings were; 4) observations related to the research subjects' background, experience and education in aviation, and 5) observations related to the research subjects' participation in the manned air traffic system as passengers. Finding four will be examined first.

Finding 4

The fourth finding identified observations related to the research subjects' background, experience and education in aviation. The researcher examined and compared the 25 research subjects' responses to two demographic questions that identified their background, experience and education in aviation. These were question one in the first part of the data collection instrument, and question one in the second part of the data collection instrument. The purpose of this inquiry was to identify if the subjects had a knowledge of aviation that was attained through their technical background and experience, and/or technical training and/or academic education in the field of aviation. To include, a background, experience and education as an aircraft pilot or mechanic.

Question one in the first part of the data collection instrument qualitatively explored this exposure to the manned air traffic system by asking the subjects an open-ended question to generally describe their background, experience and education in aviation. The results of this analysis were a categorization of the subjects into two groups; 1) the first group that consisted of 12 subjects who indicated they did not have a background, experience and/or education in aviation; and, 2) the second group that consisted of 13 subjects who indicated they had a background, experience and/or education in aviation. The second group will be examined because the first group indicated it had no background, experience and/or education in aviation.

The same descriptors listed in Table 4.3 will be used to qualitatively describe the number of research subjects in each of the individual first and second groups. However, throughout the remainder of this chapter, Table 4.6 will be used when qualitatively describing the collective, or combined number of subjects out of all 25 research subjects.

Table 4.6

Descriptors of All Research Subject Quantities

Descriptor	Collective Number of All Research Subjects
Some	1 to 8 out of 25
Less Than Half	9 to 12 out of 25
More Than Half	13 out of 25
Most	14 to 22 out of 25
Nearly All	23 to 24 out of 25
All	25 out of 25

The 13 research subjects' in the second group who indicated they had a background, experience and/or education in aviation consisted of the following:

- Background and experience:
  - Three (3 out of 13) subjects described a background and experience in both piloting manned aircraft and in aviation maintenance.
  - Five (5 out of 13) indicated they only had experience in aviation maintenance.
  - One (5 out of 13) was a commercial aircraft flight attendant.
  - One (1 out of 13) was an airline ticket and loading agent.
  - One (1 out of 13) was an air traffic controller.
  - One (1 out of 13) was a commercial pilot.
  - One (1 out of 13) provided administrative support in airmen toxicology investigations of aircraft accidents.
- Education in aviation:
  - Twelve (12 out of 13) subjects indicated having technical and/or academic education in aviation subject matter
    - All (12 out of 12) indicated they had aviation technical education.
    - Four (4 out of 12) indicated they also had additional undergraduate and graduate college academic degrees in aviation related subject matter.
  - One (1 out of 13) subject, the airline ticket and loading agent, indicated having neither technical nor academic aviation education.

Of significance, the researcher observed that all 25 research subjects indicated they had previously flown as passengers in a commercial aircraft, while some had flown as passengers in small non-commercial aircraft. Responses to this question provided evidence that all 25 research subjects were exposed to the manned air traffic system as passengers in commercial aircraft, while more than half (13 out of 25) subjects had exposure other than being a passenger. The related impacts and recommendations will be examined at the end of this section. Question one in the second part of the data collection instrument will be examined next.

Question one in the second part of the data collection instrument explored a similar exposure to the manned air traffic system by asking the research subjects a close-ended question to determine if they were an aircraft pilot or mechanic. As identified in question one of the first part of the data collection instrument, the first group (12 out of 25 of the subjects) indicated it had no background, experience, or education in aviation subject matter. The responses to this question yielded the same results for the first group, as none of the subjects indicated they were a pilot or mechanic.

However, out of the 13 research subjects in the second group who indicated they had a background, experience, or education in aviation subject matter, most indicated they were specifically a pilot, mechanic, or both as follows:

- Some (3 out of 13) of the research subjects indicated they were only a pilot.
- A few (5 out of 13) subjects indicated they were only a mechanic.
- One (1 out of 13) indicated being both a pilot and mechanic.

The researcher identified that responses to question one of the second part of the data collection instrument not only aligned with responses to question one of the first part of the data collection instrument, it further clarified whether the subjects were an aircraft pilot or an aircraft mechanic. Additionally, examination of these responses provided evidence that all 25 research subjects were exposed to the manned air traffic system as passengers in commercial aircraft, while more than half (13 out of 25) subjects had further exposure other than being a passenger.

The researcher notes the related impact of this finding of exposure to the manned commercial aviation system to be the potential for research subject bias towards manned aviation versus unmanned aviation, based on manned aviation's relatively good safety record. As detailed within the manned aircraft accident data and statistics section of the review of literature chapter of this dissertation, it was noted by the researcher that there were 415 fatalities in aviation accidents in 2015, compared to the 35,092 in highway, 716 railways, and 683 marine modes of transportation in the United States during 2015 (NTSB, 2015b). Detailing manned aviation as a relatively safe mode of transportation in 2015 compared to the number of fatalities that occurred, the NTSB published the following total number of flight hours; 17,820,000 hours flown in Part 121 commercial aviation; 3,909,000 hours flown in Part 135 commercial aviation; and, 20,576,000 hours flown in general aviation under Part 91 (NTSB, 2015c).

Specifically, this data reflects 0.155/0.260 accidents per 100,000 flight hours for §121 scheduled/nonscheduled air carrier operations respectively, and zero fatal accidents; 1.458/1.07 accidents and 0.292/0.20 fatal accidents per 100,000 flight hours for §135 commuter/on-demand air carrier operations respectively; and, 5.85 accidents and 1.09 fatal accidents per 100,000 flight hours for general aviation operations (NTSB, 2015c).

Because the related impacts of this finding suggest that exposure to the relatively safe manned aviation system can cause a bias from passengers towards manned aircraft versus unmanned aircraft, the researcher recommends that the government, unmanned aircraft operators and unmanned aircraft manufacturers explore these suggestions and similarly expose potential customers of unmanned aircraft and the public in order to elicit trust in unmanned aircraft. The researcher details this recommendation in chapter five. Finding five will be examined next.

Finding 5

Finding five identified observations related to the research subjects' participation in the manned air traffic system as passengers. Question three in the second part of the data collection instrument explored a similar exposure to the manned air traffic system as identified in the evidence observed in finding four, which indicated that all 25 research subjects had flown in manned commercial aircraft. Question three asked the research subjects to identify how often they flew as passengers in a commercially manned aircraft to establish their amount of exposure.

Out of the 12 research subjects in the first group who indicated they had no background, experience, or education in aviation subject matter:

- Some (3 out of 12) of the research subjects indicated they flew as passengers in commercially manned aircraft four or more times per year.
- Some (3 out of 12) of the subjects indicated they flew as passengers in commercially manned aircraft at least two to three times per year.
- Half (6 out of 12) indicated they had flown as passengers in commercially manned aircraft in the past, but it was less than two to three times per year.

Out of the 13 research subjects in the second group who indicated they had a background, experience, or education in aviation subject matter:

- Less than half (6 out of 13) of the research subjects indicated they flew as passengers in commercially manned aircraft four or more times per year.
- Some (4 out of 13) of the subjects indicated they flew as passengers in commercially manned aircraft at least two to three times per year.
- Some (3 out of 13) indicated they had flown as passengers in commercial manned aircraft in the past, but it was less than two to three times per year.

The researcher identified that the research subjects' responses to question three in the second part of the data collection instrument aligned with and validated their responses to question one in the first part of the data collection instrument. In that, all 25 research subjects indicated that they had flown in commercially manned aircraft. The researcher further identified the frequency, or amount of exposure the research subjects had to the manned commercial aviation system. In that, most of the subjects (16 out of 25) flew at least two to three times per year, while less than half (9 out of 25) flew four or more times per year.

The researcher notes the related impact of this finding of exposure to the manned commercial aviation system to be the potential for research subject bias towards manned aviation versus unmanned aviation, based on manned aviation's relatively good safety record as detailed in finding four.

Because the related impacts of this finding suggest that exposure to the relatively safe manned aviation system can cause a bias from passengers towards manned aircraft versus unmanned aircraft, the researcher recommends that the government, unmanned aircraft operators and unmanned aircraft manufacturers explore these suggestions and similarly expose potential customers of unmanned aircraft and the public in order to elicit trust in unmanned aircraft. The researcher details this recommendation in chapter five.

Findings Related to Factors that Affect Research Subject Trust in Unmanned Manned Aviation Safety

Following data collection, the researcher identified three findings related to the factors that affected the research subjects' trust in unmanned aviation safety, identified here as findings six, seven, and eight. The findings that were identified were; 6) the research subjects' level of trust in unmanned aircraft safety, 7) the factors that affected the research subjects' trust in unmanned aircraft, and 8) factors related to publicity of UAS. Finding six will be examined first.

<u>Finding 6</u>

Finding six identified the research subjects' level of trust in unmanned aircraft safety. The researcher examined and compared the 25 research subjects' responses to question three in the first part of the data collection instrument, which asked the research subjects to describe their level of trust in unmanned aircraft safety. The finding also examined the research subjects' responses to questions 11 and 12 in the second part of the data collection instrument, which identified their willingness to fly as passengers in unmanned aircraft. The purpose of this inquiry was to answer the first main question desired to be answered by this research study listed in chapter five of this dissertation, which sought to determine if the research subjects trusted UAS safety. Question three will be examined first.

Analysis of question three yielded four possible responses from the research subjects for large and small unmanned aircraft. The responses were a high, medium, low, or no level of trust. As previously noted, the 25 research subjects were categorized into two groups; the 12 research subjects in the first group who indicated they had no background, experience, or education in aviation subject matter; and, the 13 research subjects in the second group who indicated they had a background, experience and/or education in aviation subject matter. Large unmanned aircraft will be examined first.

For large unmanned aircraft, responses from the 12 research subjects in the first group indicated that some (2 out of 12) had a medium level of trust or higher for large unmanned aircraft safety, while most (10 out of 12) had a low or no level of trust. Responses from the 13 research subjects in the second group indicated that most (10 out of 13) had a medium level of trust or higher for large unmanned aircraft safety, while a some (3 out of 13) had a low or no level of trust.

Further analysis revealed that the first group had less trust than the second group in the concept of large unmanned aircraft safety. While, more than half (13 out of 25) of all research subjects had a low or no level of trust in the concept of large unmanned aircraft, some (6 out of 25) had a medium level of trust, and some (6 out of 25) had a high level of trust. Of significance, most (19 out of 25) of the research subjects had a medium level of trust or lower in the concept of large unmanned aircraft safety.

For small unmanned aircraft, responses from the 12 research subjects in the first group indicated that half (6 out of 12) had a medium level of trust or higher, while half (6 out of 12) had a low or no level of trust. Response from the 13 research subjects in the second group indicated that a few (5 out of 13) had a medium level of trust or higher, while a majority (8 out of 13) had a low or no level of trust.

Further analysis revealed that the first group had more trust than the second group in the concept of small unmanned aircraft safety. While, most (14 out of 25) of the research subjects had a low or no level of trust in the concept of small unmanned aircraft, less than half (9 out of 25) had a medium level of trust, and some (2 out of 25) had a high level of trust. Of significance, nearly all (23 out of 25) of the research subjects had a medium level of trust or lower in the concept of small unmanned aircraft safety. Questions 11 and 12 will be examined next.

Analysis of questions 11 and 12 in the second part of the data collection instrument examined the research subjects' willingness to fly as passengers in unmanned aircraft. Question 11 asked the research subjects if they would volunteer to be the first person to fly in an unmanned aircraft, while question 12 asked the research subjects if they would fly as a passenger in an unmanned aircraft if it were proven safe and reliable. Question 11 will be examined first.

Analysis of question 11 yielded three possible responses that were categorized as either no, maybe, or yes. As previously noted, the 25 research subjects were categorized into two groups; the 12 research subjects in the first group who indicated they had no background, experience, or education in aviation subject matter; and, the 13 research subjects in the second group who indicated they had a background, experience and/or education in aviation subject matter.

When asked if they would volunteer to be the first person to fly in an unmanned aircraft, responses from the 12 research subjects in the first group indicated that most (8 out of 12) of the subjects responded no, some (2 out of 12) responded maybe, and some (2 out of 12) responded yes. Responses from the 13 research subjects in the second group indicated that slightly more than half (7 out of 13) of the subjects responded no, some (4 out of 13) responded maybe, while some (2 out of 13) responded yes.

Further analysis revealed that more than half (13 out of 25) of the research subjects responded no, they would not volunteer to be the first person to fly in an unmanned aircraft. Some (6 out of 25) responded maybe. And, some (4 out of 25) responded yes, they would volunteer to be the first person to fly in an unmanned aircraft.

Analysis of question 12 yielded two possible responses that were categorized as either maybe, or yes. As previously noted, the 25 research subjects were categorized into two groups; the 12 research subjects in the first group and the 13 research subjects in the second group as previously described in this section.

When asked if the they would fly as a passenger in an unmanned aircraft once it was proven safe and reliable, responses from the 12 research subjects in the first group indicated that less than half (5 out of 12) of the subjects responded maybe, while a majority (7 out of 12) responded yes. Responses from the 13 research subjects in the second group indicated that only two (2 out of 13) of the subjects responded maybe, while most (11 out of 13) responded yes.

Further analysis revealed that most (18 out of 25) of the research subjects responded yes, they would fly as a passenger in an unmanned aircraft once it was proven safe and reliable, while some (7 out of 25) indicated maybe. It was noted that none of the subjects responded no.

Analyzing responses to the three data collection instrument questions, the researcher notes the related impacts were the identification of the research subjects' trust in large and small unmanned aircraft, as well as their willingness to fly in unmanned aircraft as passengers. These related impacts aligned with the purpose of this inquiry to answer the first main question desired to be answered by this research study listed in chapter five of this dissertation, which sought to determine if the research subjects trusted UAS safety.

Impact analysis revealed that most (19 out of 25) of the research subjects had a medium level of trust or lower in the concept of large unmanned aircraft safety, while nearly all (23 out of 25) of the research subjects had a medium level of trust or lower in the concept of small unmanned aircraft safety. The researcher makes the assessment that these results indicate a certain level of distrust of both large and small unmanned aircraft, given the argument that anything less than a high level of trust would be a level of distrust.

Secondly, the impact analysis revealed that more than half (13 out of 25) of the research subjects responded no, they would not volunteer to be the first person to fly in an unmanned aircraft as a passenger, while some (6 out of 25) responded maybe, or were otherwise undecided. Combined, the researcher makes the assessment that these responses indicate most (19 out of 25) of the research subjects had a certain level of distrust in unmanned aircraft to be the first person to fly in one, given the argument that anything other than a response of yes would be a level of distrust.

Lastly, the impact analysis revealed that most (18 out of 25) of the research subjects responded yes, they would fly as a passenger in an unmanned aircraft once it was proven safe and reliable, while some (7 out of 25) indicated maybe. The researcher makes the assessment that the overall results indicate most of research subjects trusted unmanned aircraft, once proven safe and reliable, given the argument that any response other than yes indicated distrust. Finding seven will be examined next.

Finding 7

Finding seven identified the factors that affected the research subjects' trust in unmanned aircraft. The researcher examined and compared the 25 research subjects' responses to question four in the first part of the data collection instrument. The purpose of this inquiry was to answer the second main question sought to be answered by the research study listed in chapter five of this dissertation, which was to identify the factors that affect the research subjects' trust in UAS safety.

Question four in the first part of data collection instrument asked the research subjects to identify the factors that affected their trust of unmanned aircraft. Their qualitative descriptions of these factors were analyzed and categorized into the five common causal themes that affect aviation safety that were identified in finding three of this section; the man, the machine, the environment, the system and security.

As previously noted, the 25 research subjects were categorized into two groups; the 12 research subjects in the first group who indicated they had no background, experience, or education in aviation subject matter; and, the 13 research subjects in the second group who indicated they had a background, experience and/or education in aviation subject matter.

Responses from the 12 research subjects in the first group indicated that most (8 out of 12) of the subjects only identified two common themes in describing the factors that affect their trust of unmanned aircraft, some (3 out of 12) identified one common theme, while one (1 out of 12) did not identify any common themes. Further analyzed, it was observed that all (12 out of 12) of the research subjects identified two or less factors. Collectively, the first group identified four common themes as factors that affected their trust of unmanned aircraft; the man, the machine, the system, and security.

The responses from the 13 research subjects in the second group indicated that one (1 out of 13) of the subjects identified four common themes in describing the factors that affected their trust of unmanned aircraft, less than half (6 out of 13) of the subjects identified three common themes, and less than half (6 out of 13) identified two common themes. Further analyzed, it was observed that nearly all (12 out of 13) of the research subjects identified three or less factors. Collectively, the second group identified four common themes as factors that affected their trust of unmanned aircraft; the man, the machine, the environment, and the system.

Analyzing responses to question four in the first part of the data collection instrument, the researcher notes the related impacts were the identification of the factors that affected the research subjects' trust of unmanned aircraft. This aligned with the purpose of this inquiry, which was to answer the second main question sought to be answered by the research study listed in chapter five of this dissertation, to determine the factors that affect the research subjects' trust in UAS safety.

The first group collectively identified four common themes as factors that affected their trust of unmanned aircraft; the man, the machine, the system, and security. While, the second group collectively identified four common themes as factors that affected their trust of unmanned aircraft; the man, the machine, the environment, and the system. Combined, the 25 research subjects collectively identified all five common themes in description of the factors that affect their trust in unmanned aircraft; the man, the machine, the environment, the system, and security. However, nearly all (23 out of 25) of the research subjects individually only identified three or less of the five common causal themes. Finding eight will be examined next.

Finding 8

Finding eight identified factors related to the publicity of UAS. The researcher examined and compared the 25 research subjects' responses to question eight in the first part of the data collection instrument. The purpose of this inquiry was to answer the fifth main question sought to be answered by the research study listed in chapter five of this dissertation, which was to determine the effect that UAS publicity has had on the research subjects' willingness to fly as passengers in UAS.

Question eight in the first part of the data collection instrument asked the research subjects to describe what had been publicized about UAS by the government and media, and how the publicity had affected their opinions about UAS. The researcher captured and categorized the qualitative data identifying how publicity had affected the research subjects' overall opinions about UAS. The responses were categorized as either "positive", "negative", or "neutral".

The researcher observed that some (2 out of the 25) of the research subjects were unaware of any government or media publicity about UAS, less than half (11 out of the 25) of the subjects recalled specific publicity that affected their opinions, and less than half (12 out of 25) had formed opinions about UAS based on a conglomerate of publicity without being able to fully articulate any specific publicity that affected their opinion.

The research data, for those research subjects (11 out of 25) who indicated that specific publicity affected their overall opinions about UAS, reflected the following qualitative information. Two (2 out of 11) research subjects indicated that specific publicity about UAS positively affected their opinions and was categorized as “positive”. Six (6 out of 11) subjects indicated that specific publicity about UAS had a negative effect on their opinions, and was categorized as “negative”. Three (3 out of 11) subjects indicated that specific publicity about UAS had a neutral effect on their opinions, and was categorized as “neutral”.

The research data, for those research subjects (12 out of 25) who indicated that the conglomerate of publicity affected their overall opinions about UAS, reflected the following qualitative information. All (12 out of 12) of the research subjects indicated that the conglomerate of publicity about UAS negatively affected their opinions.

Findings Related to the Research Subjects’ Perceived Knowledge of Factors that Affect Unmanned Aviation Safety

Following data collection, the researcher identified two findings related to the research subjects’ perceived knowledge of factors that affect unmanned aviation safety, identified here as findings nine and ten. The findings that were identified were; 9) qualitative descriptors of the research subjects’ perceived level of knowledge about unmanned aircraft safety; and, 10) comparison of reality to the research subjects’ perceived knowledge of technical aspects of aviation safety. Finding nine will be examined first.

Finding 9

Finding nine identified qualitative descriptors of the research subjects' perceived level of knowledge about unmanned aircraft safety. The researcher examined and compared the 25 research subjects' responses to question six in the first part of the data collection instrument, which asked the subjects to describe their knowledge of factors that affect unmanned aircraft safety. The purpose of this inquiry was to answer the third main question desired to be answered by this research study listed in chapter five of this dissertation, which sought to determine if the research subjects knew and understood the factors that affect UAS safety.

Question six in the first part of the data collection instrument asked the research subjects to describe their level of knowledge about the factors that affect unmanned aircraft safety. These factors were identified in finding seven, which detailed categorization of the subjects' qualitative descriptions into five common themes; the man, the machine, the environment, the system and security.

Based on the number of common themes each research subject identified in their qualitative response to the question, the researcher assigned a qualitative descriptor to describe their perceived level of knowledge about unmanned aircraft safety. These knowledge level descriptors were; a novice, having described one common theme; intermediate, having described two common themes; advanced, having described three common themes; expert, having described four common themes; and superior, having described five common themes.

As previously noted, the 25 research subjects were categorized into two groups; the 12 research subjects in the first group who indicated they had no background, experience, or education in aviation subject matter; and, the 13 research subjects in the second group who indicated they had a background, experience and/or education in aviation subject matter.

Responses from the 12 research subjects in the first group indicated that some (3 out of 12) of the subjects identified one common theme and were assigned a level of novice. While, most (9 out of 12) of the subjects described no level of knowledge.

Responses from the 13 research subjects in the second group indicated that some (2 out of 13) of the subjects identified five common themes and were assigned a level of superior. One (1 out of 13) subject identified four common themes and was assigned a level of expert. Some (2 out of 13) identified three common themes and were assigned a level of Advanced. Some (4 out of 13) identified two common themes and were assigned a level of Intermediate. One (1 out of 13) subject identified one common theme and was assigned a level of novice. And, some (3 out of 13) of the subjects described no level of knowledge.

Analyzing responses to question six in the first part of the data collection instrument, the researcher notes the related impacts were the identification of the research subjects' collective level of knowledge about the factors that affect unmanned aircraft safety. This aligned with the purpose of this inquiry, which was to answer the third main question desired to be answered by this research study listed in chapter five of this dissertation, which sought to determine if the research subjects knew and understood the factors that affect UAS safety.

The researcher observed that, collectively, most (20 out of 25) of the research subjects described an intermediate or less level of knowledge of factors that affect unmanned aircraft safety by identifying two or less common themes. While, some (5 out of 25) of the subjects described an advanced or greater level of knowledge of factors that affect unmanned aircraft safety by identifying three to five common themes. Finding ten will be examined next.

Finding 10

Finding ten identified the research subjects' perceived knowledge of the technical aspects of aviation safety compared to the reality of those technical aspects. The researcher examined and compared the 25 research subjects' responses to questions four through 10 of the second part of the data collection instrument, which examined their specific knowledge of the technical regulatory requirements for the operation and maintenance of unmanned aircraft. The purpose of this inquiry was to answer the third main question desired to be answered by this research study listed in chapter five of this dissertation, which sought to determine if the research subjects knew and understood the factors that affect UAS safety.

As previously noted, the 25 research subjects were categorized into two groups; the 12 research subjects in the first group who indicated they had no background, experience, or education in aviation subject matter; and, the 13 research subjects in the second group who indicated they had a background, experience and/or education in aviation subject matter. Question four will be examined first.

Question 4

Question four asked the research subjects if UAS were regulated and overseen for safety the same as manned aircraft._Their responses were categorized as either "I don't know", "No", or "Yes".

The researcher observed that, collectively, some (8 out of 25) of the research subjects answered correctly, while most (17 out of 25) of the research subjects did not know the correct answer.

After review of relevant literature, the researcher notes the overall correct answer to be no, they are not regulated and overseen for safety the same as manned aircraft. Because, at the time of this research, no regulations were promulgated for the operation of large civil UAS, passenger carrying or not. Additionally, small civil UAS regulations published under 14 CFR Part 107 were not as extensive and restrictive in content and nature as those regulations published throughout all other 14 CFR parts for the certification, operation and airworthiness of manned aircraft.

Out of the 12 research subjects in the first group, most (10 out of 12) of the research subjects indicated they did not know, while two (2 out of 12) of the subjects indicated no. Out of the 13 research subjects in the second group, some (4 out of 13) of the research subjects indicated they did not know, less than half (6 out of 13) of the subjects indicated no, while three (3 out of 13) indicated yes. Question five will be examined next.

Question 5

Question five asked the research subjects if UAS were considered to be as technically reliable and safe as manned aircraft. Their responses were categorized as either "I don't know", "No", or "Yes".

The researcher observed that, collectively, less than half (12 out of 25) of the research subjects answered correctly, while more than half (13 out of 25) did not know the correct answer.

After review of relevant literature, the researcher notes the overall correct answer to be no, for two reasons. First, as noted in the previous examination of regulation and oversight listed in Question 4, UAS are not regulated and overseen for safety the same as manned aircraft because no regulations have been promulgated for the operation of large civil UAS and small civil UAS regulations published under 14 CFR Part 107 are not as extensive and restrictive in content and nature as those regulations published throughout all other 14 CFR parts for the certification, operation and airworthiness of manned aircraft and airmen.

Secondly, although there is an absence of regulations for the certification of UAS to ensure a comparable technical reliability and safety to manned aircraft, it is ultimately unknown if UAS are any more, or less safe than manned aircraft as noted in finding two of this section. Finding two identified an absence of accident/incident statistics for UAS in which to compare to manned aircraft accident/incident statistics.

Out of the 12 research subjects in the first group, half (6 out of 12) of the research subjects indicated they did not know, a few (4 out of 12) of the subjects indicated no, and two (2 out of 12) indicated yes. Out of the 13 research subjects in the second group, two (2 out of 13) of the research subjects indicated they did not know, a majority (8 out of 13) of the subjects indicated no, and some (3 out of 13) indicated yes. Question six will be examined next.

Question 6

Question six asked the research subjects if UAS were licensed the same as manned aircraft. Their responses were categorized as either “I don’t know”, “No”, or “Yes”.

The researcher observed that, collectively, less than half (9 out of 25) of the research subjects answered correctly, while most (16 out of 25) did not know the correct answer.

After review of relevant literature, the researcher notes the overall correct answer to be no, for the following reasons related to the registration and marking, and aircraft manufacturing, certification, and airworthiness standards of both small and large civil UAS. First, regulations promulgated for the marking and registration, or licensing, of manned aircraft under 14 CFR Parts 45 and 47 were observed to be more extensive and restrictive than §48 that establishes marking and registration requirements for small UAS. In part, this is due to the larger size and specific location of marking requirements for registration numbers to be placed on manned aircraft under §45, as well as the proof of ownership requirement for registration under §47.

Secondly, at the time of this research, no regulations were promulgated for aircraft manufacturing, certification, and airworthiness standards of both small and large civil UAS that could be similarly compared to manned aircraft or rotorcraft certification standards under §§21 through 36 to ensure compliance with the general operating and flight procedure under §91.

Out of the 12 research subjects in the first group, most (9 out of 12) of the research subjects indicated they did not know, while some (3 out of 12) of the subjects indicated no. Out of the 13 research subjects in the second group, less than half (6 out of 13) of the research subjects indicated they did not know, less than half (6 out of 13) of the subjects indicated no, while one (1 out of 13) indicated yes. Question seven will be examined next.

Question 7

Question seven asked the research subjects if UAS operators were licensed and trained the same as manned aircraft pilots. Their responses were categorized as either "I don't know", "No", or "Yes".

The researcher observed that, collectively, some (7 out of 25) of the research subjects answered correctly, while most (18 out of 25) did not know the correct answer.

After review of relevant literature, the researcher notes the correct answer to be no, UAS operators are not licensed, or certificated, and trained the same as manned aircraft pilots under 14 CFR Part 61. Because, at the time of this research, no regulations were promulgated for the certification of large civil UAS operators. Additionally, small civil UAS regulations published under 14 CFR Part 107 were not observed to be as extensive and restrictive in content and nature as those regulations published under 14 CFR Part 61 that require specific medical qualifications, flight training, and flight time requirements for the type of pilot certificate and rating being sought. Similarly, Part 61 was observed to prescribe regulations specifically for pilots, flight and ground instructors of manned aircraft only, and noted the inapplicability of flight time flown under §107 small UAS operations to count towards aircraft flight time requirements under §61.

Out of the 12 research subjects in the first group, the majority (7 out of 12) of the research subjects indicated they did not know, while less than half (5 out of 12) of the subjects indicated no. Out of the 13 research subjects in the second group, most (9 out of 13) of the research subjects indicated they did not know, two (2 out of 13) of the subjects indicated no, while two (2 out of 13) indicated they are licensed the same but they not trained the same as manned aircraft pilots. Question eight will be examined next.

Question 8

Question eight asked the research subjects if UAS were allowed to operate in the same airspace as manned aircraft. Their responses were categorized as either "I don't know", "No", or "Yes".

The researcher observed that, collectively, less than half (10 out of 25) of the research subjects answered correctly, while most (15 out of 25) did not know the correct answer.

After review of relevant literature, the researcher notes the correct answer to be no, UAS are not allowed to operate in the same airspace as manned aircraft. Because, at the time of this research, no regulations were promulgated for large civil UAS operations. And, regulations for small civil UAS operated under 14 CFR Part 107.37, §107.41, and §107.43 required small UAS operators to adhere to the rules for right-of-way in order to prevent mid-air collisions, and to not be operated inside of class B, C, and D airspace, or within areas designated as an airport inside class E airspace that could cause a hazard to take-off, landing and approach for manned aircraft. Aside from these operational conditions, in accordance with §107.51, small UAS must never exceed an altitude of 400 feet AGL outside of a structure.

Out of the 12 research subjects in the first group, the majority (7 out of 12) of the research subjects indicated they did not know, a few (4 out of 12) of the subjects indicated no, and one (1 out of 12) indicated yes. Out of the 13 research subjects in the second group, some (4 out of 13) of the research subjects indicated they did not know, less than half (6 out of 13) of the subjects indicated no, while some (3 out of 13) indicated yes. Question nine will be examined next.

Question 9

Question nine asked the research subjects if UAS mechanics were licensed the same as manned aircraft mechanics. Their responses were categorized as either “I don’t know”, “No”, or “Yes”.

The researcher observed that, collectively, some (7 out of 25) of the research subjects answered correctly, while most (18 out of 25) did not know the correct answer.

After review of relevant literature, the researcher notes the correct answer to be no, UAS mechanics are not licensed the same as manned aircraft mechanics. Because, at the time of this research, no regulations were promulgated under 14 CFR Part 65 for the certification of UAS mechanics. And, no regulations were promulgated for the airworthiness and maintenance of large UAS, passenger carrying or not. Additionally, small UAS regulations published under 14 CFR Part 107 did not require the certification of mechanics and were not observed to be as extensive and restrictive in content and nature as those regulations published throughout all other parts of 14 CFR for manned aircraft maintenance.

Out of the 12 research subjects in the first group, most (10 out of 12) of the research subjects indicated they did not know, while two (2 out of 12) of the subjects indicated no. Out of the 13 research subjects in the second group, slightly more than half (7 out of 13) of the research subjects indicated they did not know, a few (5 out of 13) of the subjects indicated no, while one (1 out of 13) indicated yes. Question ten will be examined next.

Question 10

Question ten asked the research subjects if UAS were required to be maintained the same as manned aircraft. Their responses were categorized as either “I don’t know”, “No”, or “Yes”.

The researcher observed that, collectively, some (7 out of 25) of the research subjects answered correctly, while most (18 out of 25) did not know the correct answer.

After review of relevant literature, the researcher notes the correct answer to be no, UAS are not required to be maintained the same as manned aircraft. Because, no regulations were promulgated for the airworthiness and maintenance of large UAS, passenger carrying or not. Additionally, small UAS regulations published under 14 CFR Part 107 were not observed to be as extensive and restrictive in content and nature as those regulations published throughout all other parts of 14 CFR for manned aircraft maintenance that require adherence, primarily, to the manned airworthiness and maintenance standards of 14 CFR Part 43 and 65.

Out of the 12 research subjects in the first group, most (10 out of 12) of the research subjects indicated they did not know, while two (2 out of 12) of the subjects indicated no. Out of the 13 research subjects in the second group, slightly more than half (7 out of 13) of the research subjects indicated they did not know, a few (5 out of 13) of the subjects indicated no, while one (1 out of 13) indicated yes.

This section of the dissertation detailed the analysis of the data that was collected during the research interviews utilizing the data collection instrument. Specifically, the chapter detailed the demographics of the research subjects, analyzed the results of the data collection instrument, and discussed the research findings related to the common themes of the research.

CHAPTER V

CONCLUSION

The previous four chapters of this dissertation detailed the introduction of the research study, the researcher's review of literature, the research methodologies used during this study, and provided the researcher's analysis and findings of the data collection. This chapter summarizes the research study, answers the main research questions, submits recommendations to improve and advance aviation safety based on the research findings identified during the previous chapters, and concludes the study.

Summary

In summary and conclusion of this dissertation, the purpose of this research was to answer the six main research questions listed within this chapter by qualitatively studying the public's trust and knowledge of UAS safety through data collection by interviewing research subjects using a data collection instrument. The researcher sought to determine whether the research subjects would be willing to fly as passengers in UAS. And, if publicity about unmanned aircraft influenced their perception about its safety. It was perceived this could affect their decision to travel as passengers in UAS. The researcher also examined interview data to identify if any observable Dunning-Kruger Effect existed that would suggest the research subjects believed they had more knowledge about the factors that affect UAS safety than what they knew when deciding whether to fly as passengers in UAS.

As a result, the researcher aligned the topics of the review of literature with the topics of the data collection instrument to obtain a better understanding and perspective in analyzing the research data, as well as to obtain a thorough understanding of the level of knowledge the research subjects had about aviation safety. The review of literature consisted of manned aviation regulations, small unmanned aircraft regulations, large unmanned aircraft regulations, aircraft accident statistics, aircraft accident causes, unmanned aircraft human factors, public trust in automation, unmanned aircraft publicity, and the Dunning-Kruger effect.

This researcher used what Creswell (2012) described as purposeful sampling of a population to intentionally select research subjects in order to learn about the central concepts, themes or phenomenon of the study (p. 206). The researcher used Creswell's purposeful sampling method by identifying a typical sample of the public who 1) did not have a technical background in manned or unmanned aviation, but was aware of the concepts of manned and unmanned aircraft and may or may not have flown in manned aircraft, and 2) did have a technical background in manned or unmanned aviation. After identifying and recruiting the initial number of research subjects, the researcher also used what Creswell defined as a snowball sampling method to identify and recruit additional research subjects, in which the initial research subjects recommended other people who fit the purposeful sampling profile identified by the researcher. The researcher recruited 25 research subjects who consisted of 22 subjects in the purposeful sample category and three subjects in the snowball sample category.

The researcher used Creswell's (2012) described process for collecting, analyzing and interpreting qualitative data that included; 1) collecting data by recording interviews, 2) preparing recorded data from interviews by transcribing it into meaningful written text, 3) reviewing the transcribed data to identify central themes and categories, and 4) coding the central themes and categories for analysis and interpretation detailed in the final dissertation report (p. 237).

Because of the qualitative design of this study, the data collection instrument contained both open-ended and closed-end questions designed to determine; if the subjects trusted UAS safety; if the subjects had a knowledge of factors that affected UAS safety; if the subjects believed that UAS publicity affected their trust of UAS safety; and overall, if the subjects were willing to fly as passengers in UAS. Upon completing Creswell's (2012) described process for collecting, analyzing and interpreting the qualitative data obtained from interviewing the research subjects, the researcher was able to answer the six main questions sought to be answered by this research study.

Main Research Questions

The researcher notes that the beneficiaries of this study are the regulatory, public, business, and academic stakeholders of the aviation industry. These beneficiaries will gain a greater understanding of the relationship between the public's knowledge of factors that affect safe operations of UAS within the NAS, and the level of trust the public has in UAS safety. This understanding can be used to increase public trust and demand of UAS by making the UAS product safer, more reliable and efficient, which will foster its further development and integration into the NAS as a viable alternative and replacement to manned aircraft. This section provides conclusion of the research study by answering each of the following main research questions.

1. Do the research subjects trust UAS safety?

To answer this main research question, the researcher analyzed finding six in the analysis and findings chapter, which identified the research subjects' level of trust in unmanned aircraft safety. The researcher examined and compared the 25 research subjects' responses to question three in the first part of the data collection instrument, which asked the research subjects to describe their level of trust in unmanned aircraft safety. The finding also examined the research subjects' responses to questions 11 and 12 in the second part of the data collection instrument, which identified their willingness to fly as passengers in unmanned aircraft. Specifically, question 11 asked the research subjects if they would volunteer to be the first person to fly in an unmanned aircraft, while question 12 asked the research subjects if they would fly as a passenger in an unmanned aircraft if it were proven safe and reliable.

Analyzing responses to the data collection instrument questions, the researcher noted the identification of the research subjects' trust in large and small unmanned aircraft, as well as their willingness to fly in unmanned aircraft as passengers. As a result, the researcher was able to answer this main research question, which sought to determine if the research subjects trusted UAS safety. Question three will be examined first.

Analysis of question three revealed that most (19 out of 25) of the research subjects had a medium level of trust or lower in the concept of large unmanned aircraft safety, while nearly all (23 out of 25) of the research subjects had a medium level of trust or lower in the concept of small unmanned aircraft safety. The researcher made the assessment that the results indicated a certain level of distrust of both large and small unmanned aircraft, given the argument that anything less than a high level of trust would be a level of distrust. Question 11 will be examined next.

Analysis of question 11 revealed that more than half (13 out of 25) of the research subjects responded no, they would not volunteer to be the first person to fly in an unmanned aircraft, while some (6 out of 25) responded maybe, or were otherwise undecided. Combined, the researcher made the assessment that the responses indicated most (19 out of 25) of the research subjects had a certain level of distrust in unmanned aircraft to be the first person to fly in one, given the argument that anything other than a response of yes would be a level of distrust. Question 12 will be examined last.

Analysis of question 12 revealed that most (18 out of 25) of the research subjects responded yes, they would fly as a passenger in an unmanned aircraft once proven safe and reliable, while some (7 out of 25) indicated maybe. The researcher made the assessment that the overall results indicate most of research subjects trusted unmanned aircraft, once proven safe and reliable, given the argument that any response other than yes indicated distrust.

2. What factors affect the research subjects' trust in UAS safety?

To answer this main research question, the researcher analyzed finding seven, which identified the factors that affected the research subjects' trust in unmanned aircraft. The researcher examined and compared the 25 research subjects' responses to question four in the first part of the data collection instrument. Their qualitative descriptions of these factors were analyzed and categorized into five common causal themes that affect aviation safety, which were identified in finding three as; the man, the machine, the environment, the system and security.

The 25 research subjects were categorized into two groups; the 12 research subjects in the first group who indicated they had no background, experience, or education in aviation subject matter; and, the 13 research subjects in the second group who indicated they had a background, experience and/or education in aviation subject matter.

Analyzing responses to question four in the first part of the data collection instrument, the researcher noted the identification of the factors that affected the research subjects' trust of unmanned aircraft. As a result, the researcher was able to answer this main research question, which was to determine the factors that affect the research subjects' trust in UAS safety.

The first group collectively identified four common themes as factors that affected their trust of unmanned aircraft; the man, the machine, the system, and security. While, the second group collectively identified four common themes as factors that affected their trust of unmanned aircraft; the man, the machine, the environment, and the system. Combined, the 25 research subjects collectively identified all five common themes in description of the factors that affect their trust in unmanned aircraft; the man, the machine, the environment, the system, and security. However, nearly all (23 out of 25) of the research subjects individually only identified three or less of the five common causal themes.

3. Do the research subjects know and understand the factors that affect UAS safety?

To answer this main research question, the researcher analyzed findings nine and ten from the analysis and finding chapter of this dissertation. Where finding nine examined the research subjects' description of their level of knowledge about the factors that affect unmanned aircraft safety, finding ten compared the research subjects' knowledge of the technical aspects of aviation safety to the correct response to questions four through 10 of the second part of the data collection instrument. Finding nine will be examined first.

Finding nine identified qualitative descriptors of the research subjects' perceived level of knowledge about unmanned aircraft safety. The researcher examined and compared the 25 research subjects' responses to question six in the first part of the data collection instrument, which asked the subjects to describe their knowledge of factors that affect unmanned aircraft safety. The factors were categorized into five common themes; the man, the machine, the environment, the system and security.

Based on the number of common themes each research subject identified in their qualitative response to the question, the researcher assigned a qualitative descriptor to describe their perceived level of knowledge about unmanned aircraft safety. These knowledge level descriptors were; a novice, having described one common theme; intermediate, having described two common themes; advanced, having described three common themes; expert, having described four common themes; and superior, having described five common themes. Analyzing responses to question six in the first part of the data collection instrument, the researcher noted the identification of the research subjects' collective level of knowledge about the factors that affect unmanned aircraft safety.

The researcher observed that, collectively, most (20 out of 25) of the research subjects described an intermediate level of knowledge or less about factors that affect unmanned aircraft safety by identifying two or less common themes. While, some (5 out of 25) of the subjects described an advanced or greater level of knowledge of factors that affect unmanned aircraft safety by identifying three to five common themes. Finding ten will be examined next.

Finding ten identified the research subjects' perceived knowledge of the technical aspects of aviation safety compared to the reality of those technical aspects. The researcher examined and compared the 25 research subjects' responses to questions four through 10 within the second part of the data collection instrument, which examined their specific knowledge of the technical regulatory requirements for the operation and maintenance of unmanned aircraft. Question four will be examined first.

Question 4

Question four asked the research subjects if UAS were regulated and overseen for safety the same as manned aircraft. The researcher observed that, collectively, some (8 out of 25) of the research subjects answered correctly, while most (17 out of 25) of the research subjects did not know the correct answer.

Question 5

Question five asked the research subjects if UAS were considered to be as technically reliable and safe as manned aircraft. The researcher observed that, collectively, less than half (12 out of 25) of the research subjects answered correctly, while more than half (13 out of 25) did not know the correct answer.

Question 6

Question six asked the research subjects if UAS were licensed the same as manned aircraft. The researcher observed that, collectively, less than half (9 out of 25) of the research subjects answered correctly, while most (16 out of 25) did not know the correct answer.

Question 7

Question seven asked the research subjects if UAS operators were licensed and trained the same as manned aircraft pilots. The researcher observed that, collectively, some (7 out of 25) of the research subjects answered correctly, while most (18 out of 25) did not know the correct answer.

Question 8

Question eight asked the research subjects if UAS were allowed to operate in the same airspace as manned aircraft. The researcher observed that, collectively, less than half (10 out of 25) of the research subjects answered correctly, while most (15 out of 25) did not know the correct answer.

Question 9

Question nine asked the research subjects if UAS mechanics were licensed the same as manned aircraft mechanics. The researcher observed that, collectively, some (7 out of 25) of the research subjects answered correctly, while most (18 out of 25) did not know the correct answer.

Question 10

Question ten asked the research subjects if UAS were required to be maintained the same as manned aircraft. The researcher observed that, collectively, some (7 out of 25) of the research subjects answered correctly, while most (18 out of 25) did not know the correct answer.

After analyzing findings nine and ten, the researcher was able to answer this main research question in the following manner. The data indicates that the research subjects did not fully know and understand the factors that affected UAS safety. The researcher observed that, collectively, most (20 out of 25) of the research subjects described an intermediate level of knowledge or less about factors that affect unmanned aircraft safety. When asked specific technical aviation safety questions, on average, most (16 out of 25) of the research subjects did not know the correct answer to questions four through 10 regarding the technical regulatory requirements for the operation and maintenance of unmanned aircraft.

4. What effect has the publicity of UAS had on the research subjects' willingness to fly as passengers in UAS?

To answer this main research question, the researcher analyzed finding eight, which examined and compared the 25 research subjects' responses to question eight in the first part of the data collection instrument that asked the subjects to identify what had been publicized about UAS by the government and media, and how the publicity had affected their opinions about UAS.

The researcher also examined the research subjects' responses to questions 11 and 12 in the second part of the data collection instrument, which identified their willingness to fly as passengers in unmanned aircraft. Specifically, question 11 asked the research subjects if they would volunteer to be the first person to fly in an unmanned aircraft, while question 12 asked the research subjects if they would fly as a passenger in an unmanned aircraft if it were proven safe and reliable. As a result, the researcher was able to answer this main research question, which was to determine the effect that UAS publicity has had on the research subjects' willingness to fly as passengers in UAS. Question eight will be examined first.

Question eight in the first part of the data collection instrument asked the research subjects to describe what had been publicized about UAS by the government and media, and how the publicity had affected their opinions about UAS. The researcher observed that some (2 out of the 25) of the research subjects were unaware of any government or media publicity about UAS, while nearly all (23 out of the 25) of the subjects stated that publicity about UAS had affected their opinions. Their responses were categorized as either "positive", "negative", or "neutral".

The research data, for those research subjects (23 out of 25) who indicated that publicity had affected their opinions about UAS, reflected the following qualitative information. Some (2 out of 25) of the research subjects indicated that publicity about UAS positively affected their opinions. Most (18 out of 25) of the subjects indicated that publicity about UAS had negatively affected their opinions. While, some (3 out of 25) of the subjects indicated that publicity about UAS had a neutral, or no effect on their opinions. Question 11 will be examined next.

Analysis of question 11 revealed that more than half (13 out of 25) of the research subjects responded no, they would not volunteer to be the first person to fly in an unmanned aircraft, while some (6 out of 25) responded maybe. Combined, the researcher made the assessment that the responses indicated most (19 out of 25) of the research subjects had a certain level of distrust in unmanned aircraft, given the argument that anything other than a response of yes represented distrust. Question 12 will be examined last.

However, analysis of question 12 revealed that most (18 out of 25) of the research subjects responded yes, they would fly as a passenger in an unmanned aircraft once proven safe and reliable. While, some (7 out of 25) indicated maybe. The researcher made the assessment that the overall results indicate most of research subjects trusted unmanned aircraft, once proven safe and reliable, given the argument that any response other than yes indicated distrust.

The researcher determined that the data indicates the research subjects collectively changed their opinions about the decision to fly as passengers in unmanned aircraft when it was suggested that unmanned aircraft were proven safe and reliable. At first, it was observed that most (18 out of 25) of the research subjects indicated that publicity about UAS had negatively affected their opinions. While, correspondingly, nearly the same number (19 out of 25) of research subjects had a certain level of distrust in unmanned aircraft to be the first person to fly as a passenger. However, the exact same number (18 out of 25) of research subjects indicated they would fly as a passenger in an unmanned aircraft once proven safe and reliable, which is a form of positive publicity about the safety and reliability of UAS. This data suggests that the publicity of UAS can have either a positive, negative, or neutral effect on the research subjects' opinions about UAS, as well as positive or negative influences on their willingness to fly as passengers in UAS.

5. Is there a relationship between the research subjects' trust and knowledge of UAS safety?

To answer this main research question, the researcher further analyzed the first and third main research questions sought to be answered by this study. Which were, do the research subjects trust UAS safety, and do the research subjects know and understand the factors that affect UAS safety? Analysis of the first main research question will be summarized first, followed by the third main research question, and then the relationship between trust and knowledge will be examined.

The first main research question sought to be answered by this study was, do the research subjects trust UAS safety? To summarize the answer, the researcher analyzed finding six in the analysis and findings chapter, which examined and compared the research subjects' responses to question three in the first part of the data collection instrument, as well as their responses to questions 11 and 12 in the second part of the data collection instrument. Overall, the researcher made the assessment that the results of the data analysis indicated most (19 out of 25) of research subjects did not trust unmanned aircraft, and most

(19 out of 25) would not fly in an unmanned aircraft as a passenger unless it were proven safe and reliable.

The third main question sought to be answered by this research study was, do the research subjects know and understand the factors that affect UAS safety? To summarize the answer, the researcher analyzed findings nine and ten from the analysis and finding chapter. Overall, the researcher made the assessment that the results of the data analysis indicated the research subjects did not fully know and understand the factors that affected UAS safety. The researcher observed that, collectively, most (20 out of 25) of the research subjects described an intermediate level of knowledge or less about factors that affect unmanned aircraft safety. And on average, most (16 out of 25) of the research subjects did not know the correct answers to questions four through 10 regarding the technical regulatory requirements for the operation and maintenance of unmanned aircraft. However, the researcher notes that because most (20 out of 25) of the research subjects described an intermediate level of knowledge or less about factors that affect unmanned aircraft safety, it is reasonable to assume that some of the subjects did not know the correct answer and could have guessed the correct answer to questions four through 10 in the second part of the data collection instrument, thus skewing the data.

To summarize the data from the first and third main research questions, most (19 out of 25) of research subjects did not trust unmanned aircraft, and most (19 out of 25) would not fly in an unmanned aircraft as a passenger unless it were proven safe and reliable. Yet, most (20 out of 25) of the research subjects described an intermediate level of knowledge or less about factors that affect unmanned aircraft safety, and most (16 out of 25) did not know the correct answer to questions four through 10 regarding the technical regulatory requirements for the operation and maintenance of unmanned aircraft. Further described, both trust and knowledge were observed to be relatively low. The relationship between low trust and low knowledge will be examined next.

A potential bias towards manned aircraft, the researcher determined that the relationship between the research subjects' low trust and low knowledge of UAS safety resides in: 1) their lack of exposure to publicity depicting unmanned aircraft to be relatively safe; as well as, 2) their exposure to the publicity of a relatively safe manned air traffic system; and overall, 3) the influence that publicity has on the subjects' decisions to fly as passengers in either manned or unmanned aircraft, in the absence of knowledge about factors that affect aviation safety. Lack of exposure to publicity depicting unmanned aircraft to be relatively safe will be examined first.

As identified in the fourth main research question, the researcher sought to identify the effect that publicity of UAS had on the research subjects' willingness to fly as passengers in UAS. It was observed that most (18 out of 25) of the research subjects indicated that publicity about UAS had negatively affected their opinions. While, correspondingly, nearly the same number (19 out of 25) of research subjects had a certain level of distrust in unmanned aircraft causing an unwillingness to be the first person to fly as a passenger. However, the exact same number (18 out of 25) of research subjects indicated they would fly as a passenger in an unmanned aircraft once proven safe and reliable, which is positive publicity about the safety and reliability of UAS. After analysis, the researcher determined that the data indicates the research subjects collectively changed their opinions about the decision to fly as passengers in unmanned aircraft when it was suggested that unmanned aircraft were proven safe and reliable. This positive influence, being in the overall absence of the research subjects' full knowledge about the factors that affect unmanned aircraft safety, as identified in the third main research question. Research subject exposure to the publicity of a relatively safe manned air traffic system will be examined next.

The researcher noted that research subject exposure to the relatively safe manned aircraft system was identified in findings four and five of the analysis and findings chapter. Those findings were; finding 4, observations related to the research subjects' background, experience and education in aviation, and finding 5, observations related to the research subjects' participation in the manned air traffic system as passengers.

The researcher observed that findings four and five both identified that all 25 research subjects were exposed to the relatively safe manned air traffic system as passengers in commercial aircraft, while more than half (13 out of 25) of subjects had further exposure due to their background and experience in their aviation professions. Detailed in finding four, the researcher noted that manned aviation maintains relatively low fatal accident rates and the research subjects share in the benefit of that exposure when traveling as passengers, as the data reflects 0.155/0.260 accidents per 100,000 flight hours for §121 scheduled/nonscheduled air carrier operations respectively, and zero fatal accidents; and, 1.458/1.07 accidents and 0.292/0.20 fatal accidents per 100,000 flight hours for §135 commuter/on-demand air carrier operations respectively (NTSB, 2015c).

Additionally, finding five further identified the frequency, or amount of exposure, the research subjects had to the manned commercial aviation system. In that, most of the subjects (16 out of 25) infrequently flew at least two to three times per year, while less than half (9 out of 25) frequently flew four or more times per year. This data indicates that decisions to fly as passengers in manned commercial aircraft are influenced by positive publicity, and the frequency is reinforced by repetitive exposure as passengers with continued low accident/fatal-accident rates. Interestingly, the researcher observed an overall similar low level of research subject knowledge about factors that affect manned aircraft safety, as compared to their knowledge about factors that affect unmanned aircraft safety. These will be examined next.

Question seven in the first part of the data collection instrument asked the research subjects to describe their knowledge of factors that affect manned aircraft safety. The researcher observed that, collectively, most (16 out of 25) of the research subjects described an intermediate level of knowledge or less about the factors that affect manned aircraft safety. Yet, in the absence of a self-described full knowledge about the factors that affect manned aircraft safety, all 25 research subjects indicated they had chosen to fly as passengers in manned commercial aircraft. This data indicates, collectively, a high level of trust in manned aircraft safety, with a relative low level of knowledge about the factors that affect manned aircraft safety.

In response to the fourth main research question, the researcher determined that the data indicates the research subjects collectively changed their opinions about the decision to fly as passengers in manned aircraft based on proven safety and reliability due to the influence of positive publicity, and by the frequency and reinforcement of repetitive exposure as passengers with continued low accident/fatal-accident rates. This being in the absence of a full knowledge about the factors that affect manned aircraft safety.

6. Will the Dunning-Kruger Effect be observed in the research findings?

To answer this main research question, the researcher analyzed literature about the Dunning-Kruger effect listed in the review of literature chapter, as well as responses to the main research question answered within this chapter, and findings listed in the analysis and findings chapter. The literature about the Dunning-Kruger Effect will be summarized first.

As previously identified in this dissertation, the researcher questioned if the Dunning-Kruger Effect would be observed in the research findings, which could suggest that people think more highly of their cognitive decision-making abilities even when they have limited knowledge in which to make a competent decision (Kruger & Dunning, 1999, p. 1121). As a result, the researcher reviewed the study by Kruger and Dunning (1999) published in the Journal of Personality and Social Psychology titled, *Unskilled and Unaware of It: How Difficulties in Recognizing One's Own Incompetence Lead to Inflated Self-Assessments*.

Kruger and Dunning (1999) maintained the belief and assumption that under-skilled people overestimate and maintain higher opinions about their skills and abilities than skilled people in a particular knowledge area, suffering the ability to realize incompetence brought about by the lack knowledge or skill (p. 1121). They identified the result as an incorrect assumption of competence. The research pair explained this phenomenon with the relatable example of being competent to detect grammatically correct sentences. The premise being that, in order to detect errors in grammatically incorrect sentences, one must be competent in reading and writing grammatically correct sentences in the first place.

This is similar to being able to assess whether unmanned aircraft are safe and reliable, and basing the decision to fly as a passenger in an unmanned aircraft on that knowledge, or the lack thereof. The premise being that, in order to determine unmanned aircraft safety and reliability, one must be competent in the factors that affect unmanned aircraft safety, have direct knowledge of an associated accident rate and safety record, or benefit from the influences of positive publicity depicting it as safe and reliable in the absence of direct knowledge.

Kruger and Dunning (1999) focused their research and predictions on the competence and metacognitive skills, which are the foundational knowledge and subsequent experiences one has about personal cognitive abilities. The authors predicted these to be lacking in the incompetent person, which are required skills for correctly assessing one's own abilities for proper decision making (Kruger & Dunning, 1999, p. 1122). In reviewing the study, the researcher identified Kruger and Dunning's (1999) four predictions based on their beliefs and assumptions about the metacognitive abilities of incompetent people (p. 1122):

1. People who are incompetent will overestimate their own cognitive abilities more than those who are competent.
2. People who are incompetent will be less likely than people who are competent to recognize competence in themselves and others.
3. People who are incompetent will be less likely than people who are competent to learn from assessing the performance of other people, in order to assign a correct assessment of self-performance.

4. People who are incompetent can become competent by being taught about their errors, which provides them with the needed metacognitive skills to properly assess self-performance.

In analysis of the fifth main research question answered within this chapter, the researcher determined that the relationship between the research subjects' trust and knowledge of UAS safety resided in; 1) their lack of exposure to publicity depicting unmanned aircraft to be relatively safe; as well as, 2) their exposure to the publicity of a relatively safe manned air traffic system; and overall, 3) the influence that publicity has on the subjects' decisions to fly as passengers in either manned or unmanned aircraft, in the absence of knowledge about factors that affect aviation safety.

To summarize the fifth main research question, the research data indicated that the research subjects had a low level of trust and low level of knowledge of unmanned aircraft safety. After further analysis, the researcher determined that the data also indicated that the research subjects collectively changed their opinions about the decision to fly as passengers in unmanned aircraft when it was suggested that unmanned aircraft were proven safe and reliable, thus representing a form of positive publicity having positive influence on the research subjects. This positive influence being in the overall absence of the research subjects' full knowledge about the factors that affect unmanned aircraft safety, as identified in the third main research question. Research subject exposure to the publicity of a relatively safe manned air traffic system will be examined next.

The researcher noted that research subject exposure to the relatively safe manned aircraft system was identified in findings four and five of the analysis and findings chapter. Those findings were; finding 4, observations related to the research subjects' background, experience and education in aviation; and finding 5, observations related to the research subjects' participation in the manned air traffic system as passengers.

In analysis of the response to the fifth main research question, it was identified that all 25 research subjects were exposed to the relatively safe manned air traffic system as passengers in commercial aircraft, to include its publicized low accident rates. While, more than half of subjects had further exposure due to their background and experience in their aviation professions. Detailed in finding four, it was observed that manned aviation has maintained relatively low fatal accident rates and the research subjects share in the benefit of that exposure when traveling as passengers. Interestingly, however, the researcher observed that the research subjects had an overall similarly low level of research subject knowledge about factors that affect manned aircraft safety, as well as their knowledge about factors that affect unmanned aircraft safety.

This was detailed in the analysis of question seven in the first part of the data collection instrument, which asked the research subjects to describe their knowledge of factors that affect manned aircraft safety. The researcher observed that, collectively, most of the research subjects described an intermediate level of knowledge or less about the factors that affect manned aircraft safety. Yet, in the absence of a self-described full knowledge about the factors that affect manned aircraft safety, all 25 research subjects indicated they had chosen to fly as passengers in manned commercial aircraft. Which indicates, collectively, a high level of trust in manned aircraft safety and a relatively low level of knowledge about the factors that affect manned aircraft safety, while having exposure to the safety of commercial manned aviation.

Additionally, finding five further identified the frequency, or amount of exposure, the research subjects had to the manned commercial aviation system. In that, most of the subjects infrequently flew at least two to three times per year, while less than half frequently flew four or more times per year. This information suggests that decisions to fly as passengers in manned commercial aircraft, while having relatively low knowledge about its safety, are influenced by positive publicity about its safety, reliability, and low accident/fatal-accident rates.

In relation to Kruger and Dunning's (1999) study, the researcher answered this main research question by assessing whether the central phenomenon of the Dunning-Kruger Effect was observed in the research findings of this study. The researcher determined that Kruger and Dunning's first and fourth predictions, and the research methods used to test those predictions, were more applicable to the qualitative design of this study than were the second and third predictions. As a result, predictions one and four were assessed. Predictions two and three, however, as well as the quantitative design of Kruger and Dunning's research methods used to test them, were not applicable to the qualitative design of this study and were not assessed. Prediction one is examined first.

Kruger and Dunning's (1999) first prediction stated that people who are incompetent will overestimate their own cognitive abilities more than those who are competent. This prediction was observed during this research study given the researcher's observations identified in response to the fifth main question sought to be answered by this research study.

The researcher observed that most (19 out of 25) of research subjects did not trust unmanned aircraft, and most (19 out of 25) would not fly in an unmanned aircraft as a passenger unless it were proven safe and reliable. Yet, most (20 out of 25) of the research subjects described an intermediate level of knowledge or less about factors that affect unmanned aircraft safety, and most (16 out of 25) did not know the correct answer to questions four through 10 regarding the technical regulatory requirements for the operation and maintenance of unmanned aircraft. Further described, the research subjects' overall trust and knowledge of unmanned aircraft safety were observed to be low.

The researcher made the observation during the review of literature that current FAA regulations were promulgated for the safe operation, maintenance, and certification of the manned aviation system. And, regulations promulgated for carrying passengers for commercial purposes were observed to be more prescriptive and required more safety measures than general aviation. As a result, it is expected that, although none existed at the time of this research, future regulations promulgated for transporting passengers for commercial purposes in unmanned aircraft will ensure an equivalent level of safety as manned aircraft. The fourth prediction will be examined next.

Kruger and Dunning's (1999) fourth prediction stated that people who are incompetent can become competent by being taught about their errors, which provides them with the needed metacognitive skills to properly assess self-performance. This prediction was observed during this research study given the researcher's observations identified in response to the fifth main question sought to be answered by this research study.

In addition to observing the research subjects' low trust and low knowledge of unmanned aircraft safety, and the expectation that future regulations for transporting passengers for commercial purposes in unmanned aircraft would ensure an equivalent level of safety as manned aircraft, the researcher observed that the research subjects collectively changed their opinions about the decision to fly as passengers in unmanned aircraft when it was suggested that unmanned aircraft were proven safe and reliable.

At first, it was observed that most (18 out of 25) of the research subjects indicated that publicity about UAS had negatively affected their opinions. While, correspondingly, nearly the same number (19 out of 25) of research subjects had a certain level of distrust in unmanned aircraft which caused their unwillingness to be the first person to fly in one. However, the exact same number (18 out of 25) of research subjects indicated they would fly as a passenger in an unmanned aircraft once proven safe and reliable, which is a form of positive publicity about the safety and reliability of UAS. Recommendations to improve and advance aviation safety based on the research findings identified during this study and detailed within this chapter will be examined next.

Recommendations

During this research, the researcher identified the beneficiaries of this study who are the regulatory, public, business, and academic stakeholders of the aviation industry. Additionally, the researcher also identified findings affecting aviation safety and sustainability. As a result, the researcher makes the five recommendations listed in this section to improve and advance aviation safety and sustainability for the beneficiaries of this study. These recommendations are to; 1) enhance general aviation accident statistics; 2) enhance unmanned aviation accident statistics; 3) enhance unmanned aircraft accident research; 4) increase public trust in unmanned aircraft; and 5) recommend further research.

Recommendation 1 – Enhance General Aviation Accident Statistics

Detailed in finding one of the analysis and findings chapter, the first finding that was identified during the review of relevant literature was the FAA's method of collecting flight hour data that the NTSB uses to calculate general aviation accident rates. The researcher identified, within the manned aircraft accident data and statistics section of the review of literature chapter of this dissertation, that the FAA's methods do not accurately capture flight hour activity data for general aviation as it does for Parts 121 and 135 commercial air carriers. As a result, the data in which the NTSB estimates general aviation accident rates are calculated based on voluntary submission of flight hour activity summaries by operators, which can be reported late, not reported at all, or contain inaccurate flight hour data (NTSB, 2015c).

The researcher notes the related impacts of this finding are an inaccurate assessment and comparison of accident rates within aviation and across multiple modes of transportation. Resultantly, it is arguably and ultimately unknown if general aviation is any more, or less, safe than other modes of transportation, to include modes within aviation. So, public policy, law and rule making dependent upon this data may be focused in the wrong area of transportation accident prevention. Additionally, inaccurate aircraft accident statistics can have a misleading effect on public perceptions of general aviation safety.

The researcher recommends that the government track this data accurately instead of estimating it, determine the applicable accident rate, and conduct further research into the comparison of general aviation accident rates to other modes of aviation in order to determine if general aviation is any more or less safe, then focus policy and rule making appropriately. Finding two will be examined next.

Recommendation 2 – Enhance Unmanned Aviation Accident Statistics

Detailed in finding two of the analysis and findings chapter, the second finding that was identified during review of relevant literature was the lack of aircraft accident statistics for civil unmanned aircraft. The researcher identified, within the unmanned aircraft accident/incident data and statistics section of the review of literature chapter, that the FAA did not track and publish flight hour data for UAS. As a result, the NTSB did not publish accident statistics for civil UAS at the time of this research.

Without accurate accident/incident statistics, it is arguably and realistically unknown if UAS are any more, or less, safe than other modes of transportation, to include modes within aviation. However, throughout the unmanned aircraft publicity section of the review of literature chapter, negative publicity was identified that depicted unmanned aircraft to be unsafe and pose a hazardous threat to the safety of other aircraft within the NAS. Yet, at the time of the review of literature, no known injuries or fatalities were identified related to the operation of either a large or small civil unmanned aircraft, not including hobbyists. To a further point, given the current FAA incident statistics, it is also unknown if small UAS present any more of a mid-air collision hazard and subsequent safety risk to other aircraft within the NAS than birds.

The researcher notes the related impact of this finding is primarily the lack of a proper assessment and comparison of UAS accident statistics against other modes of transportation, to include other modes within aviation. As a result, it is arguably and ultimately unknown if UAS are any more, or less, safe than other modes of transportation, to include modes within aviation. Because public policy, law and rule making are dependent upon such data, a latent impact is that the government may be focused in the wrong area of transportation accident prevention. This lack of empirical analysis by the government also leaves room for media speculation and negative publicity about UAS. Furthermore, negative publicity about UAS based on the lack of accurate accident statistics may have a misleading effect on public perceptions of UAS safety.

The researcher recommends that the government track this data, determine an applicable accident rate, and conduct further research into the comparison of UAS accident rates versus other modes of aviation in order to determine if UAS are any more or less safe.

Recommendation 3 – Enhance Unmanned Aircraft Accident Research

Detailed in finding two of the analysis and findings chapter, the researcher examined UAS accident data between January 1, 2002 and September 26, 2017 within the NTSB aviation accident database by conducting a keyword search using six common terms related to unmanned aircraft. A keyword search was conducted because the NTSB did not provide a search option for UAS as an aircraft category. As a result, the research notes that the related impacts of this finding are limited research options for the public and academia to conduct a thorough analysis of aircraft accident data.

The researcher makes the recommendation that the NTSB develop a search option for UAS as an aircraft category within the aviation accident database in order to allow the public and academia to conduct an adequate search of aircraft accident database information.

Recommendation 4 – Increase Public Trust of Unmanned Aviation

Findings four and five within the analysis and findings chapter both identified a potential bias towards manned aircraft travel versus future unmanned aircraft travel due to passenger exposure to the relatively safe manned aircraft system and its publicity, as well as the lack of exposure to a safe unmanned aircraft system and its publicity. To include, a passenger exposure to negative publicity about the safety of UAS, in the absence of accurate accident statistics.

The related impacts of this finding suggest that exposure to the relatively safe manned aviation system can cause a bias from passengers towards manned aircraft versus unmanned aircraft, affecting the viability of UAS as a future mode of transportation. The researcher recommends the government, unmanned aircraft operators and unmanned aircraft manufacturers explore these suggestions and similarly expose potential customers of unmanned aircraft and the public in order to elicit trust in unmanned aircraft.

Recommendation 5 – Recommended Further Research

This study has led to new ideas, further questions and areas of opportunity for academic research. As a result, the researcher recommends further studies in the following areas to advance the safety, viability and sustainability of manned and unmanned aviation.

1. A study into the correlations and differences between the public's trust in unmanned air transportation and its trust in unmanned ground transportation.
2. A study into the amount of exposure to positive publicity that is needed for a person to establish trust and become willing to travel as a passenger in unmanned air transportation.

3. A study into the amount of exposure to positive publicity that is needed for a person to establish trust and become willing to travel as a passenger in unmanned ground transportation.
4. A study into the effects that passenger travel preferences, for either unmanned air transportation and/or unmanned ground transportation, would have on the current hub-and-spoke air transportation system model.

Conclusion

In conclusion, this dissertation detailed the introduction of the research study, the researcher's review of literature, the research methodologies used during the study, the analysis and findings of the data collection, and summarized the research study by answering the main research questions, and submitting recommendations to improve and advance aviation safety for its beneficiaries. It represents the researcher's own interpretations and analysis and do not reflect the opinions of Oklahoma State University or the researcher's employer.

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APPENDICES

APPENDIX A

IRB APPROVAL LETTER

Oklahoma State University Institutional Review Board

Date: Wednesday, August 03, 2016

IRB Application No ED16125

Proposal Title: A qualitative inquiry into public perceptions of unmanned aviation safety

Reviewed and Processed as: Exempt

Status Recommended by Reviewer(s): Approved Protocol Expires: 8/2/2019

Principal Investigator(s):

Brian Rochester	Timm Bliss
	318 Willard
Stillwater, OK 74078	Stillwater, OK 74078

The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46.

☐ The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:

1.Conduct this study exactly as it has been approved. Any modifications to the research protocol must be submitted with the appropriate signatures for IRB approval. Protocol modifications requiring approval may include changes to the title, PI advisor, funding status or sponsor, subject population composition or size, recruitment, inclusion/exclusion criteria, research site, research procedures and consent/assent process or forms
2.Submit a request for continuation if the study extends beyond the approval period. This continuation must receive IRB review and approval before the research can continue.
3.Report any adverse events to the IRB Chair promptly. Adverse events are those which are unanticipated and impact the subjects during the course of the research; and
4.Notify the IRB office in writing when your research project is complete.

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact Dawnett Watkins 219 Scott Hall (phone: 405-744-5700, dawnett.watkins@okstate.edu).

Sincerely,

Hugh Crethar, Chair
Institutional Review Board

APPENDIX B

PARTICIPANT RECRUITMENT LETTER

PARTICIPANT RECRUITMENT LETTER

Dear Mr./Ms. ________________________________

I am a student in the Educational Doctorate degree program in Aviation and Space Science at Oklahoma State University. As part of the program, I am required to complete a research study and dissertation. My topic is: *A Qualitative Inquiry into Public Perceptions of Unmanned Aviation Safety.*

The purpose of this research is to qualitatively study the public's trust and knowledge of Unmanned Aircraft System (UAS) safety. Additionally, the research will determine whether, or not, the public would be willing to fly as passengers in UAS in the future.

The beneficiaries of this study will be regulatory, public, business, and academic interests. As stakeholders in aviation commerce, these beneficiaries will gain a greater understanding of the relationship between the public's knowledge of factors that affect safe operations of UAS within the National Air Space, as well as the level of trust the public has in UAS safety.

These beneficiaries can utilize this understanding to increase public trust in UAS safety and foster its development and progress by taking actions and making corrections to the specific aspects of the UAS industry that may contribute to the public's lack of knowledge and mistrust of the reliability and safety of UAS. Of greatest benefit, the beneficiaries will have an opportunity to utilize this information to not only make the UAS product safer, more reliable, and efficient for public transportation, but to also increase public demand for the UAS product.

I would like to extend an invitation to you to participate in this ground breaking research study. If you are interested, please review the attached Informed Consent Document, sign and return to me via email at your earliest convenience. The document contains the purpose and procedures of the study, as well as confidentiality for each participant.

If you have any questions about the study, the process, or the Informed Consent Document, please please contact me by email at brian.rochester@okstate.edu or by telephone at (580) 278-1760.

Thank you,

Brian L. Rochester

Okla. State Univ.
IRB
Approved 8-3-16
Expires 8-2-19
IRB # ED-16-125

APPENDIX C

INFORMED CONSENT DOCUMENT

INFORMED CONSENT DOCUMENT

PROJECT TITLE:

A Qualitative Inquiry into Public Perceptions of Unmanned Aviation Safety (UAS).

RESEARCH INVESTIGATORS:

Brian L. Rochester, Department of Aviation and Space, Oklahoma State University
Dr. Timm Bliss, Department of Aviation and Space, Oklahoma State University

PURPOSE:

You are invited to voluntarily participate in a study to investigate the public's trust and knowledge of UAS safety, and determine its willingness to fly as passengers in UAS in the future.

PROCEDURES:

You were selected to participate in this research study because you are either a person who has a background in aviation, or are a person who does not have a background in aviation. Up to 40 participants may be selected to participate in this study.

If you choose to participate, you will be interviewed by the primary research investigator and asked to respond to questions related to the following topics, which will be audio recorded:

- Your background in aviation,
- Your trust in UAS safety,
- Your knowledge of factors that affect UAS safety,
- What factors affect your trust of UAS safety, and
- Your willingness to fly as passengers in UAS in the future.

RISKS OF PARTICIPATION:

There are no known risks associated with this study that are greater than those ordinarily encountered in everyday life.

CONFIDENTIALITY:

In order to protect your identity, personally identifiable information will be replaced by a participant number before recording and transcribing audio from the interview, and coding and categorizing of data to complete the research study.

The Informed Consent Document, audio recorded interview, and audio transcriptions will not be made available to anyone other than the researcher investigators.

COMPENSATION:

There is no compensation for participation in this research study.

Okla. State Univ.
IRB
Approved 8-3-16
Expires 8-2-19
IRB # ED-16-125

BENEFITS:

The beneficiaries of this study are regulatory, public, business, and academic interests. These beneficiaries may gain a greater understanding of relationships between the public's knowledge and trust of UAS safety. These beneficiaries may also utilize this information to make UAS safer, more reliable, and efficient for public transportation in the future.

CONTACTS:

If you have questions about this research study, you may contact the Primary Investigator; Brian L. Rochester, Aviation and Space Science, 318 Willard Hall, Stillwater, Oklahoma 74078, telephone: 580-278-1760, email: brian.rochester@okstate.edu; or, the Faculty Advisor: Dr. Timm Bliss, Aviation and Space Science, 318 Will Hall, Stillwater, Oklahoma 74078, telephone: 405-744-8062, email: timm.bliss@okstate.edu.

If you have questions about your rights as a voluntary research participant, you may contact the Oklahoma State University Institutional Review Board (IRB); Dawnett Watkins, IRB Manager, telephone: 405-744-5700, email: dawnett.watkins@okstate.edu; or, Whitney McAllister, IRB Coordinator, telephone: 405-744-3377, email: whitney.mcallister@okstate.edu.

PARTICIPANT RIGHTS:

I understand that my participation is voluntary, that there is no penalty for refusal to participate, and that I am free to withdraw my consent and participation in this project at any time, without penalty.

CONSENT DOCUMENTATION

I have been fully informed about the procedures listed here. I am aware of what I will be asked to do and of the benefits of my participation. I also understand the following statements:

- I affirm that I am 18 years of age or older.
- I have read and fully understand this consent form and I sign it freely and voluntarily. A copy of this form will be given to me. I hereby give permission for my participation in this study.

____

Signature of Research Participant / Date

I certify that I have personally explained this document before requesting that the participant sign it.

____

Signature of Researcher Investigator / Date

Okla. State Univ.
IRB
Approved 8-3-16
Expires 8-2-19
IRB # ED-16-125

APPENDIX D

INTERVIEW GUIDE

INTERVIEW GUIDE

DISCLAIMER

Hello Mr./Ms.__________________ (participants name). My name is Brian L. Rochester and I am conducting a research study for the Educational Doctoral degree requirements in Aviation and Space Science at Oklahoma State University. I would like to thank you for your voluntary participation in this research study.

The purpose of this research is to qualitatively study the public's trust and knowledge of Unmanned Aircraft System (UAS) safety, and determine whether, or not, the public would be willing to fly as passengers in UAS in the future.

This interview will last approximately 45 minutes and will be recorded as stated in the Informed Consent Document that you signed, ensuring complete confidentiality and at no harm to you.

I welcome your candid and honest responses and opinions to the questions asked during this interview. If any question makes you uncomfortable and/or you do not wish to answer it, please state so and the question will be skipped. If the process itself makes you uncomfortable in any way and you wish to end the interview, please state so and the interview will be stopped.

You are free to take a break at any time during the interview.

- Do you have any questions? If not, let's begin.
- Do I have permission to record this interview?
- Researcher states, "I will now start recording this interview" and begins recording.
- Researcher states, "Doctoral Research Study, Oklahoma State University, date (state the date), Title of Project: A Qualitative Inquiry into Public Perceptions of Unmanned Aviation Safety, Research Participant # (state participant number)".

<u>Open-Ended Interview Questions and Statements:</u>

1. Please describe your background, experience and education in aviation *[Is the participant male or female, and do they fall between the ages of (1) 18-35; (2) 36-50; and (3) over 50]*

2. Can you describe your level of trust in manned aircraft safety?

3. Can you describe your level of trust in unmanned aircraft safety?

4. What factors affect your trust of unmanned aircraft?

5. What factors affect your trust of manned aircraft?

6. Can you describe your knowledge of factors that affect unmanned aircraft safety?

7. Can you describe your knowledge of factors that affect manned aircraft safety?

8. Can you describe what has been publicized about UAS by the government and media, and how this publicity has affected your opinions about UAS?

Follow-on Closed-Ended Questions:

1. Are you an aircraft pilot or mechanic?

2. Do you, or anyone you know operate UAS?

3. How often do you fly as a passenger in a commercially manned aircraft?

4. Are UAS regulated and overseen for safety the same as manned aircraft?

5. Are UAS considered to be as technically reliable and safe as manned aircraft?

6. Are UAS licensed the same as manned aircraft?

7. Are UAS operators licensed and trained the same as manned aircraft pilots?

8. Are UAS allowed to operate in the same airspace as manned aircraft?

9. Are UAS mechanics licensed the same as manned aircraft mechanics?

10. Are UAS required to be maintained the same as manned aircraft?

11. Would you volunteer to be the first person to fly in an unmanned aircraft?

12. If proven safe and reliable, would you fly as a passenger in an unmanned aircraft?

13. Would you recommend another person who may be suitable for this study?

VITA

Brian L. Rochester

Candidate for the Degree of

Doctor of Education

Dissertation: A QUALITATIVE INQUIRY INTO PUBLIC PERCEPTIONS OF UNMANNED AVIATION SAFETY

Major Field: Applied Educational Studies

Biographical:

Education:

Completed requirements for the Doctor of Education in Applied Educational Studies at Oklahoma State University, Stillwater, Oklahoma in May, 2018.

Completed requirements for the Masters of Aeronautical Science at Embry-Riddle Aeronautical University, Daytona Beach, Florida in 2008.

Completed requirements for the Bachelor of Science in Professional Aeronautics at Embry-Riddle Aeronautical University, Daytona Beach, Florida in 2002.

Completed requirements for the Associate of Applied Science in Airframe Repair Technology at the Community College of the Air Force, Maxwell-Gunter AFB, Alabama in 1999.

Experience:

Federal Aviation Administration-US DOT, Manager, Regulatory Standards Division, FAA Academy, 2016 to the present.

Transportation Safety Institute-US DOT, Manager, National Aircraft Accident Investigation School, 2014 to 2016.

Federal Aviation Administration-US DOT, Aviation Safety Inspector, 2010 to 2014.

Professional Memberships:

International Society of Air Safety Investigators, Full Member