5-2020

Pilot's Willingness to Operate in Unmanned Aircraft System Integrated Airspace

Lakshmi Vempati

Follow this and additional works at: <https://commons.erau.edu/edt>

Part of the [Aerospace Engineering Commons](#), and the [Management and Operations Commons](#)

Scholarly Commons Citation

Vempati, Lakshmi, "Pilot's Willingness to Operate in Unmanned Aircraft System Integrated Airspace" (2020). *Dissertations and Theses*. 501.
<https://commons.erau.edu/edt/501>

This Dissertation - Open Access is brought to you for free and open access by Scholarly Commons. It has been accepted for inclusion in Dissertations and Theses by an authorized administrator of Scholarly Commons. For more information, please contact commons@erau.edu.

**PILOTS' WILLINGNESS TO OPERATE IN UNMANNED AIRCRAFT SYSTEM
INTEGRATED AIRSPACE**

By

Lakshmi Vempati

A Dissertation Submitted to the College of Aviation
in Partial Fulfillment of the Requirements for the Degree of
Doctor of Philosophy in Aviation

Embry-Riddle Aeronautical University
Daytona Beach, Florida
May 2020

© 2020 Lakshmi Vempati
All Rights Reserved.

**PILOTS' WILLINGNESS TO OPERATE IN UNMANNED AIRCRAFT SYSTEM
INTEGRATED AIRSPACE**

By

Lakshmi Vempati

This Dissertation was prepared under the direction of the candidate's Dissertation Committee Chair, Dr. Scott R. Winter, and has been approved by the members of the dissertation committee. It was submitted to the College of Aviation and was accepted in partial fulfillment of the requirements for the
Degree of
Doctor of Philosophy in Aviation

Scott R. Winter, Ph.D.
Committee Chair

Stephen Rice, Ph.D.
Committee Member

Steven Hampton, Ed.D.
Associate Dean, School of Graduate
Studies, College of Aviation

Valerie J. Gawron, Ph.D.
Committee Member (External)

Alan J. Stolzey, Ph.D.
Dean, College of Aviation

John M. Robbins, Ph.D.
Committee Member

Jan. 27, 2020

Date

ABSTRACT

Researcher: Lakshmi Vempati

Title: PILOTS' WILLINGNESS TO OPERATE IN UNMANNED AIRCRAFT
SYSTEM INTEGRATED AIRSPACE

Institution: Embry-Riddle Aeronautical University

Degree: Doctor of Philosophy in Aviation

Year: 2020

The interest in Unmanned Aircraft Systems (UAS) use for private, civil, and commercial purposes such as package delivery, inspection, surveillance, and passenger and cargo transport has gained considerable momentum. As UAS infiltrate the National Airspace System (NAS), there is a need to not only develop viable, safe, and secure solutions for the co-existence of manned and unmanned aircraft, but also determine public acceptance and pilots' willingness to operate an aircraft in such an integrated environment. Currently there is little or no research on pilot's perceptions on their willingness to operate an aircraft in UAS integrated airspace and airports.

The purpose of this study was to determine what effect the type of UAS integration, the type of UAS operations, and the airspace classification will have on pilot's perspectives and willingness to operate an aircraft in UAS integrated airspace and airport environment. This study surveyed the eligible pilot population in hypothetical scenarios using convenience sampling to measure their willingness to operate an aircraft in UAS integrated airspace and airports using the Willingness to Pilot an Aircraft Scale, which has been shown to be valid and reliable by Rice, Winter, Capps, Trombley, Robbins, and Milner (2020). A mixed factorial design was used to study the interaction

effects between the independent variables and the effects on the dependent variable, i.e., willingness to pilot an aircraft.

The results of the mixed analysis of variance (ANOVA) indicated a significant interaction between type of UAS integration and airspace classification. Overall willingness decreased with airspace and differences in willingness to pilot an aircraft were based on segregated and integrated operations. The average pilot's willingness to pilot an aircraft score differed from the highest score being for Class B, decreasing with decreasing airspace classes, with the lowest being for Class G.

Analysis of pilot perspectives collected through open ended questions using text-mining techniques showed agreement with mixed ANOVA analysis that the primary factor in the pilot's perception was airspace. Key concerns voiced by the pilots were situation awareness, risk and safety of operations, aircraft certification and airworthiness, and operator experience and regulatory conformance. The most positive sentiment was observed among pilots presented with the hypothetical scenario of fully autonomous UAS operations in a segregated environment. Findings from the study could aid regulators in developing better policies, procedures, integration solutions, improved training, and knowledge sharing.

DEDICATION

I dedicate this dissertation to the memory of my late mother, Vempati Suryakantam. Without her unrelenting support, none of this would have been possible. She would have been extremely proud to finally see me achieve this milestone.

ACKNOWLEDGEMENTS

The dissertation process has been one of the most challenging endeavors of my life, and there were many individuals who have supported, guided, and helped me along the way. First and foremost, I would like to recognize my faculty and dissertation adviser, Dr. Scott Winter. You took me on as a student even before we formally met and continued to keep me on schedule and on track. Your guidance and advice have been invaluable to me in this effort. I would also like to recognize other members of my committee – Drs. Valerie Gawron, Stephen Rice, and John Robbins for their time and effort. Dr. Valerie Gawron, thank you for guiding me, providing me with literary resources, and keeping tabs on me to ensure timely completion of my dissertation. Dr. Stephen Rice, thank you for allowing me to use the willingness to pilot an aircraft scale, your valuable feedback, and assistance throughout the dissertation process. Dr. John Robbins, thank you for all your feedback and assistance in improving my dissertation.

I wish to also thank Dr Haydee Cuevas for her support as faculty advisor through this journey and for always being there to listen and offer advice. Thanks also to Dr. Dothang Truong and other College of Aviation faculty members for their continued support as I meandered through the program. Special thanks to Dr. Valerie Gawron, Dr. Paul Meyers, Robert Solano, Robert Brents, Sabrina Woods, and Kabir Kasim for testing my factorial survey, and providing valuable feedback. I also wish to thank other College of Aviation students and alumni, and my fellow pilot friends who took the test survey and optionally provided feedback. Shout out also goes to Cohort 7 for all the fun times, in and out of class, for the camaraderie and support.

Last but not the least, I wish to acknowledge the support my family and friends have shown through the good, the bad, and the ugly times; for putting up with me and being there for me. I could not have done this alone!

TABLE OF CONTENTS

	Page
Signature Page	iii
Abstract	iv
Dedication	vi
List of Tables	xiv
List of Figures	xv
Chapter I Introduction.....	1
Background	2
Statement of Problem.....	9
Purpose Statement.....	10
Significance of the Study	10
Research Question and Hypotheses	11
Delimitations.....	13
Assumptions.....	13
Limitations	14
Definition of Key Terms	15
List of Acronyms	17
Summary	19
Chapter II Review of the Relevant Literature.....	21
Overview of Underlying Theory.....	21
A Framework for Willingness	23
Measuring Willingness	30

	Perceptions of UAS Operations in the NAS	33
	Gaps/Need for the Study	36
	Independent and Dependent Variables	37
	Independent Variables	38
	Dependent Variable: Willingness to Pilot an Aircraft	41
	Overview of UAS	41
	Brief history of UAS	45
	Classification of UAS	46
	Significance of Commercial UAS Operations	49
	Integration of UAS in the NAS	51
	Policy, Regulation, & Rulemaking	52
	Challenges of UAS Integration into the NAS	54
	Human Factors Implications of Integration	55
	Technology solutions	57
	Summary of Chapter 2	58
Chapter III	Methodology	60
	Introduction	60
	Research Method Selection	60
	Research Method	61
	Research Design	61
	Research Questions and Hypotheses	65
	Willingness to Pilot an Aircraft Scale	66
	Population and Sample	67

Population and Sampling Frame	68
Sample Size.....	68
Sampling Strategy	69
Participant Eligibility and Recruitment	71
Participant Protections and Ethical Considerations	72
Data Collection Process	73
Design and Procedures.....	73
Apparatus and Materials	75
Sources of Data	77
Measurement Instrument	77
Variables and Scales	79
Validity and Reliability	80
Data Analysis Approach	85
Initial Data Analysis	86
Descriptive Statistics.....	87
Assumptions of Proposed Statistical Tests	87
Participant Demographics.....	88
Reliability Assessment Method	88
Validity Assessment Method	89
Data Analysis Process/Hypothesis Testing.....	90
Pilot Perspectives Analysis	91
Summary	91

Chapter IV	Results	92
	Research Tools.....	92
	Descriptive Statistics.....	93
	Descriptive Statistics.....	93
	Reliability and Validity	97
	Initial Data Analysis and Assumptions Testing.....	98
	Outliers.....	99
	Homogeneity of Variances	100
	Mauchly's Test of Sphericity	100
	Normality	101
	Inferential Statistics	104
	Hypothesis Testing.....	111
	Pilot Perspectives	112
	Summary	119
	Summary	119
Chapter V	Discussion, Conclusions, and Recommendations	120
	Discussion	121
	Conclusions.....	130
	Theoretical contributions	131
	Theoretical Contributions	131
	Limitations of the Findings.....	132
	Recommendations.....	133
	Recommendations for the Target Population	133

References	136
Appendices.....	149
A ERAU Internal Review Board (IRB) Application Form	149
B Approval Notes from pilot groups and mailing list owners	154
C Questionnaire Recruitment Notice	157
D Consent Form and Questionnaire.....	158

LIST OF TABLES

Table	Page
1 UAV Classification from the UAS Army Roadmap for UAS 2010-2035.....	48
2 Willingness to Pilot an Aircraft Scale.....	67
3 Pilot statistics by ratings at the end of December 2018.....	68
4 Pilot Demographics.....	94
5 Pilot Demographics for Condition 1.....	95
6 Pilot Demographics for Condition 2.....	95
7 Pilot Demographics for Condition 3.....	96
8 Pilot Demographics for Condition 4.....	97
9 Summary of Internal Consistency and Reliability Analysis.....	98
10 Z Skewness and Z Kurtosis for the Four Conditions.....	103
11 Three-way Mixed ANOVA Output.....	105
12 Simple Main Effects for Two Way Interaction Between Levels of Airspace and Integration Type.....	106
13 Simple Main Effects for Levels of Integration Type with Airspace.....	106
14 Estimates of Main Effect of Airspace.....	110

LIST OF FIGURES

Figure	Page
1 Summary of steps used in data collection.....	75
2 Data Collection and Analysis Steps.....	85
3 Boxplots for the four conditions.....	100
4 Q-Q plots: Segregated and remotely piloted condition for 5 airspace classes.....	102
5 Mean differences for Class B airspace with other airspace classes for segregated operations.....	108
6 Mean differences for Class D airspace compared to other airspace classes for integrated operations.....	109
7 Main effects (with standard error bars) for the five airspace classes.....	110
8 Word frequency cloud for pilot perspectives.....	116
9 Pilot perspectives by type of emotion and sentiment.....	117
10 Pilot perspectives by condition, and Type of Sentiment.....	118

CHAPTER I

INTRODUCTION

In recent years, there has been a tremendous increase in interest in Unmanned Aircraft Systems (UAS) use for public, private, civil, and commercial purposes. Companies such as Amazon, Uber, Facebook, Google, Airbus, and others have actively engaged with federal, state, and local governments in developing solutions for package delivery, surveillance, passenger and cargo transport, and other operations. The introduction of UAS within the National Airspace System (NAS) presents innumerable challenges for air traffic, pilots in manned aircraft, and remote operators controlling the UAS. The focus of this research study was to gain an understanding from one particular perspective, namely, the pilots in the manned aircraft's views and their willingness to operate in such UAS integrated airspace and airports.

This chapter introduces the research that was conducted in this study. Detailed background information on the evolution of UAS operations, the emerging interest in commercial applications of both small UAS (sUAS) at low altitudes and medium to large UAS at higher altitudes, and the challenges for their integration within the NAS are presented. This is followed by a description of the problem statement, purpose statement, significance of the research, and research questions and hypotheses that define the study. The assumptions, limitations, and delimitations are presented. Finally, a definition of key terms and glossary of acronyms is provided.

Background

Until recently, UAS, colloquially known as drones, have primarily been used for military and border security operations, and UAS operations have mostly been segregated from traditional flight operations. A Certificate of Waiver or Authorization (COA) is currently used to allow UAS access to public operators and special airworthiness certificates in the experimental category to civil operators (FAA, 2018a). As of January 2019, there were more than 1,314,768 small UAS registrations, 121,126 remote pilot certificates issued, 2,362 Part 107 waivers with the majority of them for night operations, and 32,619 airspace waivers (FAA, 2019a). In the most recent Aerospace Forecast, the FAA estimated average weekly UAS registrations ranging between 8,000 and 9,000 for the period from January to December 2018 with an annual growth rate of 13% compared to 2017 (FAA, 2019b). There were 277,000 registered non-model aircraft by the end of 2018, with almost 14,600 registrations a month during 2018. By the end of December 2018, 50% of airspace authorizations and waivers issued were for operations in controlled airspace, with 50% of these in Class D airspace (FAA, 2019b). There is currently a known gap in lack of equivalent understanding of large UAS fleet (greater than 55 lbs) numbers and trends. In addition, NASA launched the Urban Air Mobility (UAM) Grand Challenge to understand and address challenges posed by the significant role UAS might play in transforming short haul air transportation including financial and business opportunities that exist (FAA, 2019b). As the number of UAS operations continues to increase, the ability to maintain segregated operations between manned and unmanned aircraft operations will be challenging.

UAS can be classified by weight, size, or operating characteristics such as small, medium, and large; or by type of control such as ground-control or remotely piloted, semi-autonomous, and autonomous (Gupta, Ghonge & Jawandhiya, 2013). There has been considerable focus on sUAS that are less than 55 lbs in weight and are expected to operate below 400 ft. These vehicles are expected to have a varied range of capabilities from hand launched and recovered, to vehicles that can take off like rotary wing aircraft but fly like a fixed-wing (Kopardekar, Rios, Prevot, Johnson, Jung, & Robinson, 2016). There are different classifications of UAS larger than 55 lbs in weight such as by size, range, and endurance, but no single standard. The Department of Defense (DoD), the primary user of UAS until recently, has the most comprehensive classification of UAS that is based on weight, altitude, airspeed, and mission type such as micro, mini, tactical, persistent, or penetrating (U.S. Army, n.d.).

Several solutions currently exist for sUAS operations below 400 ft, such as NASA's UAS Traffic Management (UTM) concept that enables sUAS to operate simultaneously in the NAS, DroneZone for drone registrations, Low Altitude Authorization and Notification Capability (LAANC), a map-based tool for data exchange for airspace approvals, and Facility Maps (FM), which provides maps that indicate maximum altitudes where FAA may authorize Part 107 operations; these are a few example tools that are currently in use to facilitate safe and efficient UAS operations in low altitude airspace (FAA, n.d.-a; FAA, n.d.-b; FAA, n.d.-c; FAA, 2017c; Johnson et al., 2017). There are no existing solutions to facilitate high density operations of medium to large UAS operations from airports and higher altitudes in complex airspace across the NAS.

Polarczyk, Trombino, Wei, and Mitici (2019) reviewed current technology and research in the area of on demand air mobility applications. The study outlines 44 electronic Vertical Takeoff and Landing (eVTOL) projects in various stages of design. There is ongoing research on aircraft design, batteries, fleet management, management of airspace capacity for high-density on-demand mobility solutions, ground infrastructure development, and arrival and departure sequencing (Polarczyk et al., 2019). According to a study conducted by Porsche Consulting, by 2035, the eVTOL market is expected to rise to \$230 billion with potentially 200,000 eVTOL operating, assuming about 100 vertiports per major city (Porsche Consulting, 2018).

Smith et al. (2012) conducted a study to estimate potential demand and potential impacts of autonomous on demand aircraft on the NAS. Their findings suggest that by 2035, on-demand aircraft will take more than 600 million-person trips annually, and significantly impact the NAS. The aircraft considered in this study were small, autonomous, horizontal takeoff and landing aircraft operating out of small and medium hub airports. As autonomous aircraft begin to invade the skies, gaining an understanding of impacts of such high-density operations within an already congested airspace will help identify potential issues and facilitate developing alternate solutions to enable such operations.

In the near term, on demand highly automated passenger air transport, also known as Urban Air Mobility (UAM), is gaining momentum with Airbus, Uber, Boeing, NASA, and other government and industry partners actively engaged to find solutions (Lascara, Spencer, DeGarmo, Lacher, Maroney, & Guterres, 2018). UAM represents the next generation of air taxi, similar to Uber and Lift, not on the streets, but in the air. In

October 2016, Uber released a white paper outlining their vision for a future on demand air transportation. The demand for faster travel in urban areas will necessitate a significantly higher frequency and airspace density of mixed fleet operating over metropolitan areas simultaneously. To meet this demand, the operational complexity of managing airspace will increase exponentially beyond existing operational activities. It is essential that alternative solutions must be developed to enable safe, efficient, and high-density operations in urban environments to accommodate this dramatic increase in air traffic (Uber Elevate, 2016).

The high tempo operations envisioned for UAM operations in dense urban environments as well as interest in other commercial applications of medium to large UAS that will operate to/from airports but also operate at higher altitudes without impacting existing NAS operations will necessitate fully integrated solutions. One of the key challenges to such mixed mode operations is ensuring safe integration into existing NAS operations (NASA, 2017, Uber Elevate 2016). The key airspace integration principles for on demand mobility under consideration include limiting any additional air traffic control (ATC) infrastructure and workload, limiting impact on traditional airspace users, meeting existing safety thresholds and requirements, and supporting operational scalability while allowing flexibility where possible and structure where necessary (Mueller, Kopardekar, & Goodrich, 2017). Impact on traditional airspace users can arise from multiple areas such as the nature of integration, the level of autonomy, the airspace where operations are being conducted, flight rules, environmental conditions such as weather, and time of day, to name a few.

Since 2006, Southern California Logistics Airport in Victorville, CA (VCV), has been operating in mixed-mode operations (Smith & Taylor, 2013). VCV airport lies within Class D airspace, and air traffic controllers provide airspace segregation, runway separation, two-way communication, and UAS see-and-avoid services for the UAS operator (Smith & Taylor, 2013). Operations between manned and unmanned aircraft are segregated by either holding manned aircraft on the ground until the UAS has safely exited the airspace, or the UAS is directed to a predefined holding point if manned operations are in progress (Neubauer, Fleet, Grosoli, & Verstynen, 2015). Lessons learned with the integration of UAS at VCV indicate that airports need to be able to handle mixed environment operations between high performance, high-speed aircraft and low performance, slow-speed types, weather, night, instrument meteorological conditions, communication and coordination, training, and abnormal conditions such as emergencies (Neubauer et al., 2015). Further, such segregated operations cannot be sustained with high density UAS operations that can negatively impact airport and airspace capacity, especially near major airports. Enabling fully integrated solutions can mitigate the impact on airspace and airports.

Endsley and Kaber (1999) defined five levels of automation (LOA) and its impacts on performance, situation awareness, and workload. The five levels are defined as follows: 1) manual control, 2) decision support by the operator with input in the form of recommendations provided by the system, 3) consensual artificial intelligence by the system with the consent of the operator required to carry out actions, 4) monitored and automatically implemented unless vetoed by the operator, and 5) full automation with no operator interaction. Endsley (2017) suggests that there is an automation conundrum:

reliability and robustness of automation increases with increased automation while situation awareness of human operators reduces. The complexity of human-automation interaction between UAS, manned aircraft pilots, remote operators, and ATC far exceeds the traditional five levels as defined previously, and there is a need to establish a shared situation awareness. For example, there might be a need for coordination between the pilot in the manned aircraft and an autonomous vehicle to share information such as location, speed, trajectory, and other pertinent information. There can be a significant different world view between the systems that drive the decisions that each makes, and therefore, there is a need to develop methods for not only sharing of data but also on how the information is interpreted and used by each entity (Endsley, 2017). In order to achieve this shared situation awareness, further research is necessary on how to create such understanding among human automation teams.

The expansion of UAS operations into airports across the NAS in varying complexity airspace presents additional challenges. Airspace classification varies from uncontrolled airspace (Class G) to more complex airspace such as Class E, Class D, Class C, Class B, and Class A. Separation standards, weather minima, and flight rules differ depending on the airspace. Further, frequency of operations, congestion, and fleet mix can vary based on the airspace and size of airports. In order to support the high density UAS operations, not only airspace where operations will occur but also the type of integration and level of automation will present unique challenges for safe and efficient NAS.

Recent incidents in London and Newark that resulted in shutting down airports due to drone sightings on final causing massive disruptions to air travel further highlight

the growing threat of drones. According to UK Airprox Board (UAB) there were 120 near misses between aircraft and drones between December 2017 and December 2018 (BBC News, 2019). More recently, drone sightings halted flights at Newark airport for an hour in January 2019, when the drones came within 20 ft of aircraft on final at altitudes of upwards of 3,500 ft (Levin, 2019). As U.S. regulators seek to expand drones to civilian uses, there is an urgent need to establish procedures that can help mitigate the impact on NAS operations.

There has been some research on the visual detection of sUAS. Wallace, Loffi, Vance, Dunlap, and Mitchell (2018) conducted a study to determine the effectiveness of using strobe lights on sUAS to assist in visual detection. Pilots flying a general aviation aircraft were asked to indicate when they observed the unmanned aircraft. Their findings, although inconclusive due to small sample sizes, indicated that pilots were able to detect the UAS during 7.7% of the intercepts. Further research is necessary to determine the effectiveness of strobe lights as aid in visual detection of sUAS. Likewise, in a study conducted by Woo (2017) using limits of human visual acuity, found that probability of sUAS detection was less than 50%.

Wallace, Kiernan, Robbins, Haritos, and Loffi (2019) used a passive radiofrequency detection device, AeroScope, to detect UAS activity in an urban airspace near the Tampa International Airport and characterized operator behavior. The device is limited to DJI sUAS devices, and 258 detections were collected over a sample 19-day period. The findings from the study indicate several violations of regulations such as exceeding maximum flight altitudes and flying outside the bounds of official daylight conditions. These operations presented potential conflicts and collision hazard to manned

aircraft operations at nearby heliports and airports. Further, existing geofencing systems were ineffective and not a deterrent to sUAS activity.

Ott (2015) conducted a study to determine pilot perceptions on the well clear boundary. Findings from that study identified not only differences in pilot perceptions based on their pilot type ratings but also differences in interaction with manned versus unmanned aircraft. As outlined by these studies, there are known issues with visual detection of UAS. Further pilot perceptions vary by not only their qualifications but also by the type of interaction.

Previous research (Altawy & Youssef, 2016; Clothier, Greer, Greer, & Mehta, 2015; Kamienski & Semanek, 2015; Kreps, 2014; Pestana, 2011; Ott, 2015; Winter, Rice, Tamilselvan, & Tokarski, 2016) has considered public acceptance of drones, public acceptance of drones for package delivery and commercial flight, air traffic control (ATC) perspectives, remote pilot perspectives, privacy, security, and safety concerns of UAS integration into controlled airspace. However, there is very little, or no research on pilots' perceptions and willingness to operate an aircraft in UAS integrated airspace and airports. As mixed capability UAS operations proliferate into the NAS, the type of UAS integration, the type of UAS operation, as well as the airspace and airports where they occur will play a vital role in their safe and efficient integration. Understanding pilots' views and willingness to operate an aircraft under such integrated operations will aid in the development of solutions for safe and efficient integration of UAS in the NAS.

Statement of Problem

UAS use for commercial purposes is revolutionizing the global market and will soon present important challenges in the airspace and airport environment as they evolve

to accommodate for this new entrant in their operations. Recently there has been an increase in interest by companies such as Uber and Airbus as they explore new commercial on demand highly automated air transport applications that will operate in airspace where other manned aircraft conduct operations. While work under the UTM considers the integration of sUAS operations below 400 ft, there is very little research on the combined operations of medium to large sized UAS and manned aircraft operating out of airports and busy controlled airspace. Further, there is little or no research on how the *pilots* in manned operations view operating in such a UAS integrated environment and what factors would influence their willingness to operate an aircraft. This research aimed to gain an understanding of pilots' perceptions and their willingness to operate an aircraft in a UAS integrated airport and airspace environment.

Purpose Statement

The purpose of this proposed research was to conduct a mixed factorial experimental study using hypothetical scenarios to capture attitudinal data using an electronic instrument from the pilot population to determine how the type of UAS integration, the type of UAS operations, and airspace classification influenced a pilot's willingness to operate in UAS integrated airport and airspace.

Significance of the Study

The advent of autonomous aircraft in the NAS continues to bring forth various challenges to their integration. There is ongoing research on safety and security issues for abnormal situations, policies, procedures, regulations, command, control, and communication, navigation, detect, and avoid technologies. The introduction of UAS into the NAS also poses human factors issues between and among ATC, pilot in the manned

aircraft, remote operator, and the general public. Further, there are also issues related to privacy and acceptance of such operations.

This research helped understand and identify factors that influenced pilots' willingness to operate an aircraft out of UAS integrated airports and airspace. The findings from the study are intended to benefit academicians, regulators, and technology developers, specifically, contributing to integration of unmanned aircraft systems into the national airspace from the manned aircraft pilot's perspective. The results are also expected to contribute to the body of knowledge on acceptance of drones from the perspective of pilots and aid regulators in developing better integration solutions, improved training and knowledge sharing mechanisms, policies, and procedures.

Research Question and Hypotheses

This research conducted a quantitative methodology and a mixed factorial experimental design that manipulated the type of UAS integration, the type of UAS operations, and the airspace classification to collect attitudinal data from the pilot population to determine what factors affected pilots' willingness to operate an aircraft in UAS integrated airspace and airports. The research questions and hypotheses used in the study include:

RQ₁) What type of UAS integration will affect pilot's willingness to pilot an aircraft?

H₀₁: There will be no significant difference in pilot's willingness to pilot an aircraft based on the type of UAS integration.

H_{A1}: There will be a significant difference in pilot's willingness to pilot an aircraft based on the type of UAS integration.

RQ₂) What type of UAS operations will affect pilot's willingness to pilot an aircraft?

H₀₂: There will be no significant difference in pilot's willingness to pilot an aircraft based on the type of UAS operations.

H_{A2}: There will be a significant difference in pilot's willingness to pilot an aircraft based on the type of UAS operations.

RQ₃) What airspace classification will affect pilot's willingness to pilot an aircraft?

H₀₃: There will be no significant difference in pilot's willingness to pilot an aircraft based on airspace classification.

H_{A3}: There will be a significant difference in pilot's willingness to pilot an aircraft based on airspace classification.

RQ₄) Will there be any significant interactions between the independent variables?

H₀₄: There will be no significant interaction between the type of UAS integration and type of UAS operations.

H_{A4}: There will be a significant interaction between the type of UAS integration and type of UAS operations.

H₀₅: There will be no significant interaction between the type of UAS integration and airspace classification.

H_{A5}: There will be a significant interaction between the type of UAS integration and airspace classification.

H₀₆: There will be no significant interaction between the type of UAS operations and airspace classification.

H_{A6}: There will be a significant interaction between the type of UAS operations and airspace classification.

H₀₇: There will be no significant interaction between the type of UAS integration, type of UAS operations and airspace classification.

H_{A7}: There will be a significant interaction between the type of UAS integration, type of UAS operations and airspace classification.

Delimitations

A delimitation of the study was that participants were solicited from only Curt Lewis Flight Safety newsletter, Embry-Riddle pilots, local pilot chapters, and social media outlets using a convenience sample. This delimitation, while it enabled structured recruitment of participants, restricted the generalizability of the study. Another delimitation was that only the three factors were considered, namely: Type of UAS integration, Type of UAS operations, and Airspace Classification. Further, this study was delimited to manned aircraft pilots' perspectives for operations within the NAS only and did not address system design, safety concerns, technology, or other hazards. Other delimitations within this study included the size of UAS under consideration (medium to large), operations occurred in Visual Meteorological Conditions (VMC) in visual flight rules (VFR), no assumption was made on the type of UAS applications under consideration, and the availability of technologies such as ADS-B (in/out) to facilitate detect and avoid (DAA) capability.

Assumptions

An electronic questionnaire deployed via Survey Monkey was used to collect data for this research project. Participants were polled via Curt Lewis' Flight Safety Newsletter (www.fsinfo.com), Embry-Riddle student pilots, local aviation group chapters, local area pilots, social media, and word of mouth. An assumption of taking this

approach was that pilots do tend to be highly likely to follow aviation-related journals, websites, news sources, mailing lists, and fraternal organizations. It was also assumed that pilots know other pilots, and hence will be willing to forward the electronic questionnaire that will improve the response rate. A further assumption was that willingness to perform an action could be measured using hypothetical scenarios, and that such intent will translate into actual behavior. Finally, it was assumed that participants could read, meet the minimum prescreening requirements, and would answer the questions truthfully.

Limitations

There were several limitations to this study. First, there was a limitation on the sample size, since data were collected through voluntary participation, and larger sample sizes might yield different results. The sample of participants was predominantly from Curt Lewis Safety Newsletter, Embry-Riddle pilots, and local area pilots. A further limitation of polling through such an approach was that it might not produce representativeness of pilots of all experience levels and operating environment. A similar study conducted with different demographics and experience level can yield different results. Another limitation to this research was it was limited by convenient sampling strategy to recruit participants for the study. This study also used snowball sampling which is subject to sampling bias. Sampling bias means that those selected are not representative of the larger population they have been chosen from; therefore, additional rigor concerns might arise. In this study, participants were selected for specific attributes deemed necessary for research and by controlling who initially receives the questionnaire and by maintaining control on the resulting sample through adjustment of research

questions, recruitment methods, and instrument, sufficient control was maintained on the sample. Third, authenticity of pilot responses was not guaranteed. Although all effort was taken to ensure confidentiality and anonymity, there was still a slight possibility that pilots might not answer truthfully. Lastly, this study was conducted at a single point in time, and attitudinal data were collected through hypothetical scenarios and not within a behavioral setting or laboratory environment.

Definition of Key Terms

Certificate of Waiver or Authorization (COA) Refers to special permission required by operators to operate UAS under conditions outside FAR Part 107 such as UAS heavier than 55 lbs, operate over people, operate from a moving vehicle, operate at night, operate beyond visual line of sight, single pilot operating multiple UAS or operate above 400 ft or near airports in controlled airspace (FAA, 2017b).

Federal Aviation Regulation Part 101 Applies to modelers and hobbyists. According to this rule, operators are required to notify airport or ATC if operating within 5 sm from the airport (FAA, 2017b).

Federal Aviation Regulation Part 107 Defines the sUAS flight rule under which operators register as a non-modeler, obtain a remote pilot certificate, and can operate an UAS that is less than 55 lbs within visual line of sight, during daylight hours with at least 3 sm visibility, below 400 ft, and maximum speeds of

100 mph. To operate in controlled airspace, special authorization is required from Air Traffic Control (FAA, 2017b).

General Aviation Refers to all civilian flying except scheduled passenger service. It encompasses complex and diverse flights from a trip home to overnight package delivery to airborne law enforcement to keep peace, emergency medical evacuation to save lives, inspection at remote sites to aerial application to keep crops healthy (AOPA, n.d.).

Instrument Meteorological Conditions (IMC) Refers to weather conditions when either visibility falls below 3 sm or ceiling falls below 1000 ft above ground level (FAA, n.d.).

Instrument Flight Rules (IFR) Refers to flight where ATC provides positive control for all aircraft in controlled airspace. Aircraft must meet minimum equipment requirements, and pilots must be certified and meet proficiency requirements. IFR flight can occur both in IMC and VMC, although only IFR flight is possible in IMC (FAA, n.d.).

Small Unmanned Aircraft System Refers to an aircraft that can be operated remotely and weighs less than 55 lbs including payload (FAA, 2017b).

Unmanned Aircraft System Is an aircraft without a human pilot onboard. It can have varying levels of automation and can be remotely

controlled by an operator or be fully autonomous (FAA, 2017b).

Visual Flight Rules (VFR) Refers to flight under which a pilot is solely responsible for seeing and maintaining separation from other aircraft. Aircraft operate typically by geographical or visual references. VFR flight is conducted in VMC only (FAA, n.d.).

Visual Meteorological Condition (VMC) Refers to fair or good weather (FAA, n.d.).

Vertiport Refers to the type of airport where aircraft takeoff and land vertically.

Willingness Refers to the readiness or inclination to take action. As a metric, it has been used to measure willingness to perform actions such as consumers' willingness to pay under real and hypothetical pay conditions in a hypothetical market (Ajzen, Brown, & Carvajal 2004), consumers views toward controlled rest procedures (Winter, Carryl, & Rice, 2015), or General Aviation pilots' willingness to takeoff in marginal weather conditions (Knecht, 2005).

List of Acronyms

ADS-B	Automatic Dependent Surveillance Broadcast
ANOVA	Analysis of Variance
ATC	Air Traffic Control

ATM	Air Traffic Management
BVLOS	Beyond Visual Line of Sight
CFR	Code of Federal Regulations
COA	Certification of Authorization
DoD	Department of Defense
DV	Dependent Variable
EASA	European Aviation Safety Organization
EUROCONTROL	European Organization for the Safety of Air Navigation
EVLOS	Extended Visual Line of Sight
eVTOL	Electrical Vertical Takeoff and Landing
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulations
FM	Facility Maps
FRMA	FAA Modernization and Reformation Act
HTOL	Horizontal Takeoff and Landing
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
IMC	Instrument Meteorological Conditions
IRB	Internal Review Board
IV	Independent Variable
KMO	Kaiser-Meyer-Olkin
LAANC	Low Altitude
MTOW	Mean Takeoff Weight

NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NOTAM	Notices to Airmen
PCA	Principal Components Analysis
RPAS	Remotely Piloted Aircraft System
RQ	Research Question
RTCA	Radio Technical Commission for Aeronautics
SESAR	Single European Sky ATM Research
sUAS	small Unmanned Aircraft System
UAM	Urban Air Mobility
UAS	Unmanned Aircraft System
UAV	Unmanned Aerial Vehicle
US DOT	United States Department of Transportation
USS	UAS Service Suppliers
UTM	UAS Traffic Management
VFR	Visual Flight Rules
VLOS	Visual Line of Sight
VMC	Visual Meteorological Conditions
VTOL	Vertical Takeoff and Landing
WTP	Willingness to Pay

Summary

This chapter provided an overview of the research study by addressing the background and rationale, the statement of the problem, and purpose statement. The

research questions and corresponding research hypotheses were outlined. The significance of the study, assumptions, limitations, and delimitations of the study were presented. Finally, a summary of key terms and definitions were provided.

CHAPTER II

REVIEW OF THE RELEVANT LITERATURE

This chapter provides an overview of the theoretical foundation and the relevant theory used in the current research, a brief history of UAS, existing gaps, and relevance of the current research. An overview of the underlying theories typically used in measuring willingness is presented. Traditionally, surveys have been used in the past to collect data to understand the effect of attitudes, norms, and intentions on behavior. In recent years, Factorial Survey Experiments (FSE) have often been used to draw conclusions about human behavior. A brief description of FSE and its use in the current research is presented next. This is followed by a brief history of UAS, example UAS classifications from literature, and the significance of commercial UAS operations in the NAS including issues of integration of UAS in the NAS pertaining to policy, process, and rulemaking, challenges, and human factors implications. An overview of perceptions of UAS operations in the NAS by the various stakeholders such as the public, air traffic controllers, UAS operators, and other entities; a description of independent and dependent variables used in the current research along with their relevance; gaps in existing literature; and the urgent need for the current research is presented in the next section.

Overview of Underlying Theory

To understand a pilot's willingness to operate an aircraft in UAS integrated NAS, it is essential that the technology is trustworthy, reliable, and safe. Technology adoption is a complex process that is related to factors other than technology alone, such as, user attitude and personality, social influence, trust, and numerous other conditions (Sharma &

Mishra, 2014). Most theories in behavioral science believe that behavior is best predicted by intention to engage in that behavior. To reduce the inconsistencies between what people, say and what people do, researchers have also studied other proximal measures such as Implementation Intentions, Behavioral Expectations, and Behavioral Willingness.

Gollwitzer (1999) suggests that predictive power of intentions can be increased by making it more concrete such as defining when, where, and how it will be performed, or implementation intentions. Warshaw and Davis (1985) suggest defining an estimate or subjective probability of whether the behavior will be performed or behavioral expectation. Gibbons and Gerrard (1995) suggest that behavior is not intentional, rather a reaction to social circumstances and suggest the behavior willingness construct to capture the reactive component of risky behavior. Using three studies dealing with substance use in adolescents, Pomery, Gibbons, Reis-Bergan, and Gerrard (2009) compared the predictive capability of the three constructs. Their findings indicated that among more experienced students, behavior intentions were a better predictor, but among less experienced students, behavior willingness was a better predictor. They propose the prototype willingness model (PWM) to predict occurrence of behaviors that are neither reasoned nor rational.

Since behavior is an observable event, it can also be measured through direct observation or through self-reporting. Measuring behavior through direct observation, especially over a long period of time, can be a daunting task and often unrealistic (Fishbein & Ajzen, 2011). Therefore, self-reports of behavior are often used in research, and developing good measures, while complex, can provide a common understanding of behavioral category between the researcher and the participants. Self-reports often can be

unreliable, and past studies have shown that attitudes and subjective norms do not correlate with documentary evidence, suggesting their unreliability in comparison to objective behavior measures (Armitage & Connor, 1999, 2001).

A Framework for Willingness

Willingness to Pay (WTP) as a concept first appeared more than a century ago in economic literature, and its use in marketing is more recent (Le Gall-Ely, 2009). It was designed to estimate prices for goods and services. WTP is defined as the maximum price a buyer is willing to pay for goods or services. There are three concepts that are of interest when a transaction is evaluated: proposed price, the WTP, and reference price. If WTP is greater than the proposed price, there is surplus; whereas, if the reference price is greater than the proposed price then it leads to perception. Thus, reference price enables the buyer to formulate a judgement (Le Gall-Ely, 2009).

The WTP framework has more recently been used quite extensively in the marketing environment to understand customer perceptions to estimate and forecast market response to price changes. There are varied analytical techniques that have been used to measure WTP such as revealed and stated preference methods (Breidert, Hahsler, & Reutterer, 2006). Revealed preference methods typically are used to elicit information based on actual response data, whereas stated preference methods are often used to estimate willingness based on direct or indirect surveys. Directly asking participants their willingness to perform an act has not been found to be reliable method (Breidert et al., 2006). Indirect surveys, where participants are provided a profile have been found to be more reliable. Participant's willingness preferences can be measured via a systemic

variation of key attributes in an experiment design which can then be used to make inferences (Green & Rao, 1971).

Willingness to pay (WTP) has been used to study consumer WTP for green products in air travel (Jou & Chen, 2015; Hinnen, Hille, & Witmer, 2015; Lu & Wang, 2018), improvements to airline services (Molin, Blange, Cats, & Chorus, 2017), and noise reduction in residential areas near airports (Duarte, 2008), to name a few. Passengers are often unaware of environmental impacts of aviation and air travel and the actions that can be taken to mitigate these impacts. Lu and Wang (2018) conducted a study to address this information gap by developing media tools to provide passengers basic information on aviation impacts and carbon offsetting concepts with the aim to measure willingness of fully informed passengers to participate in carbon offsetting or intentions to change their travel behavior to mitigate carbon emissions. Using a combination of printed material and video communication media, one of which was randomly assigned to each participant, the researcher conducted an online survey. The final analysis was conducted using 553 responses. The findings from the study revealed that the low engagement of passengers in carbon offsetting is due to lack of awareness and using communication media such as written or video material can enhance voluntary participation. In particular, the researchers found video media could enhance participation by more than 10%.

In another study conducted by Jou and Chen (2015), which focused on economy class passenger's WTP for airline carbon offset policy, data were collected from passengers for a flight between Hong Kong and Taiwan. Passengers were informed about carbon emissions for their trip, and a donation method was used to determine how much

they were willing to pay to offset. Findings from the study indicated that utilizing socioeconomic factors and behavioral intentions can lead to a more representative estimation of WTP. Thus, if airlines explain and promote the policy, WTP can be enhanced. This study further validated the study by Lu and Wang (2018) on the relevance of communication media.

Hinen et al. (2015) conducted a study to determine consumers' WTP for green products. Green products can range from using organic food on board the flight to carbon offsetting fuel sources. The researchers conducted an adaptive choice based conjoint analysis which mimics decision making processes that influence real world choices. An online survey was used to collect data from 811 Swiss travelers. Their findings suggest 20% of the participants interested in supplementary services showed WTP for green products and the behavior of the green segment differed from the regular segment in behavioral features.

Molin et al. (2017) conducted two stated choice experiments to understand passenger's WTP for improvements made to a range of airline services from a safety perspective. The first experiment was conducted from a safety perspective and used six attributes: airline safety index, carrier type, number of accidents with fatalities, flying over water, flying over conflict areas, and bad weather conditions. The second experiment was conducted from a flight choice perspective and considered travel costs, travel time, comfort, and safety perception. The researchers used snowball sampling and collected data from passengers who had completed a transcontinental trip within the last five years with a resulting sample size of 161 participants who had completed the entire questionnaire. Although further research is necessary, initial findings from the studies

suggest that safety plays a key role in passenger's flight choices and their WTP for higher classified airlines.

Duarte (2008) conducted a study to determine WTP for noise reduction in areas affected by airport traffic in Barcelona, Spain. The research utilized contingent value approach to glean the stated preferences for noise reduction from a representative sample from a residential neighborhood. Two approaches were used. In the first approach, participants stated their preferences directly, while in the second approach, participants hypothesized real estate value that would occur with noise reduction. In the direct approach, 493 valid surveys were collected, while in the indirect approach, respondents were tasked with stating their hypothesis for the house revalorization in the event noise reduction happens. Findings from the study indicated that WTP as measured by the protest rate was higher for the first approach and lower from the second. Further analysis indicates that the more knowledgeable the participants are, the higher the WTP and hence the higher the protest rate. Opinion and value of the good are not only influenced by individual perceptions but also improve predictive capacity.

These studies provide a small sample of research areas where WTP framework has been used successfully to estimate consumer WTP or participate in events. Each of these research studies highlights a use case where WTP has been used to not only estimate the price of a good or service, but to also assess behavior or intentions of the participants, factors that might influence willingness, and the value that participants place on the activity either in seeking green solutions, noise reduction, or airline safety. The studies also highlight the importance of knowledge and information sharing that improves WTP or participate.

Willingness has also been used to measure consumers' WTP under real and hypothetical pay conditions in a hypothetical market for renewable energy sources (Ivanova, 2013; Kainz, 2016), and WTP for airline services (Pereira, Almeida, de Menezes, & Vieira, 2009). Ivanova (2013) conducted an extended analysis of consumer WTP for electricity using renewable energy sources using a stated preference choice experiment. To understand the attitudinal preferences of consumers, the researcher used latent class modeling to identify heterogeneity of consumer preferences. Findings from the study indicated 83% of the participants indicated a WTP for renewable energy sources.

Kainz (2016) conducted a study to determine consumer's perceptions on biopolymers. A preliminary questionnaire was used to collect information from consumers to gain an understanding of consumer knowledge on the topic, to determine what information was of interest to consumers, and what their attitudes were on biopolymers and renewable energy sources. Derived from the information collected in this pre-study, an experimental auction was designed with six treatments, each of which was randomly assigned to 40 participants. Key findings from the study include low awareness of participants on bioplastics, which highlights the ambivalence of participants on biopolymers. Participants were also found to bid higher after receiving general information on biomass products.

Pereira et al. (2009) conducted a stated choice experiment to gain an understanding of airline passenger preferences in the selection of airline. Using two virtual airlines serving the same route frequented by tourists between two cities, they consider attributes such as cost, punctuality, daily frequency, and airline penalties for

changing tickets. Their findings suggest that there are systemic variations between passengers traveling for business versus those traveling for pleasure. Improvements in service levels, such as punctuality, hinges on the reasons why passengers undertake the trip, and airlines can gain from non-marginal changes in service levels. Such methods can provide the tools to devise effective service differentiation strategies (Pereira et al., 2009).

Consumer willingness has also been studied in other studies such as consumers' willingness to ride in a driverless ambulance or bus (Winter, Keebler, Rice, Mehta, & Baugh, 2018a; Winter et al., 2018b), parents willingness to let their children ride in driverless vehicles and school buses (Anania, Mehta, Marte, Rice, & Winter, 2018a; Anania, Rice, Winter, Milner, Walters, & Pierce, 2018b; Anania, Rice, Walters, Pierce, Winter, & Milner, 2018c), consumers' willingness to fly in autonomous commercial airplanes (Rice, Winter, Mehta, & Ragbir, 2019; Vance & Malik, 2015), air travelers mode choice behavior for flying in remotely piloted aircraft (Lee, Kim, & Sim, 2019), consumers' willingness to fly based on gender of the crew composition and configuration using automation (Mehta, Rice, Winter, & Eudy, 2017), pilots' willingness to fly under different circumstances such as weather (Beringer & Ball, 2003; Knecht, 2005; Knecht, Harris, & Shappell, 2005), and psychological health (Herkimer, 2017).

Lee, Kim, and Sim (2019) conducted a stated preference survey to gain an understanding of air traveler's considerations in mode choice of travel. Their findings concur with other research studies that safety is the key factor that people consider in their selection. Further, they found that cost reduction especially for frequent travelers

and older female travelers could improve their willingness to fly, although there is still concerns about remotely piloted aircraft (RPA).

In recent years there has been much research and interest on autonomous vehicles and there has been ongoing research on consumer perceptions and acceptance. Anania et al. (2018a, 2018b, 2018c) conducted a study on the factors that influence parent's willingness to let their children ride in driverless buses, and on the reasons and the effect of information (both positive and negative) that might influence them. Their findings indicate that gender has a definite influence, and that females are less willing. Nationality also has a strong influence: Americans are less likely than Indians. Further, positive information has a greater influence on willingness than negative information.

There has also been some research on consumer perceptions and willingness to fly in autonomous aircraft. Rice et al. (2019) conducted a study to identify early adopters of autonomous aircraft. Using hypothetical scenarios 1,042 potential passengers were tasked to rate their willingness to fly in autonomous aircraft. Faces using six universal emotions were randomly presented to participants to rate the strength of their emotions. The researchers identified seven significant predictors of willingness to fly, namely, familiarity, fun factor, wariness, fear, happiness, age, and education.

Vance and Malik (2015) conducted a study to investigate the main decisions that influence passenger's decisions to fly in fully autonomous airlines from the perspective of aviation and technology perspective. The researchers considered eight factors in trust, safety, and cost, such as automation levels, safety records, liability guarantees, airline integrity, and service disruptions. A two-level fractional factorial survey instrument was used to sample passengers' views. A comparison between current results and prior results

from 2003 suggests a significant difference between the sampled population willingness to fly. The researchers suggest that an additional ten years of technology infusion into society likely improved the comfort level of autonomous airlines, although global events might change public opinions in the short term. The researchers also note that three factors had strong positive influence on the willingness to fly, namely, service provider characteristics, automation sophistication, and system response to interruptions. The one factor that had a negative influence was contracts and guarantees provided by the airline.

Each of these studies has considered different attributes such as race, gender, nationality, culture, safety, cost, and other factors that could influence consumers' willingness to perform a given behavior. While these studies address willingness from the consumer perspective of riding in autonomous vehicles, this study proposes to address willingness from the perspective of the pilot in the manned aircraft and his or her willingness to operate in UAS integrated airspace and airports. In the context of the current study, willingness will be measured using the Willingness to Pilot an Aircraft Scale adapted from Rice et al. (2020). The proposed study intends to measure willingness to pilot an aircraft using hypothetical scenarios using three key factors namely: Type of UAS Integration, Type of UAS Operation, and Airspace Classification.

Measuring Willingness

Traditionally, survey-based methods have been used in social science to understand attitudes, social norms, behavior intentions, and behavior. Experiments in survey research have gained attention over the last few decades because the experiment's internal validity is augmented by the survey's external validity. Vignette experiments embedded in surveys, also known as factorial surveys, are becoming more popular.

Factorial surveys (FS) were introduced to sociology by Rossi more than five decades ago (Rossi & Anderson, 1982). A vignette experiment consists of a collection of vignettes, i.e., “a collection of systematically varied descriptions of subjects, objects, or situations in order to elicit respondents’ beliefs, attitudes, or intended behaviors with respect to the presented vignettes” (Steinmer, Atmuller, & Su, 2016, p. 52).

In a factorial survey experiment, only a few dimensions and a few levels within each dimension can be used in an experiment (Rossi & Anderson, 1982). This by no means limits FS, in fact, “from the experiment tradition, the factorial survey borrows and adapts the concept of factorial orthogonality and from the survey tradition it borrows greater richness of detail and complexity that characterizes real-life circumstances” (Rossi & Anderson, 1982, p. 16). Human judgment, albeit structured, is believed to be driven by a small subset of characteristics, i.e., people use fewer characteristics when making decisions. For example, when buying a car, people chose fewer characteristics such as cost and color, although there might be an infinite number of choices. In FSE, participants are presented with hypothetical scenarios or vignettes that constitute situations. A vignette represents different combinations of levels of the different dimensions that are of relevance as determinants of the judgement of interest.

FSE have been used in several studies to understand beliefs and norms in several industries such as health, sociology, crime, and so on. Wallander (2009) conducted a review of 106 research papers attributed to factorial surveys from the last 25 years used to study a variety of forms of judgements, including normative judgements, positive beliefs, and individuals’ estimations of their own actions, thoughts, and feelings as well as intentions to act. For example, Petzold and Moog (2018) conducted a factorial survey

experiment employing hypothetical study abroad situations to study student's intentions to study abroad. The researchers utilized an experimental design to examine intentions to study abroad, using random assignment of subjects to comparison groups, and by the variation of independent variables, the impact of the independent variables on the dependent variable could be identified. By utilizing a factorial survey experiment and Theory of Planned Behavior (TPB) as theoretical foundation, the researchers gained a deeper insight into students' intentions to study abroad.

Drasch (2017) conducted a factorial survey experiment to gain an understanding of the relationship between behavior intention and actual behavior using TPB as the underlying theoretical basis. Data were collected using a factorial survey from prospective female labor market re-entrants, to determine their willingness to accept lower wages if compensated by positive nonmonetary job characteristics. A follow-on study, a year later, was conducted to determine actual behavior. Findings from the study indicated a high correlation between results from the survey and actual behavior; and that personality traits have only a minor influence on behavior intentions and actual behavior.

FSE has also been used to study willingness to fly. Herkimer (2017) conducted a vignette experiment to gain an understanding of the impact stigmatizing attitudes and psychological treatment have on flight deck crew's willingness to fly. The study used a combination of mental illness stigma, social distance, and willingness to fly scales to study the effect of attitudes. The study used a sample size of 184 participants, and one of the key findings of the study was that psychological treatment does have a significant effect on willingness to fly.

Perceptions of UAS Operations in the NAS

There has been considerable research on public perspectives of drone use for defense applications, privacy concerns overpopulated areas, package delivery, and surveillance missions. Winter et al. (2016) conducted a study to gain an understanding of public perspectives on privacy for UAS use in police missions. The researchers conducted studies to manipulate the length of UAS mission to determine how public perceptions on privacy vary. The results from the study validated the researcher's prediction that public perception of privacy would differ based on the duration of the UAS mission. Their findings indicated that the public was more amenable to single limited duration UAS missions as opposed to continuous 24-hour UAS operations, and the effect of the relationship between the two types highlighted the level of privacy concerns the public might have (Winter et al., 2016).

Using a combination of discussions with facilities, subject matter experts, human in the loop simulations, and analysis of operations, Kamienski and Semanek (2013) conducted a study to gain an understanding of ATC perspectives on UAS integration. Their primary goal was to gain an understanding of how large UAS fit in the NAS and what their impact was on ATC. Their findings identify five major areas on ATC impacts: UAS flight planning and automation, UAS control link, UAS procedures, ATC training, and UAS interaction (Kamienski & Semanek, 2013).

Richards and Edgell (2018) conducted an online survey to gain an understanding of the attitudes of ATC, pilots of manned aircraft, and UAV pilots toward UAV integration in the NAS. A survey of 131 pilots showed that pilots of manned aircraft had a more negative attitude toward integration compared to ATC and UAV pilots. In relation

to integration of UAV into the different classes of airspace, the greatest distinction was noted among pilots of manned aircraft. Except for Class A airspace, pilots of manned aircraft slightly or moderate to extremely high level of concern for operations in other classes of airspace. Manned pilots also felt strongly that unmanned aircraft should give way under VFR.

Likewise, in an analogous study conducted by Comstock, McAdaragh, Ghatas, Burdette, and Trujillo (2014) of a survey of ATC, pilots of manned aircraft, and UAS pilots to collect perspectives to establish future requirements for UAS in the NAS, a majority of the pilots of manned aircraft thought it was desirable or essential for sUAS flying below 400 ft to display their position for aircraft flying between 1,000 ft to 3,000 ft. With respect to airspace classifications, their findings indicated both ATC and pilots of manned aircraft responses were less positive with decreasing airspace classification especially Class E and Class G. Considering the size of the UAS, pilots of manned aircraft and even ATC agreed there was no need for a new airspace definition for sUAS transmitting position information and communicating with ATC or medium to large UAS. All pilots of manned aircraft and ATC agreed that in the absence of ATC communication or no positional information for sUAS there was a need for new airspace definition.

Since 2006, NASA has been flying Ikhana, a MQ-9 Reaper, with flight clearance from the FAA under special provision, to support technology development of UAS integration in the NAS. Pestana describes his experience of flying the UAS remotely using only one sense namely, vision, as opposed to the five senses that a typical pilot in a manned aircraft uses (2011). The single biggest challenge to integrated operations is the

FAA requirement to see and avoid other traffic. Even on a clear day, often it is impossible to see traffic in close proximity, and this is true for remote pilots operating only with visual tools (Pestana, 2011).

Visual detection of sUAS is especially challenging for pilots in manned aircraft. There are several studies that have been conducted to determine the effectiveness of using strobe lights on sUAS to assist in visual detection (Wallace et al., 2018), understanding limits of human visual acuity (Woo, 2017), and gaining an understanding of well clear definition for pilots in manned aircraft (Ott, 2015), to name a few. Ott (2015) experimented to study the perceptions commercial and general aviation pilots have toward the concept of the well clear boundary. *Well clear* is the terminology that is used between ATC and pilots when traffic alerts of potential conflicts between aircraft are issued and pilots maintain visual contact and report to ATC when they are *clear* from the conflicting aircraft (Ott, 2015). The study identified not only differences in pilot perceptions based on their pilot type ratings but also differences in interaction with manned versus unmanned aircraft (Ott, 2015). While Ott's study focused on the well clear boundary and whether that boundary changed between manned aircraft and unmanned aircraft operations, this proposed research focused on pilots' perceptions and willingness to operate an aircraft in an UAS integrated airspace and airport environment based on UAS integration, UAS operations type, and airspace classification.

Some research has focused on other perceptions such as, drone controllers' privacy perceptions and practices (Yao, Xia, Huang, & Wang, 2017) and drone use for combat, public, and law enforcement purposes in the U.S. (Eyerman et al., 2013; Kreps, 2014). There has also been other research on drone use for package delivery (OIG USPS,

2016), remotely piloted commercial flight, and societal impact of commercial drones (Mehta, Rice, Winter, & Oyman, 2014; Rao, Gopi, & Maione, 2016), and risk perception (Clothier et al., 2015).

Clothier et al. (2015) conducted two surveys to gain an understanding on how the public perceives drones: whether they consider drones riskier than manned aircraft operations and what concerns the public might have that will influence their acceptance of drones. Their findings indicate that the public did not differentiate risk between manned and unmanned aircraft; although, the results of the study did indicate that there is a large gap in public perception. Often risk plays a vital role in a pilot's willingness to operate an aircraft under specific conditions, hence understanding those conditions will help understand a *pilot's willingness to operate an aircraft* in an UAS integrated airport environment.

Gaps/Need for the Study

Interest in UAS use for recreational, civil, and commercial purposes is growing at a fast pace, and forecasts predict accelerated growth over the next few years. There are several issues and challenges that must be addressed to ensure safe integration of UAS in the NAS such as safety, security, privacy, and technology. There is a need to determine the acceptance of UAS use, not only by the public, but also the pilot population about UAS integrated operations.

There is some research on public acceptance of drones for package delivery and commercial flight, air traffic control (ATC) perspectives, remote pilot perspectives, privacy, security, and safety concerns of UAS integration into controlled airspace (Altawy & Youssef, 2016; Clothier et al., 2015; Kamienski & Semanek, 2015; Kreps,

2014; Pestana, 2011; Winter et al., 2016). There is also ongoing research on well clear boundary between manned and unmanned aircraft and how pilots perceive this boundary during UAS encounters (Ott, 2015). However, review of existing literature confirms there is very little or no research on pilots' perceptions and willingness to operate an aircraft in UAS integrated airspace, and particularly at UAS integrated airports. Determining pilot perspectives and willingness will provide valuable insights to regulators in developing better policies, procedures, integration solutions, technological capabilities, training, and knowledge sharing.

The proposed study used three dimensions, namely, type of UAS integration with two levels, type of UAS operations with two levels, and airspace classification with five levels, to understand pilots in manned aircraft beliefs, attitudes, or judgements for operating in UAS integrated airspace and airports.

Independent and Dependent Variables

The proposed study had three independent and one dependent variable. A brief description of the independent variables, followed by the dependent variable from the perspective of the extant literature, and how willingness was measured are discussed next. As previously noted, level of specificity will define how well willingness can be measured, so it is essential that the specific conditions under which pilots will operate in an integrated environment must be clearly defined so their willingness can be measured.

The current study hypothesized that neither independent variables will significantly impact willingness to pilot a manned aircraft in UAS integrated airspace and airports. During the last century of flight, varied and complex aircraft types have been integrated into the NAS. The integration of UAS presents heretofore unknown challenges

to the human-autonomy teams that will require new and innovative solutions. Pilot in manned aircraft represent one team member in this symbiotic relationship. It is anticipated that findings from this research will help inform if the chosen dimensions will have an influence in pilot judgements and hence their willingness to pilot an aircraft in this integrated airspace.

Independent Variables

The three independent variables used in the study were type of UAS integration, type of UAS operations, and airspace classification. A brief description of the three variables are provided in the next section.

Type of UAS Integration

Integration of UAS in the NAS can be achieved using various levels of integration, from fully segregated, varying levels of integration and fully integrated operations. Currently, UAS operations are conducted using Notices to Airmen (NOTAM) and segregated from all other air traffic for safety reasons (Dalamagkidis, Valavanis, & Piegil, 2008). Flight-testing is currently underway to support future integrated operations. For this research, segregated and fully integrated categories are considered.

In a segregated environment, it might be necessary for ATC to provide the necessary separation and hence ensure safety of operations. Considering the volume of UAS operations that are anticipated for either package delivery or surveillance, to name a few, at low altitudes, or passenger or cargo transport at higher altitudes, providing segregated services might not only be extremely challenging but infeasible. Providing the most precise specifications under which pilots will be expected to operate will provide the most specific condition where their willingness can be measured and hence type of

UAS integration is an extremely valid variable essential to understand the willingness of pilots operating in an UAS integrated environment.

Type of UAS Operations:

UAS operations can span from remotely piloted to fully autonomous operations. There are various ways to define levels of autonomy such as (Endsley & Kaber, 1999; Sheridan & Parasuraman, 2006):

1. Manual control with no assistance from the system,
2. Decision support with input in the form of recommendations,
3. Consensual artificial intelligence (AI) with the consent to carry out actions,
4. Monitored AI and automatically implemented unless vetoed by the operator, and
5. Full automation with no interaction.

According to these categories, most autopilot systems in manned aircraft or remotely piloted UAS are classified into category 4: monitored with veto capability. Based on the level of autonomy, initially UAS can be expected to operate in these three categories:

- Remotely piloted,
- Remotely operated and monitored by an operator, and
- Fully autonomous.

As commercial applications for UAS become more prevalent, it might become necessary for pilots to co-exist with UAS integrated operations that span this domain.

Assessing their willingness to pilot in this environment under these specific conditions is necessary to achieve safe and efficient integration of UAS in the NAS.

Airspace Classification

There are two broad categories of airspace: controlled and uncontrolled.

Controlled airspace is further classified into different categories, Class A, Class B, Class C, Class D, and Class E. Each of these classes of airspace have different boundaries defined by the airports or airspace they span. All airspace above FL180 and up to FL600 is categorized as Class A airspace, and all operations in this airspace are conducted under instrument flight rules (IFR). Class B typically goes from surface to 10,000 feet MSL and surrounds some of the busiest airports in the NAS, while Class C typically goes from surface to 4000 feet AGL and surrounds airports with a control tower, terminal radar control, and moderate passenger enplanements.

Class D airspace goes from surface to 2,500 ft AGL surrounding smaller airports with a control tower, while all other controlled airspace is classified as Class E. The boundaries of Class E can vary by location going from surface to below 700 ft AGL or 1200 ft AGL around airports with instrument procedures, above class B, C, or D airspace and up to FL180. All airspace above FL600 is also designated as Class E. All airspace that is not designated as B, C, D, or E is uncontrolled airspace that is designated as Class G.

The type of aircraft and airspace classification defines the applicable operating rules such as speed to enable pilots to self-separate from other traffic, clouds and terrain clearance, and environmental limits. It is anticipated that airspace classification will also define the type of UAS operations as well as the type of UAS integration. For the purpose

of this research, all classes of airspace except Class A and upper Class E were considered.

Dependent Variable: Willingness to Pilot an Aircraft

The single dependent variable in this study was willingness to pilot an aircraft. Willingness refers to the readiness or inclination to take action. It has been used to measure consumers' willingness to pay under real and hypothetical pay conditions in a hypothetical market (Ajzen, Brown, & Carvajal 2004), consumers views toward controlled rest procedures (Winter et al., 2015), pilots' willingness to fly an aircraft under different circumstances such as weather (Beringer & Ball, 2003; Knecht, 2005; Knecht, Harris, & Shappell, 2005), and psychological health (Herkimer, 2017) to name a few. In this study, willingness to pilot an aircraft was the dependent variable of interest. Understanding pilots' willingness to pilot an aircraft in an UAS integrated NAS will provide valuable information to facilitate fully integrated mixed mode operations.

Overview of UAS

The term unmanned aerial vehicle (UAV) came into use in the 1990s to describe robotic vehicles, to distinguish them from other ballistic missiles, balloons, blimps, and projectiles. The UAV has since been referred to as UAS, Remote Piloted Vehicles (RPV) by United States Air Force, Remotely Piloted Aircraft System (RPAS) in the United Kingdom, or simply as drones (Dalamagdakakis, 2015a; Newcome, 2004). UAS have primarily been used for military and border security operations, and operations have mostly been segregated from traditional flight operations. A Certificate of Waiver or Authorization (COA) is currently used to allow UAS access to public operators and

special airworthiness certificates in the experimental category to civil operators (FAA, 2013).

Congress passed the Federal Aviation administration (FAA) Modernization and Reformation Act (FRMA) of 2012 that is now a public law (Argrow & Frew, 2017). The passing of this act has greatly influenced UAS operations in the NAS. Two other key outcomes of this act include FRMA Section 333 which empowers the FAA administrator to establish processes and policies to authorize civil UAS operations in the NAS, and a second outcome was the creation of six test sites and the FAA UAS Center for Excellence (Argrow & Frew, 2017; Neubauer et al., 2015). The FAA has also created the Focus Area Pathfinder program with industry partners to investigate: a) Visual line of sight (VLOS) operations in rural areas; b) Extended visual line of sight (EVLOS) operations in rural areas; and c) Beyond visual line of sight (BVLOS) operations in rural areas (Argrow & Frew, 2017).

From a planning perspective, the FAA released a five-year roadmap for the integration of civil UAS in the NAS in 2013 and established six test sites to research integration issues (FAA, 2013). In August 2016, the FAA also published the sUAS rule, 14 Code of Federal Regulations (CFR) Part 107, that defines the UAS, remote pilot, and operating limitations of a sUAS, less than 55 lbs in weight (FAA, 2016). In October 2017, the White House released a memorandum initiating the launch of a UAS Pilot Integration Program that will facilitate state, local, and tribal governments to collaborate with the UAS users and manufacturers to accelerate the safe integration of UAS (White House, 2017). This is further expected to accelerate the use of UAS for governmental and commercial applications. The FAA has recently released the second edition of the five-

year roadmap for the integration of civil UAS, in the NAS, updated since its initial release in 2013 (FAA, 2018a). The revised roadmap outlines the government-industry partnerships as well as the strategies in the near term necessary to harmonize UAS integration efforts in the NAS. In 2017, the FAA launched the UAS Integration Pilot Program (IPP) to bring together all stakeholders to facilitate integration efforts and identified ten lead participants (FAA, n.d.-d; FAA, n.d.-e).

There are integration challenges that must be addressed before their use for commercial purposes can be implemented (U.S. DOT, 2014). Lascara, Lacher, DeGarmo, Maroney, Niles, and Vempati (2019) address the challenges to incorporating UAS and in particular UAM into today's operational constructs such as existing flight rules and meteorological conditions that are geared toward having a human in the cockpit and at the controls. Existing communication, navigation, and surveillance methods including safety of operations are all designed with a manned pilot in mind. There is ongoing research in this area, and Lascara et al. (2019) propose a few ideas to enable UAM integration. Although, before high density UAS operations can become a reality, all these challenges will need to be first addressed.

There are also safety and security issues for abnormal situations, policies, procedures, regulations, command, control, and communication, navigation, and detect and avoid situations that are still being researched. As an example of the fluidity of UAS integration challenges, in May 2017, the U.S. Court of Appeals for the District of Columbia invalidated the registration requirement of UAS pertaining to the hobby or recreational use (FAA, 2017a). The National Defense Authorization Act of 2018 was passed on December 12, 2017, and drone registration was once again reinstated (FAA,

2017b). Further, the FAA Reauthorization Act of 2018, passed in October 2018, further established new conditions for the recreational use and immediately repealed the Special Rule for Model Aircraft, and the regulation and policies continue to evolve as the FAA implements the new legislation (FAA, 2018b). The UAS Traffic Management (UTM) Research Transition Team (RTT) was established in 2015, and the two key areas of this team are low altitude UAS traffic management, and UAS in the NAS, which focuses on UAS operating in higher altitudes and controlled airspace (FAA, 2017c).

The importance and advantages of UAS use, both in military and civilian applications is unquestionable; especially their use in search and rescue, surveillance and monitoring, reconnaissance, meteorology, maritime operations, warfare, disaster and crisis management, aerial mapping, communications relay, inspection, law enforcement, policing, traffic spotting, pipeline survey, and firefighting, to name a few (Gupta et al., 2013). The evolution and revolution of new technologies, and the advancement in automation has transformed the drone not only into a domesticated item that is used recreationally by millions of people, but the list of commercial uses continues to grow. Companies such as Amazon, Google, and Facebook have expressed a strong interest in the use of UAS for commercial applications such as package delivery, aerial mapping, and internet service to remote areas (Szondy, 2013).

Until recently, UAS operations were exclusively limited to military use, but over the last decade, interest in the use of UAS in civil and public applications has been growing. Despite interest in commercial applications of UAS, progress has been limited due to lack of appropriate regulation and technologies to support the safe integration of

UAS into the NAS (Dalamagkidis, Valavanis, & Piegl, 2008). Subsequent sections provide a brief history of UAS, classifications, uses, and significance of commercial uses.

Brief history of UAS

Although early use of unmanned aircraft dates back to ancient times, the modern origin of UAS began almost 95 years ago with the development of aerial torpedoes (Keane & Carr, 2013). During the World Wars, they were used extensively for reconnaissance. The first unmanned aerial vehicle flew merely a decade after the first successful Wright Brothers flight (Dalamagkidis, 2015b; Qaisrani, Ali, Mirza, & Naqvi, 2016). In 1917, Elmer Sperry and Peter Hewitt constructed a radio-controlled automatic airplane called the “Hewitt-Sperry Automatic Airplane” that could fly 50 miles and carry a 300 lb bomb. The success of the “flying bomb” led to the rail launched Kettering Aerial Torpedo “Bug” (Shaw, n.d.).

During World War 1, the U.S. Army and Navy experimented with aerial torpedoes and bombs. Experimentation on missions, sensors, and munitions continued through the Korean War (Keane & Carr, 2013). World War II ushered in a new era of drone development with the OQ-2 which first flew in 1939 and became the first mass produced drone. The “Pilotless Aircraft Branch” of the U.S. Air Force was established in 1946, and three types of drones were developed with air launched Q-2, the most important one that became the “father” of target drones (Shaw, n.d.). Following the success of pilotless and remotely piloted technologies, the U.S. Air Force began experiments in the 1950s for high altitude reconnaissance (Dalamagkidis, 2015b; Keane & Carr, 2013).

The end of World War II saw an increase in the interest on reconnaissance missions and the birth of the first reconnaissance drone the SD-1, which was also known as MQM-57, and by the end of its career, almost 1,500 were built (Dalamagkidis, 2015b). The period between the 50s and the cold war saw different variations of unmanned reconnaissance drones being developed and used by not only the United States but also other parts of the world such as the Soviet Union, Germany, Israel, the United Kingdom, and Canada. Today, larger UAS with greater endurance such as Global Hawk RQ-4, Reaper, MQ-9, and Neptune capable of multiple roles such as reconnaissance and hunter killer are in use (Dalamagkidis, 2015b).

There is also a growing interest in UAS use for scientific, academic, and commercial purposes. Modern examples include the long endurance UAS such as Helios, Altair, and Ikhana used by NASA for Earth science missions and quad-rotor design CyberQuad and AirRobot UAS used in academic environments (Dalamagkidis, 2015b). As interest in commercial uses grows, there are several commercial class drones such as the DGI series, Uber electrical vertical take-off and landing (eVTOL) for passenger transport, Amazon quadcopter for small package delivery, long endurance Vanilla Aircraft for civilian and government agencies, and solar powered Facebook Aquila, to name a few.

Classification of UAS

The increasing use of UAS in disparate missions has resulted in efforts not only to increase endurance but also payload capability. UAS can be classified based on their weight, size, and aerodynamic characteristics (Gupta et al., 2013):

- Fixed-wing, rotary wing, blimps or flapping-wing UAS based on their aerodynamic characteristics;
- Remotely piloted, semi-autonomous, and autonomous based on the type of UAS operations; and
- Micro (less than 2kg), mini (2-20 kg), small (20-150kg), tactical (150-600kg), and medium and high altitude, long endurance UAS that can weigh greater than 600 kg.

There has been considerable focus on sUAS that are less than 55 lbs in weight and are expected to operate below 400 ft. These vehicles are expected to have a varied range of capabilities from hand launched and recovered to vehicles that can take off like rotary wing aircraft but fly like a fixed-wing (Kopardekar et al., 2016).

Dalamagkidis (2015c) presents a comprehensive classification of UAS, drawing from existing literature based on mean take-off weight (MTOW), size, operating conditions, capabilities, or any combination of these and other characteristics. He presents classification by MTOW and ground impact risk, operational altitude, and midair collision risk, based on autonomy, military classifications, and based on ownership.

According to Hayhurst, Maddalon, Morris, Neogi, & Verstynen (2014), the key terms that are relevant to classifying an UAS are airworthiness, class, and category, which are described as follows:

- Airworthiness represents the aircraft to enable safe flight from take-off to landing.
- Class represents the grouping of flights to include airplane, rotorcraft, glider, balloon, land, and seaplane.

- Category represents the intended use: normal, utility, acrobatic, limited, restricted, and provisional.

Hassanalian and Abdelkefi (2017) propose a new classification of drones using operational purpose of the drone, complexity and cost of the control system, and the materials used in the drone fabrication as the basis. In addition to weight, size, and mission properties, their classification outlines the following types of drones: horizontal take off landing (HTOL), vertical take-off landing (VTOL), hybrid model, i.e., tilt-wing, tilt-rotor, tilt-body, and ducted fan, helicopter, heliwing, and unconventional types (Hassanalian & Abdelkefi, 2017).

As can be seen by the few examples presented so far, there are several different views on classifications and no single standard. The Department of Defense (DoD), the primary user of UAS until recently, has the most comprehensive classification of UAS that is based on weight, altitude, airspeed and mission type such as micro, mini, tactical, persistent, or penetrating (U.S. Army, n.d.). The classification of UAS by size and weight is shown in Table 1.

Table 1

UAV Classification from the UAS Army Roadmap for UAS 2010-2035

Category	Size	Maximum Gross Takeoff Weight (MGTW) (lbs)	Normal Operating Altitude (ft)	Airspeed (knots)
<i>Group 1</i>	Small	0-20	<1,200 AGL	<100
<i>Group 2</i>	Medium	21-55	<3, 500	<250
<i>Group 3</i>	Large	<1,320	<18,000 MSL	<250
<i>Group 4</i>	Large	>1,320	<18,000 MSL	Any airspeed
<i>Group 5</i>	Largest	>1,320	>18,000	Any airspeed

Table adapted from the UAS Army Roadmap for UAS 2010-2035. Retrieved from <http://www.rucker.army.mil/usaace/uas/US%20Army%20UAS%20RoadMap%202010%202035.pdf>

Based on the different FAA Orders, advisory circulars, public law, and regulation, the primary elements are weight, airspeed, altitude, user, and operations. Likewise, NASA's primary elements for classification of UAS are also based on weight, airspeed, and type of operation. In addition, there are other classifications by standards groups such as Radio Technical Commission for Aeronautics (RTCA), International Civil Aviation Organization (ICAO), European Aviation Safety Organization (EASA), European Organization for the Safety of Air Navigation (EUROCONTROL), Single European Sky ATM Research (SESAR), and others.

Significance of Commercial UAS Operations

The advantages of UAS use, both in military and civilian applications, especially their use in search and rescue, surveillance and monitoring, reconnaissance, meteorology, maritime operations, warfare, disaster and crisis management, aerial mapping, communications relay, inspection, law enforcement, policing, traffic spotting, pipeline survey, and firefighting, is unquestionable (Gupta et al., 2013; Szondy, 2013).

New technologies and advancement in automation have transformed the drone into a domesticated item that is used recreationally by millions of people, and the plethora of commercial uses continues to grow with companies such as Amazon, DHL, Google, and Facebook expressing a strong interest in the use of UAS for commercial applications such as package delivery, aerial mapping, and internet service to remote areas (Maharana, 2017).

In recent years there has also been a widespread interest in UAS use by individuals, commercial organization, entities, and governments. Amazon obtained an experimental airworthiness certificate from the FAA in March 2015 (FAA, 2015).

According to the provisions of the certificate, Amazon is allowed to fly up to 400 ft in altitude and up to 100 miles an hour in visual meteorological conditions (VMC) while always remaining within visual line-of-sight (VLOS) of the pilot and observer.

More recently, there has been considerable interest in Urban Air Mobility (UAM). UAM represents the next generation of air taxi, like Uber and Lift, not on the streets, but in the air. It is expected to be a safe and efficient air passenger and cargo transportation system, which is gaining momentum to become the next disrupter. One of the key challenges to UAM operations is ensuring safe integration of operations into existing NAS operations (NASA, 2017, Uber Elevate 2016).

In a study conducted by the Center for the Study of the Drone at Bard College, it was determined that at least 910 state and local police, fire, and emergency services have acquired drones (Gettinger, 2018). The study findings indicate that 2017 saw a spike of almost 82% increase in drones used by these agencies. The most commonly used drones include DJI (Phantom, Inspire, Matrice, and Mavic) and Yuneec (Typhoon), and about 40% of these are owned and operated by agencies in California, Florida, and Texas (Gettinger, 2018).

As noted previously, UAS for commercial and public use is growing at an alarming pace. With almost 13,000 waivers and 10,000 registered commercial operators, the FAA forecast projects commercial UAS operations over the next five years could reach almost half million operations (FAA, 2018b). As the UAS operations proliferate into the NAS, the type of operations, type of integration, and the airspace where they occur will play a vital role in their safe and efficient integration, and ultimately pilots' willingness to pilot an aircraft under such integrated operations.

Integration of UAS in the NAS

Congress passed the FAA Modernization and Reformation Act (FRMA) of 2012 that is now a public law (Argrow & Frew, 2017; Congress, 2012). The passing of this act has greatly influenced UAS operations in the NAS. Two other key outcomes of this act include FRMA Section 333 which empowers the FAA administrator to establish processes and policies to authorize civil UAS operations in the NAS, and a second outcome was the creation of six test sites and the FAA UAS Center for Excellence (Argrow & Frew, 2017; Neubauer et al., 2015). The FAA has created the Focus Area Pathfinder program with industry partners to investigate: a) Visual line of sight (VLOS) operations in rural areas; b) Extended visual line of sight (EVLOS) operations in rural areas; and c) Beyond visual line of sight (BVLOS) operations in rural areas (Argrow & Frew, 2017; FAA, n.d.-a).

The FAA also released a five-year roadmap for the integration of civil UAS in the NAS in 2013, and created the Unmanned Aircraft Systems Integration Office to facilitate the safe integration of UAS into the NAS (Argrow & Frew, 2017; FAA, 2013). To achieve this goal, the FAA has been collaborating with stakeholders from a broad spectrum such as manufacturers, commercial vendors, standards organizations, academic institutions, government agencies, industry trade associations, research and development centers, and other regulators (FAA, 2013). Later that year, in December, the FAA announced the selection of six UAS test sites for researching the challenges involved with integration of UAS: University of Alaska, State of Nevada, New York's Griffiss International Airport, North Dakota Department of Commerce, Texas A&M University-Corpus Christie, and Virginia Polytechnic Institute and State University (Neubauer et al.,

2015). Further, in 2017, the FAA launched the UAS Integration Pilot Program (IPP) to bring together state, local, and tribal governments, and private sector entities such as UAS operators or manufacturers to facilitate integration efforts (FAA, n.d.-d; FAA, n.d.-e). The FAA also has recently released the second edition of the five-year roadmap for the integration of civil UAS in the NAS, updated since its first release in 2013 (FAA, 2018).

Policy, Regulation, & Rulemaking

A key outcome of the FRMA is that in August 2016, the FAA published the small UAS (sUAS) rule, 14 CFR Part 107, that defines the UAS, remote pilot, and operating limitations of a sUAS, less than 55 lbs in weight (FAA, 2016). The regulation mandates that the UAS must be operated in day Visual Meteorological Conditions (VMC) within visual line of sight, avoid other manned aircraft, and never be operated in a reckless or careless manner. Further, while flight in uncontrolled airspace does not require any ATC permission, operations in controlled airspace require ATC approval. A waiver could be requested if an operator could demonstrate that safe operation could be conducted under the waiver. Any individual operating under 14 CFR Part 107 is required to hold a remote pilot airman certificate with a sUAS rating or be under a person holding such a rating. From a planning perspective, the FAA released a five-year roadmap for the integration of civil UAS in the NAS in 2013 and established six test sites to research integration issues (FAA, 2013).

In October 2016, the FAA released Order JO 7200.23 which provided updated guidance for ATO policy for implementing 14 CFR Part 101 Subpart E, Special Rule for Model Aircraft, and 14 CFR Part 107 for sUAS. Under Part 107, sUAS operations in

uncontrolled airspace can be conducted without ATC authorization, while in operations in controlled airspace in Class B, C, D, and E surface areas, an authorization must be requested. Part 107 does not allow access to Class A airspace without a waiver (FAA, 2016). Part 101 Subpart E applies to modelers and hobbyists, and according to this rule, operators are required to notify airport or ATCT if operating within 5 SM from the airport.

NASA, in collaboration with the FAA and industry partners, has developed the UAS Traffic Management (UTM) concept that enables small UAS (sUAS) to operate simultaneously in the NAS (FAA, 2017c; Johnson et al., 2017). The UTM concept supports safe and efficient UAS operations in low altitude airspace, below 400 ft. According to UTM core principles, all operations should be authentic, UAS should avoid other UAS and manned aircraft, and have complete awareness of airspace constraints with public safety as top priority (Johnson et al., 2017). NASA has also conducted flight tests to test several enabling technologies such as the use of cellular 4G systems for vehicle control, dedicated short range communication systems, high resolution video imagery to support imaged based detect and avoid systems (Glaab et al., 2018).

In May 2018, FAA NextGen Office, in collaboration with NASA, released a Concept of Operations for UTM that defines operations below 400 ft. AGL (FAA, 2018c). The proposed architecture leverages third party service providers that provide services to UAS operators to support safe and efficient use of airspace identified as UAS Service Suppliers (USS). Operational data for UTM participants is shared via the USS Network. Data exchange between the FAA systems and UTM participants is achieved by

the Flight Information Management System (FIMS). Participation in UTM for BVLOS operations not participating in ATM is mandatory (FAA, 2018c).

There is ongoing research not only for sUAS operations below 400 ft, but also, operations at different flight levels such as on demand air carrier service below 5,000 ft, air cargo and air transport at higher altitudes, and commercial applications in Upper Class E by entities such as Facebook. In the near term, on demand air carrier service is gaining momentum with Airbus, Uber, Boeing, NASA, and other government and industry partners actively engaged to find solutions (Lascara, Spencer, DeGarmo, Lacher, Maroney, & Gutierrez, 2018).

Challenges of UAS Integration into the NAS

There are integration challenges that must be addressed before their use for commercial purposes can be implemented (US DOT, 2014). There are also safety and security issues for abnormal situations, policies, procedures, regulations, command, control, and communication, navigation, and detect and avoid situations that are still being researched. As an example of the fluidity of UAS integration challenges, in May 2017, the U.S. Court of Appeals for the District of Columbia has since invalidated the registration requirement of UAS pertaining to the hobby or recreational use (FAA, 2017a). The National Defense Authorization Act of 2018 was passed on December 12, 2017, and drone registration has once again been reinstated (FAA, 2017b).

Tests were conducted by the Air National Guard at the FAA test site in Victorville, CA, with mixed fleet operations in an airport environment (Neubauer et al., 2015). During these tests, conventional and UAS operations were segregated by either holding conventional aircraft on the ground until the UAS is clear of the airspace, or the

UAS was held at a predefined point if conventional operations were in progress. These tests identified a few of the challenges of mixed fleet, mixed equipage, and mixed environment operations at airports.

Aviation in the U.S. is currently regulated by 14 CFR Chapter 1 or Federal Aviation Regulation (FAR) and comprises of several parts that must be adhered to such as airworthiness certification, maintenance, aircraft registration and marking, pilot certification, airspace classes, and operating rules (Dalamagdikis et al., 2008). As research continues on these and other factors that can facilitate the integration of UAS in the NAS, there are also other human factors, safety, and perceptions issues that have to be tackled. The perceptions are not just of the public, remote pilots, and air traffic controllers, but also pilots of manned aircraft who will co-exist and operate with the UAS in the NAS.

Human Factors Implications of Integration

UAS integration is expected to occur in at least three stages (Kopardekar et al., 2016):

1. UAS operations in uncontrolled airspace where no interaction with ATC will occur but UAS will share airspace with other manned aircraft,
2. UAS operations in controlled airspace segregated by ATC, and
3. UAS operations fully integrated into the airspace.

Any of these stages necessitates interaction between UAS, remote pilot, ATC, and pilots of manned aircraft. There is extensive research on human factors implications of UAS operations impacts on pilots, controllers, and remote pilots. Several researchers have conducted an exhaustive review of existing literature, operational assessments,

experimental research, and analysis of archived incident and accident data. Based on this review of known human factors issues, researchers have organized and categorized key factors such as automation, communication, training, UAS performance, perceptual and cognitive aspects of pilot interface, Air Traffic Management (ATM) procedures, and crew qualifications (Cardosi & Lennertz, 2017; McCarley & Wickens, 2014; Nisser & Westin, 2006).

Further, past studies reveal issues with unpredictability of contingency operations such as lost link, lost communication, engine failure, and other emergency situations; negative impact of increasing UAS operations on safety and efficiency; lack of sense and avoid systems, and impact on airspace efficiency, training, and workload (Cardossi & Lennertz, 2017; Kamenski & Semanek, 2013).

A review of incident reports submitted by pilots of manned aircraft all involved conflict situations that were either near miss, within 500 ft, or the pilot took evasive action (Cardossi & Lennertz, 2017). Almost 50% of these events were near the airport environment either during takeoff or landing. Another concern expressed by pilots was the difficulty of sighting the UAS and the insufficient time for reaction once observed (Cardossi & Lennertz, 2017).

In a survey conducted by Yuan and Histon (2014a) of ATC and pilots encounters with UAS, they found that 60% of controllers and 42% of pilots experienced some form of UAS encounter. The key concerns reported by the pilots of information sharing about the UAS included information overload, unexpected maneuvers, distraction, communication, dependency on technology, inaccuracy, and other issues such as unreliability and slow-moving targets (Cardossi & Lennertz, 2017; Yuan, Histon &

Wasslander, 2014b). Based on these studies, there are four primary human factors issues applicable to all stakeholders that will play a vital role in the safe integration of UAS in the NAS, namely, training, communication, workload, and information sharing.

Technology solutions

There is considerable ongoing research on regulation, systems, airworthiness, operations, licensing and training, processes, and procedures by individual agencies such as FAA, NASA, ICAO, and other global aviation entities. There are efforts toward global unification of these UAS regulations and standards, which are essential for the safe integration of UAS into the NAS (Shibli, 2015). There are also gaps in existing technologies such as communication and detect and avoid technologies which are critical since typically unmanned aircraft are controlled by remote pilots from the ground using wireless technology. Suryanegara, Asvial, and Raharya (2015) take a Systems Engineering approach and present a three-domain view of technological innovation that aims to provide reliable wire transmission, international regulatory and standardization to handle compatibility issues, and country specific issues to promote an understanding of vision and profile of that country's government. Each of the key domains further define sub-goals. For example, under technological innovation domain view, a sub goal is research and development to achieve reliable wireless transmission among the UAS elements.

There has been some progress toward the development of technology solutions to support sUAS operations especially below 400 ft AGL. Solutions include DroneZone, Low Altitude Authorization and Notification Capability (LAANC), and Facility Maps (FM). DroneZone is expected to be a one-stop shop for UAS operators that provides

information on drone registration and information and options for flying a drone.

LAANC is a map-based tool for data exchange for airspace approvals. FM provides maps that indicate maximum altitudes where FAA may authorize Part 107 operations with further safety analysis (FAA, n.d.-a; FAA, n.d.-b; FAA, n.d.-c). There is also ongoing research by FAA, NASA, and industry partners on future on demand air transportation systems such as UAM that are expected to operate above 400 ft. AGL up to 5000 ft. AGL providing passenger and cargo delivery services (NASA, 2017; Uber, 2018).

Summary of Chapter 2

This chapter provided an overview of the underlying theory and its relevance to the research being conducted in this study. The chapter also provided a brief overview of UAS, issues and challenges of integration and significance of the growth in commercial use of UAS, perceptions of UAS use by the various stakeholders, as well as human factors implications of UAS in the NAS. A brief description of the independent and dependent variables and the relevance of their use was also provided.

UAS use for recreational and commercial purposes is gaining momentum, and the FAA and other forecasts predict a 40% compounded growth over the next few years. Innumerable issues and challenges must be addressed to ensure safe integration of UAS in the NAS including perspectives not only of the public but also the pilot population about such integrated operations. While there is some research on public perspectives of UAS, review of existing literature confirms there is very little published research on the specific topic of pilot's perceptions and willingness to operate an aircraft in an UAS integrated airport and airspace environment. There is ongoing research on well clear

boundary between manned and unmanned aircraft and how pilots perceive this boundary during UAS encounters.

Past research has demonstrated that willingness can be measured by asking people their intentions such as their willingness to use renewable energy sources, their travel preferences, their WTP for services, their willingness to drive in driverless cars or fly in autonomous aircraft, and willingness to fly under different conditions.

CHAPTER III

RESEARCH METHODOLOGY

Introduction

This chapter provides a detailed overview of the methodology used to conduct this study. It includes a discussion on the selection of the research method and research design as well as the proposed research questions and hypothesis, and the independent and dependent variables. Information on the population size, sample size, sampling strategies, participant recruitment strategies, and ethical considerations are presented. Next, detailed information on the data collection process is provided including apparatus and materials, instrumentation, and variables and scales. Comprehensive details are provided on validity and reliability and how internal and external threats to validity will be handled in the current research. Finally, information on data preparation and analysis approaches are discussed.

Research Method Selection

This research used a quantitative methodology and a factorial survey experiment design that manipulated the type of UAS integration, the type of UAS operations, and the airspace classification to collect attitudinal data from the pilot population to determine their effect on pilots' willingness to operate an aircraft in UAS integrated airspace and airports. A factorial survey is an experiment design that comprises of vignettes that respondents judge. Traditionally, single item questions are used in social research to garner participant's responses to questions. It is often difficult to interpret the responses since it is difficult to differentiate whether participant's responses are true opinions or socially acceptable opinions (Auspurg & Hinz, 2014). To gain deeper insights, a

situational description with varying dimensions provides a method for more subtle questioning that is less likely to be influenced by social desirability bias. Such a design will provide deeper insights into participants' judgement principles and lead to greater standardization of its stimuli (Auspurg & Hinz, 2014). A factorial survey experiment design was suitable for this research as it enabled the researcher to explore the relationships between the independent variables and the dependent variable. Attitudinal data were collected from participants using an electronic questionnaire with hypothetical scenarios, which was the primary method used for securing information relating to the variables under study.

Research Method

This study incorporated several different methodologies. A factorial survey was employed to randomly assign hypothetical scenarios to participants to collect attitudinal data. The dependent variable, willingness to pilot an aircraft, was assessed using a modified version of Rice et al.'s Willingness to Pilot an Aircraft scale. Validity and reliability of scale were verified. To answer the research questions, an analysis of variance (ANOVA) design was used. This design was appropriate since it allowed testing of interaction effects between two or more factors or dimensions.

Research Design

An experiment is a common method used to test the causal effect of an independent variable on the dependent variable. Using an experiment, the independent variable(s) can be manipulated to test their effect on the outcome by controlling for the effects of other factors. An experiment can be conducted in two ways. A between-participants design where participations are divided into two or more groups: a control

group (receiving no treatment) and n treatment groups (receiving treatments). The outcome or dependent variable of these groups can be used to compare the results. The second, a within-participants design, is when a pre-test (before treatment) and post-test (after treatment) for the same group are conducted and the results are compared. The latter method is used for repeated measures. Two key issues in the experiment is the experimental design and the sampling process which, if not done properly, can lead to threats to both internal validity and external validity.

Experimental designs require that the cause precede the effect, the cause is related to the effect, and alternative explanations for the causal relationship are implausible (Cook, Campbell, & Shadish, 2002). An experimental design is typically based on the random assignment of participants to a control or treatment group. It requires a suitable control group, control treatment, and adequate sample size.

A Factorial Survey Experiment (FSE) with quantitative data was used in this study. FSE combines the advantages of survey and experimental research. Survey studies increase the generalizability, and hence external validity, since they can be easily applied to large heterogeneous populations, whereas experiments guarantee internal validity since respondents can be randomly assigned and responses reflect variations in the experimental stimuli (Auspurg & Hinz, 2014). To answer the research questions, a mixed factorial design was used with two between subjects and one within subjects. The three independent variables were the type of UAS integration, the type of UAS operations, and the airspace classification. In a mixed factorial design, two or more independent variables are manipulated, at least one of which is between-participants and at least one is within-participants (de Winter & Dodou, 2017). As described previously, two levels each were

used for the two independent variables: type of UAS integration and type of UAS operation; while five levels were used for the airspace classification. Thus, this study used a $2 \times 2 \times 5$ mixed factorial design, resulting in 20 treatment combinations. The total number of treatment combinations in any factorial design are equal to the product of the treatment levels of all factors or variables.

There are many ways an experiment can be designed. For example, participants can all be tested under each of the treatment conditions or a different group of participants can be assigned to different treatment groups. In a between participant design, the different treatments are given to different groups of participants. The groups differ, in that, each group is given a different treatment. All conditions are treated the same, and any difference between conditions can be attributed to the treatments themselves. Randomly assigning participants to treatments ensures that all differences between conditions are chance differences.

In a within participant design the same participant is tasked to perform at all levels of the independent variable. An advantage of within participant designs is that individual differences in participants' overall levels are controlled. This is important since participants invariably, differ from one another. Within participant designs control for these individual differences by comparing the scores of a participant in one condition to the scores of the same participant in other conditions. In this sense, each participant serves as his or her own control. This enables within participant designs to have more power than between participant designs, i.e. enables detection of an effect of the independent variable better than in a between participants designs.

Factorial designs introduce the concept of interaction (Lammers & Badia, 2004). An interaction effect occurs when the effect of one independent variable on a dependent variable is different at different levels of the other independent variables. That is, the effect of one independent variable on a dependent variable depends on the level of the other independent variables. Although, determining whether there is a three-way interaction is relatively straightforward, the follow-up analyses can be complicated, and a pattern of testing is often required that examines the effects of variables and their interactions (Lammers & Badia, 2004).

There are several different ways that participants can be assigned to experiments, such as randomization, natural pairs, matched pairs, and repeated. In a completely randomized factorial design, randomization is used to assign participants to all treatment conditions, whereas in a repeated measures design, multiple observations on the same participants are used to assign participants to treatment conditions. A mixed factorial design uses a combination of randomization and repeated measures to assign participants to treatment conditions. In a mixed factorial design, participants are randomly assigned to the different levels of at least one independent variable, while they can participate in all levels of another independent variable. The current research used a mixed factorial design to answer the research questions and test the hypothesis.

A three way mixed factorial design is appropriate in this instance since it enables consideration of different combinations of the two independent variables, namely type of UAS integration and type of UAS operation, which represent the potential combinations in future mixed operations, while considering all airspace classes (the third independent variable) where such operations might occur, while keeping the design manageable. An

entirely between participant design can lead to the requirement of unmanageable sample sizes, while an entirely within participant design can lead to other issues such as participant fatigue and hypothesis guessing.

Research Questions and Hypotheses

This research conducted a quantitative methodology and a mixed factorial experimental design that manipulated the type of UAS integration at the airport, the type of UAS operations, and the airspace classification to collect attitudinal data from the pilot population to determine what factors affect pilots' willingness to operate an aircraft in UAS integrated airspace and airports.

The research questions and hypotheses that guided this study were:

RQ₁) What type of UAS integration will affect pilot's willingness to pilot an aircraft?

H₀₁: There will be no significant difference in pilot's willingness to pilot an aircraft based on the type of UAS integration.

H_{A1}: There will be a significant difference in pilot's willingness to pilot an aircraft based on the type of UAS integration.

RQ₂) What type of UAS operations will affect pilot's willingness to pilot an aircraft?

H₀₂: There will be no significant difference in pilot willingness to pilot an aircraft based on the type of UAS operations.

H_{A2}: There will be a significant difference in pilot's willingness to pilot an aircraft based on the type of UAS operations.

RQ₃) What airspace classification will affect pilot's willingness to pilot an aircraft?

H₀₃: There will be no significant difference in pilot's willingness to pilot an aircraft based on airspace classification.

H_{A3}: There will be a significant difference in pilot's willingness to pilot an aircraft based on airspace classification.

RQ₄) Will there be any significant interactions between the independent variables?

H₀₄: There will be no significant interaction between the type of UAS integration and type of UAS operations.

H_{A4}: There will be a significant interaction between the type of UAS integration and type of UAS operations.

H₀₅: There will be no significant interaction between the type of UAS integration and airspace classification.

H_{A5}: There will be a significant interaction between the type of UAS integration and airspace classification.

H₀₆: There will be no significant interaction between the type of UAS operations and airspace classification.

H_{A6}: There will be a significant interaction between the type of UAS operations and airspace classification.

H₀₇: There will be no significant interaction between the type of UAS integration, type of UAS operations and airspace classification.

H_{A7}: There will be a significant interaction between the type of UAS integration, type of UAS operations and airspace classification.

Willingness to Pilot an Aircraft Scale

The willingness to pilot an aircraft scale developed by Rice et al. (2020) was used in the current research. The scale comprises of seven statements that rate willingness to

pilot an aircraft. Likert-type rating ranging from strongly disagree (-2) to strongly agree (+2), with zero being neutral, was used to elicit pilot perceptions as depicted in Table 2.

Table 2

Willingness to Pilot an Aircraft Scale

1. I would feel safe piloting an aircraft in this situation
Strongly Disagree, Disagree, Neither Disagree or Agree, Agree, Strongly Agree
2. I would be willing to pilot an aircraft in this situation
Strongly Disagree, Disagree, Neither Disagree or Agree, Agree, Strongly Agree
3. I have no fear of piloting an aircraft in this situation
Strongly Disagree, Disagree, Neither Disagree or Agree, Agree, Strongly Agree
4. I have no problem piloting an aircraft in this situation
Strongly Disagree, Disagree, Neither Disagree or Agree, Agree, Strongly Agree
5. I feel confident piloting an aircraft in this situation
Strongly Disagree, Disagree, Neither Disagree or Agree, Agree, Strongly Agree
6. I would be confident piloting an aircraft in this situation
Strongly Disagree, Disagree, Neither Disagree or Agree, Agree, Strongly Agree
7. I would be happy piloting an aircraft in this situation
Strongly Disagree, Disagree, Neither Disagree or Agree, Agree, Strongly Agree

Population and Sample

The term population represents all the members that meet a set of specifications while sample represents a subset of members of the population (Lammers & Badia, 2004). Since it is time intensive and costly to poll the entire population, it is typical for

research studies to use a representative sample. The specific details on the sample sizes, sampling strategies, and participant eligibility and ethical considerations that were used in this research study are provided in the next sections.

Population and Sampling Frame

The target population for this research was the 600,000 plus manned aircraft pilots in the country of any rating and experience level. The breakdown of the total pilot population by rating type at the end of 2018 is shown in Table 3.

Table 3

Pilot statistics by ratings at the end of December 2018

Rating	Pilots
Student	167,804
Recreational (only)	144
Sport (only)	6,246
Airplane	
Private	163,695
Commercial	99,880
Airline Transport	162,145
Rotorcraft (only)	15,033
Glider (only)	18,370
Total	633,317

The accessible population were the United States pilots who were at least 18 years old and have flown within the last six months who could be reached through mailing lists such as Curt Lewis safety newsletter, Embry-Riddle pilots, social media, and word of mouth.

Sample Size

A mixed Analysis of Variance (ANOVA) compares the mean differences between groups that have been split on two "factors" (also known as independent variables),

where one factor is a "within-participants" factor and the other factor is a "between-participants" factor. The primary purpose of a mixed ANOVA is to understand if there is an interaction between these two factors on the dependent variable. A three-way mixed ANOVA can take on one of two possible forms: (1) two between-participants factors and one within-participants factor, or (2) one between-participants factor and two within-participants factors. Given that there are three independent variables in a three-way mixed ANOVA, several different study designs and objectives can be analyzed using this test.

This research used two between participants and one within participants analysis. To ensure the identification of the proper sample size, GPower.exe application, a power analysis tool was used. GPower is a freely available analysis tool that can be used to estimate sample size using a priori power analysis as a function of a given population effect size, pre-specified significance level, and required power level (Faul, Erdfelder, Buchner, & Lang, 2009; Faul, Erdfelder, Lang, & Buchner, 2007). The sample size was estimated for the three-way mixed ANOVA assuming an alpha value of 0.05, an effect size of 0.2, and 0.95 statistical power, number of conditions set to 20 and number of measurements 2. For a three-way mixed factorial ANOVA analysis, the minimum estimate sample size was 220 participants.

Sampling Strategy

There are two major sampling techniques: probability sampling and non-probability sampling (Lammers & Badia, 2004). In probability or random sampling, participants are randomly selected whereas in non-probability sampling, there is no way of estimating the probability a participant would be selected. Random sampling, while

optimal, is not always possible from a practical standpoint. Convenience sampling is a non-probabilistic sampling technique that is inexpensive and convenient and uses available participants (Lammers & Badia, 2004).

This research used convenience sampling, a nonprobability method of sampling, since the research focus was on assessing the relationship between the independent and dependent variables. Population statistics of the respondents were checked to assess the representativeness of the sample. The statistics were used to evaluate potential non-response bias. Snowball sampling was used to increase the response rate to the survey. This method involves asking respondents to recommend other respondents that they believe will be interested in completing the survey and assumes that members of the target population know one another (Vogt, Gardner & Haefele, 2012). The use of reminders to selected respondents was also used to increase the response rate. Sampling bias was limited through randomization of research questions, recruitment methods and instrument, and by maintaining sufficient control on the sample.

In addition, stratification techniques were used to ensure representativeness of the pilot population as well as to facilitate descriptive comparison between and among the strata. Stratification provides a means to classify or separate people into groups according to certain characteristics, such as position, rank, income, education, sex, or ethnic background (Mathers, Fox, & Hunn, 2007). In this study, the sampled data were divided into different strata post hoc, based on the type of pilot license into groups to determine how closely it reflects the behavior of the population.

One of the challenges to self-administered questionnaires is non-response rate, which is attributed to three sources: non-delivery of questionnaire to participant, non-

cooperation of the participant, and inability of the participant to provide requested information (Groves, Fowler, Couper, Lepkowski, Singer, & Tourangeau, 2009).

Information on the incomplete questionnaire as well as participants login was tracked to determine response rates. According to Vogt et al. (2012), the bigger the response rate, the better. Improving response rate will then alleviate non-response bias. There are several tools available to increase response rates such as longer data collection period, compensation, advance letters, persuasive letters to non-responders, shorter surveys, using trusted sponsors, and two-phase samples (Groves et al., 2011).

Participant Eligibility and Recruitment

The proposed study followed an experimental procedure and manipulated the independent variables. An experimental questionnaire was used to collect attitudinal data from the pilot population. The main source from which participants were polled via a convenience sample was Curt Lewis' Flight Safety Newsletter (www.fsinfo.com).

Several other secondary sources such as Embry-Riddle pilots, San Luis Obispo Chapter of the Ninety Nines (SLO99s), General Aviation News, local area pilots, social media, and word of mouth were also used to advertise and recruit participants. To participate in the electronic questionnaire, all participants were required to be at least an 18-year-old pilot with current medical, any rating, and experience level, who had flown within the last six months. To encourage pilots to participate, compensation was provided through participation in the drawing to win a prize. When using local chapters or mailing lists, prior approval was sought, and preliminary approvals are provided in Appendix B. An example email that was used to recruit participants is provided in Appendix C.

Participant Protections and Ethical Considerations

Since human participants are involved, every effort was made to safeguard the privacy and safety of the participants. Embry Riddle Aeronautical University guidelines were adhered to, prior to conducting this electronic questionnaire, by filing an application seeking the approval of Internal Review Board (IRB). The IRB application is provided in Appendix A.

To encourage participants to participate in the electronic questionnaire, compensation was provided by hosting a drawing to win a prize. All participants had the ability to participate or withdraw from consideration. A DJI Tello Quadcopter Drone with high definition camera and virtual reality starter bundle with case and headset was offered as compensation to participants who completed the entire questionnaire, were willing to forward the questionnaire to at least one other pilot, and were interested in participating in the free drawing.

Informed consent was used, and voluntary participation was noted. Unique participant information was stripped off and replaced with identifiers to ensure anonymity of participants. For those participants interested in participating in the drawing to win a recreational drone, confidentiality was maintained, and once the final winner had been selected, all unique information was safely disposed.

This study collected information on participant's judgements, their attitudes, beliefs, and perspectives. Hence, additional care was taken in the question design to mitigate any distress or discomfort to the participants while answering the questionnaire. Further, participants had the opportunity to discontinue at any time. No physical, psychological, financial, or any harm to participants was anticipated in this study. The

study used an electronic questionnaire, and there was no direct interaction with the participants, and therefore harm was unlikely in this study.

Data Collection Process

An electronic questionnaire deployed via Survey Monkey that consisted of multiple choice and open-ended questions was used to collect data for this research project. An electronic questionnaire was best suited since the pilot population poses unique challenges to gathering the desired data such as irregular work structures, dispersed domiciles, insufficient representation in common gathering locations, and other such barriers. Pilots, however, do tend to be highly likely to follow aviation-related journals, websites, news sources, mailing lists, and fraternal organizations. The use of an electronic questionnaire allowed for the greatest potential success in reaching the target population. The questionnaire included structured questions that could be easily answered in a few minutes. Curt Lewis' Flight Safety Newsletter was the primary source for collecting the data.

Commercial survey tools contain features that can assist in analyzing the number of participants that started the survey but did not complete (breakoff), those that did not pass the screening question (eligibility), and those that refused consent (refusal). These survey tools, in addition to the overall response rate of the survey frame, can assist in identifying the factors or questions that may lead to that non-response bias (Groves et al., 2011).

Design and Procedures

The target population was pilots in the country of any rating and experience level. The accessible population was those pilots reached through mailing lists such as Curt

Lewis' Flight Safety Newsletter, Embry-Riddle pilots, SLO99s, local area pilots, social media, and word of mouth. A web-based tool, Survey Monkey (<https://www.surveymonkey.com/>), was used to host an electronic questionnaire to collect data from participants over a period of three months. Prior to conducting the study, a pilot study was conducted to evaluate clarity of particular questions, soundness of the design, safety of procedures, and other factors that might inhibit the study.

The questionnaire was conducted only once. It included a combination of Likert scale and open-ended questions. Likert style questions were used to determine responders' agreement on conditions such as UAS operation type, UAS integration type, or airspace classification that influenced their willingness to operate an aircraft in UAS integrated airports. All study participants were randomly assigned one of the four scenarios and were prompted to answer five questions. Each of the scenarios was designed to capture one of the two levels of type of UAS integration and type of UAS operation, while the five following questions captured the five different levels of airspace classification.

These measures enabled summarizing responses, while open-ended questions provided greater insight on the pilot perceptions of operating in UAS integrated airports and airspace. The collected data were stored in databases and assigned unique identifiers for retrieval in the future. A summary of the procedures used to collect the data is shown in Figure 1.

Figure 1. Summary of steps used in data collection.

Apparatus and Materials

As noted previously, an electronic questionnaire was used to collect data from the pilot population about their willingness to operate from UAS integrated airports. An advantage of the questionnaire was that data could be obtained on large numbers of participants quickly and relatively inexpensively. There are two broad types of questionnaires: descriptive and analytical. Analytical questionnaires deal with

information pertaining to opinions or attitudes while descriptive questionnaires pertain to information. A combination of analytical and descriptive questionnaire was used in this research study.

An e-mail was sent to participants providing a link, asking them to complete the voluntary study. A sample email is provided in Appendix C. The questionnaire was transmitted electronically via the internet using Survey Monkey. Participants were solicited requesting their voluntary participation via a convenience sample.

Participants were presented with an electronic consent form prior to participating in the study, which they had to agree, and then they were provided instructions on how to complete the questionnaire. A screening question was used to screen the participants that did not meet the selection criteria. If the participant did not meet the criteria and answered in the negative, then the survey ended automatically.

A participant who responded in the affirmative was presented with general questions to gather information on the pilot qualifications and experience level, after which the participant was presented with several multiple-choice questions pertaining to the pilot's willingness to operate an aircraft under different conditions. Participants were randomly assigned to a different experimental condition based on the type of UAS operations (IV, between factor) and the type of UAS integration conditions (IV, between factor). All participants received all airspace classifications (IV, within factor) to assess their willingness to pilot (DV).

The questionnaire used a combination of sample scenarios, open-ended questions, and direct questions using a 7-item Likert Scale to assess a pilot's willingness to operate an aircraft under specified conditions. Participants also had the opportunity to type in

answers where appropriate to provide detailed descriptions or additional information in addition to selecting one or more of the available choices. In addition, basic demographic information such as flight experience, ratings, age, geographical region, and gender were collected.

At the completion of the study, participants were thanked for their participation, debriefed, and dismissed. To provide enough motivation to participate, interested participants were able to register to win a recreational drone as compensation for their participation. Participants interested in the drawing to win a prize were asked to provide contact information so that they could be informed if they were the winner. At the end of the questionnaire, participants were thanked and encouraged to share the questionnaire with other pilots who might be interested in participating.

Sources of Data

The primary source of the data for this research study was the data collected via questionnaire from the pilot population, as described above. Convenience sampling with stratification was used, and to ensure the sample is representative of the target population, pilots with all levels of experience and ratings were asked to participate.

Measurement Instrument

Measurement is the assignment of numbers to a variable that provides the raw data for statistical analysis. It is essential that the operational definition of observable concept that is being measured must be clear and unambiguous, so that the resulting observations being measured are accurate and reliable (Lammers & Badia, 2004). There are several different measurement scales such as nominal, ordinal, interval, and ratio. In a nominal scale, labels or numbers are assigned to objects or events for the purpose of

identification, and the value or order provides no significance. In an ordinal scale on the other hand, objects or events can be rank ordered for example as first, second, third, and so on. In an interval scale, both order and distance between events are specified, while a ratio scale has several properties such as rank order, equal intervals, and equal ratio (Lammers & Badia, 2004). The three independent variables in this research study were all nominal (or categorical). A brief description of the dependent and independent variables along with the measurement scale is provided next.

The complete questionnaire that was used in this research study is presented in Appendix D. The introductory section of the questionnaire includes background information about the study to include descriptions of the study leadership, purpose, eligibility criteria, confidentiality, and consent. In the introductory section, the participant could choose to participate in the questionnaire or not participate, thus ensuring informed consent.

The questionnaire was divided into five sections. Section 1 was the screening section. The target population for this research was any adult pilot of any rating and qualifications who had flown within the last six months, and therefore this section allowed the participant to confirm that they were part of that population. Section 2 collected background information such as license type, rating, and experience level. Section 3 was the scenario section. In this section, participants were provided specific scenarios and were able to provide information about their willingness to pilot an aircraft under those specific conditions. The order of the scenarios was randomized. Section 4 provided respondents with an opportunity to answer open-ended questions about their perspectives on flying in UAS integrated airports and airspace, and other factors that

might influence their willingness to operate an aircraft. Section 5 was the demographic section. This section collected information about, age, gender, and geographical region.

Prior to completing the questionnaire, the participant had the opportunity to enter a drawing to win a free DJI Tello Quadcopter Drone and provide contact information to be notified if he/she was the winner. The participant also had the opportunity to share the link with other pilot recipients who might be interested in participating in the questionnaire.

Variables and Scales

The FAA has recently released the second edition of the five-year roadmap for the integration of civil UAS in the NAS, updated since its initial release in 2013 (FAA, 2018). The UAS Traffic Management (UTM) Research Transition Team (RTT) was established in 2015, and the two key areas of this team are low altitude UAS traffic management and UAS in the NAS, which focuses on UAS operating in higher altitudes and controlled airspace. As the UAS operations proliferate into the NAS, the type of operations, type of integration, and the airspace where they occur will play a vital role in their safe and efficient integration and ultimately pilots' willingness to operate an aircraft under such integrated operations. The three independent variables (IV) in this study will be categorical and are as defined below:

1. Type of UAS integration (IV1) is a categorical variable with two levels namely, segregated or fully integrated.
2. Type of UAS operation (IV2) is a categorical variable with two levels namely, remotely piloted, or fully autonomous.

3. Airspace classification (IV3) is a categorical variable with five levels namely, B, C, D, E and G.

The dependent variable (DV) is:

1. Willingness to Pilot an Aircraft is a continuous variable measured using multiple questions, and the results will be aggregated using average.

Validity and Reliability

Validity is concerned with accuracy of the measurement. By framing the right questions that provide the answers to the research questions of interest, content validity can be preserved. There are two types of threats to validity: internal and external (Creswell, 2014). Internal validity threats are related to the experimental procedures, treatments, and behaviors that might lead a researcher to wrong conclusions, while external validity threats arise when a researcher draws incorrect conclusions from the same data for other situations.

There are different types of threats to internal validity such as history, maturation, regression, selection, mortality, diffusion of treatment, compensatory, testing, and instrumentation (Creswell, 2014). The passage of time can influence the outcome of the experiment and result in threats such as history, maturation, and regression. History refers to events outside the study that can influence the participants. Such threats can be mitigated by ensuring that both the experimental and control groups experience the same external events and participants of similar maturity are selected.

Selection can influence internal validity, especially if participants of similar characteristics are chosen, and end up unequally distributed amongst the experimental groups. This can be avoided through random assignment so that the probability of

characteristics is equally distributed. The risk within this study was minimized by using random assignment procedures such that events occurring in one group were likely to not occur in the other.

Maturation refers to natural physiological or psychological changes that can take place over time. Such effects play a major role in studies that span a longer time period and are usually addressed through participant matching or randomization. Maturation was not an issue in the current study since the electronic questionnaire was conducted only once over a short period of time.

Regression refers to the tendency of participants who score too high or too low to score more to the mean in subsequent tests. This can be an issue in studies with extreme values. This was not a concern in the current study since the electronic questionnaire was only administered once to each participant.

Selection refers to the manner in which participants will be selected and assigned to groups. Any differences during the course of the study can influence the study. Such effects can be minimized through subject matching and randomization. In the current study, randomization was used to assign participants to different groups.

Another threat to internal validity is mortality, which can occur due to a large number of participants dropping out. This can be mitigated by recruiting a large sample to account for the dropouts (Creswell, 2014). This study used an offer to a drawing to win a prize as further motivation to encourage participants to participate.

Diffusion on treatment threat can occur if participants in the control and experiment group communicate, but by keeping the groups separate, the research can mitigate this issue. Providing benefits to both groups, the researcher can prevent diffusion

of treatment and compensatory rivalry or resentment. To address this issue, the researcher offered compensation to any participant interested in participating in compensation to win a free drone.

Performance of participants improves the more exposed they are to an activity. Likewise, when the same test is used for both pretest and posttest, it can influence the results. Further, if the measurement devices used changes during the course of the study, changes in scores could be related to the instrumentation rather than the independent variables. Such issues can be mitigated through use of highly correlated tests.

Threats to internal validity in this research project were identified, controlled, minimized, and reported. As stated previously, the current study recruited participants from the pilot community using well established pilot mailing lists and pilot groups. The current study used a factorial survey experiment, and hence each participant was randomly assigned one of the hypothetical scenarios and was asked to answer a set of questions based on the scenario. Questions within each scenario were randomized as well. Since a one-time electronic questionnaire with no participant interaction was used, such threats were minimized. Participants were able to take the questionnaire in the comfort of their homes at their convenience and had no opportunity to meet other participants. The questionnaire had a cutoff date and time when data collection was stopped.

Threats to external validity are related to the interaction of selection, setting, and history of the treatment (Creswell, 2014). Interaction of select and treatment refers to the narrow characteristics of participants in the study that limits generalization to individuals

who do not have similar characteristics. This threat can be handled through either conducting additional studies or limiting claims to the appropriate group only.

Interaction of setting and treatment refers to the characteristics of the setting that can limit generalizability of the results to individuals in other setting. This threat can be handled through additional studies in new settings to determine if the results from the first study are similar in different settings. Interaction of history and treatment refers to whether the results of the study can be generalized to future situations. This threat can be handled by replicating longitudinally in different time periods to assess if similar results are observed.

External validity threats can be mitigated by conducting additional experiments with different groups with different characteristics, additional experiments in different settings, and replicating the study to determine if similar results occur. In this current research, specific scenarios were used to collect the data from participants on their willingness to pilot an aircraft from UAS integrated airports. Since an electronic questionnaire completed at a single point in time was used, minimal interaction between setting and history was expected. Further participants were randomly assigned to different scenarios to limit any selection interactions. A known limitation to the study was the lack of generalizability to future situations.

Reliability pertains to consistency of measurement, and whether different statements measure the same characteristics. It is defined as the extent to which each of the questions is free from non-systematic errors, which can bias responses. Reliability can be estimated using test-retest, alternate-form, split-halves, inter-rater, and internal consistency (Drost, 2011). Test-retest reliability is commonly used in questionnaires, and

it includes the same participants taking the same test at two different points in time.

Issues with test-retest reliability can be avoided by using alternate-form reliability wherein a participant is tested on one form of test and on another comparable form of test after a short period of time, usually a week or two (Lammers & Badia, 2004).

In split half approach, half the items are combined to form one measure, and likewise the other half are combined to form a second measure resulting in two tests and two measures testing the same behavior (Drost, 2011). The correlation between the two halves is adjusted to obtain reliability coefficient. In the inter-rater approach, judges are used to measure behavior. Internal consistency reliability, on the other hand, is applied to groups of items that are known to measure different aspects of the same concept.

Three main concerns with reliability testing are internal consistency, equivalence, and stability over time. In this research, internal consistency of the questionnaire was determined using the split-half method, whereby items examining the same construct were divided into two sets and compared. Estimates of reliability were based on average inter-correlations among all the items and tested using Cronbach's alpha.

Factors that can affect reliability of a test are source of errors within a test and variation between tests. Errors within a test can be attributable to sampling, incorrect answers, skipping questions, and variation between tests. In the current research, the study was conducted only once, and reliability was improved by providing clear instructions, well-written questions, and maintaining explicit and clear rules for scoring and finding the right balance of questionnaire items to prevent participant fatigue.

Data Analysis Approach

This research study used a quantitative analysis to answer the research questions and to test the hypothesis. A three-way mixed factorial analysis with two between subjects and one within subjects was used to detect interactions between the independent variables and their influence on the dependent variable. The data collection and analysis steps are depicted in Figure 2.

Figure 2. Data Collection and Analysis Steps

Initial Data Analysis

Initial data analysis was conducted to investigate the quality of the data, and descriptive statistics and distributions were used to assess the data for outliers, missing values, normality, success, or failure of randomization techniques. Each of these issues was handled appropriately prior to the full analysis of the data. The best method to handle missing data was to minimize its occurrence through better planning and data collection steps. A well-designed study that limits data collection to participants who have been trained, provided appropriate documentation, and limited follow-on visits alleviates issues with missing data. Further, using a small pilot study before the main study helped identify problems with the study. Despite this, it is not uncommon to have missing data.

Several methods are available to handle missing data such as case deletion, pairwise deletion, mean substitution, imputation, last observation carry over, maximum likelihood, and multiple imputation. Cases with extensive missing values can be excluded from the analysis, while cases with a few missing values can be adjusted using regression imputation. In regression imputation, missing data are replaced with estimated or predicted values of the existing variables. Either of these methods was not required in the current study.

Outliers represent data points that are far away from the majority of points. One of the methods that can be used to identify outliers is by the distance between a data point and the center of all the data points. A distance greater than three times the standard deviation from the mean is considered an outlier. Other techniques that can be used to identify outliers include using the median and interquartile range and creating boxplots. Identified outliers can be treated using techniques such as trimming, replacing with

expected values, or robust estimation techniques. In the current research, no significant outliers were observed and hence did not require treatment using trimming and/or replacement methods.

Descriptive Statistics

Descriptive statistics such as mean, median, mode, standard deviation, and measures of dispersion were used to describe the data. The mean provides a measure of central tendency, while the median provides the mid-point of the data and is an alternate to the mean. The mode provides the most frequent occurrence of an observation and the extent to which the data points differ from the mean, or the variability, is provided by the standard deviation. The variance enables distinguishing between two datasets and enables making inferences about the characteristics of the population (Wiggins & Stevens, 2016). Descriptive statistics in the current research are presented using age, gender, pilot qualifications, experience level, and geographical region.

Assumptions of Proposed Statistical Tests

This study comprised of three independent variables namely – UAS integration, UAS operations type, and airspace classification, and one dependent variable: willingness to pilot an aircraft. Variability levels between the groups were tested using *F* test for a significance level of $p < 0.05$. In order to satisfy the three-way mixed ANOVA analysis, it was essential that the following assumptions be met:

- a) DV is continuous (which is ensured by using an average score from the 7-point Likert scale)
- b) Within-subjects IV should contain two categories (airport classifications contain five categories)

- c) Between subjects factors should at least have two categorical variables (UAS integration type and UAS operations type each have at least two categories each)
- d) No outliers – this was ensured during preprocessing of collected data and handled
- e) DV should be normally distributed (Shapiro Wilk Test)
- f) Homogeneity of variances for each combination of the groups (Levene's Test)
- g) Sphericity (Mauchly's Test of Sphericity)

Each of the above assumptions were checked and handled as needed to ensure the data meets the requirements of the mixed ANOVA analysis.

Participant Demographics

Participants were a convenience sample of at least 220 pilots at least 18 years of age who had flown within the last six months, of any gender, rating, experience level, and from any geographical region. Participants were recruited primarily through Curt Lewis Safety Newsletter. Secondary sources such as Embry-Riddle pilots, local chapters of pilot groups, General Aviation News, social media, and word of mouth were used.

Reliability Assessment Method

Reliability was assessed using Cronbach's Alpha and Guttman's split half methods. Cronbach's alpha is a common measure of internal consistency that was used in the current research. It is typically used to determine how much the items on a scale are measuring the same underlying dimension. It is most commonly used when the questionnaire has multiple Likert type questions in a scale or subscale, and reliability of the scale needs to be determined.

In Guttman's method, reliability is measured by splitting the test into two halves. This could be achieved by keeping all the odd numbered versus all the even numbered questions, or all the questions in the first half of a test versus all the questions in the second half. The variance between the scores on each half is then calculated as well as the variance of the total test score which is then used to assess reliability and was the method employed in this research study.

Validity Assessment Method

Validity was assessed to ensure that what was being measured was in fact what the research purports to measure. There are several different types of validity such as Face, Content, Construct, and Criterion. Face validity is the extent to which an instrument appears to measure what it purports to measure. Content validity is the representativeness or sampling adequacy of the content of the measuring instrument. Construct validity is the extent to which a concrete manifestation of an abstract concept is an accurate reflection of the underlying construct. Criterion-related validity is the extent to which a score on a specific DV measure corresponds to scores on independent measure of the variable. Criterion-related validity is concurrent validity if the criterion is in the present and predictive validity if it is in the future.

Face and content validity were assessed by using an initial pilot study to ensure the clarity and soundness of the questionnaire design. Construct validity was assessed to ensure the measurement method accurately represents what is being measured. Correlation coefficients were used to assess criterion validity.

Data Analysis Process/Hypothesis Testing

Hypothesis testing is usually conducted using four steps namely hypothesis formulation, identifying a test statistic, computing the significance level or p -value, and comparing the p -value to an acceptable α value. After the data were cleansed and prepared and all assumptions were satisfied, the F test statistic was used, and the significance levels calculated to determine whether the null hypothesis or the alternate hypothesis was acceptable.

In addition to the results of the ANOVA-based analysis, the effect size and confidence intervals around the effect size and measure of association that the proportion of variation in DV is explained by the IV are also presented. Two commonly used measures of association are omega-squared and eta-squared (Vogt et al., 2014). Eta-squared is typically used in ANOVA models and was used in the current study to measure the effect of the variables. Post hoc tests are commonly used to analyze the results of experimental studies if the F -ratio is significant, indicating that a difference between means exists. If there was a statistically significant interaction, then main effects as well as differences between groups for each level of each factor were also determined.

There are several tests available for post hoc analysis such as Tukey and Bonferroni (Kao & Green, 2008). Tukey method allows comparison of all pairs of means and allows derivation of confidence intervals about the mean difference. For unequal sample sizes, Tukey method provides a conservative estimate. The Bonferroni method is often used when there are several independent or dependent variables tests at the same time. It tests the significance level of the tests as a function of the number of tests. If the number of contrasts of interest is equal to or less than the number of factor levels,

Bonferroni method is superior to Tukey (Kao & Green, 2008). The Hohm-Bonferroni test is typically used to deal with errors for multiple hypothesis tests such as those pertaining to repeated measures.

Pilot Perspectives Analysis

Pilot perspectives collected through open ended questions were preprocessed using text mining techniques and analyzed using word frequency and sentiment analysis. The narratives were processed using word and text features to visualize word frequency clouds. Bigrams were used to establish context for emotion and sentiment analysis. The emotion lexicon developed by Mohammad and Turney (2013) was used to determine the emotions and sentiments expressed by the pilots toward operating an aircraft in UAS integrated airspace and airports.

Summary

This chapter provided a detailed overview on the research methodology of this study. Detailed information of the research design, research questions, and research hypotheses were presented. A description of independent and dependent variables, as well as the data collection steps including the population, sample sizes, and sampling strategies were presented. This study used an electronic questionnaire to collect data and hence the data collection processes, participant recruitment steps, and ethical considerations were presented. Measurement instrument validity and reliability issues were discussed, and proposed methods to check and handle issues were outlined. Finally, data preparation data cleansing and analysis techniques for hypothesis testing and post hoc analysis that will be used in this research study were presented.

CHAPTER IV

RESULTS

This research study examined a pilot's willingness to operate an aircraft in unmanned aircraft system integrated airspace and airports. The purpose of this study was to determine what type of UAS integration, type of UAS operations, and airspace classification would influence pilot's perspectives and willingness to operate an aircraft in such an environment. Additionally, qualitative data on pilot perspectives for operating in such an environment were collected through closed and open ended questions. Results from the study are presented in the subsections below.

Research Tools

An electronic questionnaire hosted on SurveyMonkey (<http://www.surveymonkey.com/>) was used to collect data from the pilot population. The questionnaire was shared with five different sources: Curt Lewis Flight Safety Newsletter, Virginia Flyout Group, Aviatrix Aerogram, San Luis Obispo Ninety-Nines, and General Aviation News. Each participant or pilot group further had the option to share the questionnaire link with other pilots or pilot groups who might be interested in participating in the survey.

Each participant provided demographic information such as age, gender, geographical region, pilot qualifications, and ratings. They were presented with one of four randomly assigned scenarios that contained specific information on the UAS Integration Type and UAS Operation Type. All participants responded to their willingness to pilot an aircraft for the five Airspace Classifications of Class B, Class C, Class D, Class E, and Class G. The Willingness to Pilot an Aircraft scale created by Rice

et al. (2020) was used to capture the participants' perceptions on willingness to pilot an aircraft on the randomly assigned scenario. Pilots were also asked to provide perspectives on operating in UAS integrated airspace through closed and open-ended questions. The closed questions elicited information such as flight rules and meteorological conditions under which UAS integrated operations would be acceptable as well as any encounters with UAS or resulting evasive actions were undertaken. Open-ended questions enabled pilots to share their opinions and concerns for operating in such a UAS integrated environment.

Three hundred and sixteen responses were collected over a period of one month. Of the 316 responses, only 227 participants completed all the Willingness to Pilot an Aircraft scale questions. The final data set used in the analysis comprised of these 227 responses. All identifying responses provided by the participants interested in the prize drawing were removed prior to analysis.

Descriptive Statistics

The sample size used in the study was 227 participants, of which 51 were female, 161 were male, and 15 declined to answer. The mean age for female participants was 55.8 ($SD = 12.1$) years, while mean age for male participants was 55.9 ($SD = 15.9$) years. The mean age of all participants was 55.93 ($SD = 15.1$) years. A summary of the demographics is presented in Table 4.

Table 4

Pilot Demographics

Gender	Participants	Mean (Age)	SD (Age)	Part 121	Part 135	Part 91 (Business/ Corporate)	Part 91 (Recreational)
<i>Female</i>	51	55.8	12.1	4.8%	0.4%	2.6%	14.1%
<i>Male</i>	161	55.9	15.9	9.7%	3.5%	11.9%	45.4%
<i>Decline to answer</i>	5	58.0	19.2	0.4%	0.0%	1.3%	0.4%
<i>No Response</i>	10			1.8%	0.4%	0.4%	1.8%
<i>Total</i>	227			16.7%	4.4%	16.3%	61.7%

Eighty five percent of the participants were white Caucasian, 2.6% Asian or Asian American, 1.3% Black, 1.8% Hispanic, 3% another race or mixed race, and 7% did not provide their ethnicity. The majority of the participants, 59.5% (45.4% Male and 14.1% female), were general aviation pilots who flew recreationally. About 16.7% flew predominantly under 14 CFR Part 121 and 16.3% under 14 CFR Part 91 (Business/Corporate). Less than 5% pilots flew under 14 CFR Part 135 operations. The average flight hours for all the participants was 5,363 ($SD = 6,811$, $Median = 2,100$).

Four different conditions were used, and each participant was randomly assigned one of these conditions. The first condition (S1) described a situation where a remotely piloted, medium to large UAS was operating within the NAS in a segregated environment. Participants were tasked to respond to their willingness to pilot an aircraft in this situation under all classes of airspace. Fifty-three participants (13 female and 38 male) with a mean age of 54.8 ($SD = 15.1$) years were randomly presented with this scenario. Almost 62% of the pilots operate predominantly under 14 CFR Part 91. A summary of the pilot demographics for this condition is provided in Table 5.

Table 5

Pilot Demographics for Condition 1

Gender	Participants	Mean (Age)	SD (Age)	Part 121	Part 135	Part 91 (Business/ Corporate)	Part 91 (Recreational)
Female	13	52.8	14.9	6.3%	0.0%	4.8%	7.9%
Male	38	55.3	12.9	6.3%	6.3%	12.7%	34.9%
Decline to answer	1	59.0	-	0.0%	0.0%	1.6%	0.0%
No Response	1	-	-	0.0%	1.6%	0.0%	0.0%
Total	53	54.8	15.1	12.7%	7.9%	19.0%	42.9%

The second condition (S2) presented a situation of a remotely piloted, medium to large UAS operating within the NAS in an integrated environment. Participants were asked to respond to their willingness to pilot an aircraft in this situation under all classes of airspace. Sixty-three pilots (17 female, 43 male and 3 unknown) with average age of 57.1 ($SD = 17.2$) years were randomly assigned this scenario. Almost 78% of the participants operate under 14 CFR Part 91. A summary of pilot demographics for this scenario is provided in Table 6.

Table 6

Pilot Demographics for Condition 2

Gender	Participants	Mean (Age)	SD (Age)	Part 121	Part 135	Part 91 (Business/ Corporate)	Part 91 (Recreational)
Female	17	55.3	9.9	3.2%	0.0%	3.2%	20.6%
Male	43	58.5	15.1	9.5%	6.3%	6.3%	46.0%
Decline to answer	1	31.0	-	0.0%	0.0%	1.6%	0.0%
No Response	2	-	-	3.2%	0.0%	0.0%	0.0%
Total	63	57.1	17.2	15.9%	6.3%	11.1%	66.7%

The third condition (S3) described a situation where an autonomous, medium to large UAS was operating within the NAS in a segregated environment. Participants were likewise asked to respond to their willingness to pilot an aircraft in this situation under all classes of airspace. Fifty-six pilots (10 female, 38 male, and 8 unknown) with mean age of 55.4 ($SD = 23.0$) years were randomly assigned this scenario. Almost 70% of the pilots operate predominantly under 14 CFR Part 91. A summary of the pilot demographics is provided in Table 7.

Table 7

Pilot Demographics for Condition 3

Gender	Participants	Mean (Age)	SD (Age)	Part 121	Part 135	Part 91 (Business/ Corporate)	Part 91 (Recreational)
Female	10	56.3	15.4	4.8%	0.0%	0.0%	11.1%
Male	38	54.6	16.2	9.5%	0.0%	7.9%	41.3%
Decline to answer	2	68.0	-	0.0%	0.0%	1.6%	1.6%
No Response	6	-	-	3.2%	0.0%	1.6%	4.8%
Total	56	55.4	23.0	17.5%	0.0%	11.1%	58.7%

The fourth and last condition (S4) described a situation where an autonomous, medium to large UAS fully integrated with other aircraft was operating within the NAS. Participants are tasked to respond to their willingness to pilot an aircraft in this situation under all classes of airspace. Fifty-five pilots (11 female, 42 male, and 2 unknown gender) with mean age of 56.1 ($SD = 18.5$) years were randomly assigned this scenario. Almost 72% of the pilots operate under 14 CFR Part 91. A summary of collected data is provided in Table 8.

Table 8

Pilot Demographics for Condition 4

Gender	Participants	Mean (Age)	SD (Age)	Part 121	Part 135	Part 91 (Business/ Corporate)	Part 91 (Recreational)
Female	11	59.6	7.9	3.2%	1.6%	1.6%	11.1%
Male	42	55.0	18.8	9.5%	0.0%	15.9%	41.3%
Decline to answer	1	64.0	-	1.6%	0.0%	0.0%	0.0%
No Response	1	-	-	0.0%	0.0%	0.0%	1.6%
Total	55	56.1	18.5	14.3%	1.6%	17.5%	54.0%

As can be observed by the summary data for the four conditions, the groups have similar descriptive statistics. Along with using random assignment of participants to the conditions, this helps demonstrate group equivalency.

Reliability and Validity

The consumer Willingness to Fly in an Aircraft and the pilot Willingness to Pilot an Aircraft scales developed by Rice et al. (2020) have been shown to be valid and reliable. The scales use a 5-point Likert-type scale using seven questions. The current research used the Willingness to Pilot an Aircraft scale. The 5-point Likert-type scale asked participants to rate their responses from strongly disagree (-2) to strongly agree (+2) with a choice of zero as neutral. Reliability and validity of the measurement tool in particular, construct validity, is vital to ensure that the tool being used is measuring the intended research concept. The adapted Willingness to Pilot an Aircraft scale has already been demonstrated to be valid and reliable and was further tested with Cronbach's Alpha and Guttman's Split Half tests.

The internal consistency of the scale was tested for the five airspace classes using Cronbach's Alpha test, which resulted in an average value of .99, which indicates

extremely high consistency between items (Taber, 2018). The reliability was tested using Guttman's Split Half test for the five airspace classes, which resulted in an average value of .97, indicating extremely high reliability (Zhang & Liu, 2014). Highly correlated items that are paired off and placed into separate groups result in split-half coefficients that will reach their highest values for each of the individual airspace classes the results where greater than 0.9 indicating that the Willingness to Pilot an Aircraft scale was a reliable and valid scale, as shown in Table 9.

Table 9

Summary of Internal Consistency and Reliability Analysis

Willingness to pilot an aircraft (by Airspace)	Cronbach's Alpha	Guttman's Split Half
<i>Class B</i>	0.990	0.972
<i>Class C</i>	0.987	0.972
<i>Class D</i>	0.989	0.972
<i>Class E</i>	0.988	0.973
<i>Class G</i>	0.989	0.969

Initial Data Analysis and Assumptions Testing

There are seven assumptions that need to be considered for three-way mixed ANOVA. Three of the assumptions relate to the choice of study design, while the remaining four relate to the nature of the data. For a three-way mixed ANOVA, the dependent variable must be continuous; there must be one or more between subject factors with two or more levels (or independent categorical variables), and one or more within participant factors (or independent categorical variable) with two or more levels. The current study used two between participant factors with two levels each and one within subjects factor with five levels. The dependent variable, Willingness to Pilot an

Aircraft, was continuous, having been derived as the average value of a seven-point Likert scale.

The four data related assumptions include no significant outliers, homogeneity of variances, assumption of sphericity, and normality. IBM SPSSTM was used to test the data related assumptions.

Outliers

Descriptive statistics and boxplots were used to check for outliers. In SPSS, any data points more than 1.5 box-lengths is considered an outlier, and points more than three box-lengths are considered extreme points and are depicted with (*) along with the case number. No outliers were observed in the data, as shown for the four conditions in *Figure 3*.

Figure 3. Boxplots for the four conditions.

Homogeneity of Variances

Levene's test of homogeneity of variances was used to determine whether variances in groups on the dependent variable were equal. The results of the test indicated $p > 0.05$ for all groups, suggesting the assumption of homogeneity of variance was met. The homogeneity of variances for all airspace classes were non-significant: Class B, $p = 0.77$; Class C, $p = 0.768$; Class D, $p = 0.91$; Class E, $p = 0.646$; and Class G, $p = 0.131$.

Mauchly's Test of Sphericity

An examination of Mauchly's test indicated that sphericity was violated ($p < 0.05$), and corrections need to be applied. Two commonly used corrections are Greenhouse-Geisser and Huynh-Feldt, which are provided in SPSS in the Mauchly's Test

of Sphericity table. The values provided in the table represent epsilon, which is a measure of the degree of sphericity present. When the epsilon is less than 0.75, it is recommended that the Greenhouse-Geisser correction be used (Maxwell & Delaney, 2004). The results in the current study had an epsilon of 0.536, and the Greenhouse-Geisser correction was used.

Normality

The test for normal distribution of the dependent variable was violated according to the results of the Shapiro Wilk test, $p < 0.05$ for all the cells. In order for a distribution to be normal (i.e., $p > 0.05$), the Shapiro-Wilk test requires small sample sizes (i.e., less than 50). Considering the sample sizes used in the current study are greater than 50, other techniques were used to establish the normality of the data (Ghasemi & Zahediasl, 2012). In addition to Shapiro Wilk test, kurtosis and skewness and normal Q-Q plots were considered to determine if the assumption of normality was met. The data for all conditions was examined using Q-Q plots, and a sample of the Q-Q plots for condition 1 are shown in Figure 4 for all airspace classes. As can be seen, the data follows the normal curve fairly consistently with minor variation, as was the case across all conditions, suggesting the assumption of normality was met.

Figure 4. Q-Q plots: Segregated and remotely piloted condition for 5 airspace classes.

Skewness is the measure of asymmetry of the distribution of the variable while kurtosis is the measure of the peakedness of the distribution. To test normality using skewness and kurtosis, a z -test is applied (Kim, 2013). The z -score is calculated as follows:

$$z_{skewness} = \frac{\text{skew value}}{SE \text{ skewness}}$$

A similar z value is calculated for kurtosis.

$$z_{kurtosis} = \frac{\text{kurtosis value}}{SE \text{ kurtosis}}$$

The descriptive statistics, skewness, and kurtosis and z -scores for all the four conditions are shown in Table 10.

Table 10

Z Skewness and Z Kurtosis for the Four Conditions

Condition	Airspace	N		Std. Deviation	Skewness		Kurtosis		z skewness	z kurtosis
		Statistic	Mean		Statistic	Std. Error	Statistic	Std. Error		
S1	Class B	53	0.51	1.36	-0.62	0.33	-0.87	0.64	-1.90	-1.35
	Class C	53	0.43	1.33	-0.44	0.33	-0.98	0.64	-1.35	-1.53
	Class D	53	0.23	1.39	-0.18	0.33	-1.27	0.64	-0.56	-1.96
	Class E	53	-0.10	1.50	0.19	0.33	-1.45	0.64	0.59	-2.25
	Class G	53	-0.27	1.54	0.34	0.33	-1.44	0.64	1.04	-2.24
S2	Class B	56	0.57	1.36	-0.70	0.32	-0.74	0.63	-2.19	-1.18
	Class C	56	0.45	1.38	-0.51	0.32	-1.04	0.63	-1.60	-1.65
	Class D	56	0.19	1.39	-0.33	0.32	-1.20	0.63	-1.03	-1.91
	Class E	56	-0.21	1.29	0.01	0.32	-1.19	0.63	0.02	-1.89
	Class G	56	-0.32	1.35	0.09	0.32	-1.30	0.63	0.29	-2.07
S3	Class B	63	0.41	1.45	-0.51	0.30	-1.16	0.59	-1.69	-1.95
	Class C	63	0.19	1.29	-0.46	0.30	-0.92	0.59	-1.52	-1.55
	Class D	63	-0.08	1.28	-0.11	0.30	-1.13	0.59	-0.37	-1.90
	Class E	63	-0.14	1.26	0.05	0.30	-1.13	0.59	0.15	-1.91
	Class G	63	-0.30	1.25	0.24	0.30	-0.92	0.59	0.79	-1.55

Condition	Airspace	N		Std. Deviation	Skewness		Kurtosis		z skewness	z kurtosis
		Statistic	Mean		Statistic	Std. Error	Statistic	Std. Error		
S4	Class B	55	0.26	1.37	-0.30	0.32	-1.18	0.63	-0.93	-1.86
	Class C	55	0.15	1.28	-0.14	0.32	-1.10	0.63	-0.45	-1.74
	Class D	55	0.05	1.30	0.03	0.32	-1.21	0.63	0.10	-1.92
	Class E	55	-0.12	1.28	-0.19	0.32	-1.19	0.63	-0.58	-1.88
	Class G	55	-0.34	1.31	0.11	0.32	-1.24	0.63	0.35	-1.95

For medium sized samples ranging between $50 < n < 300$, it is recommended that the null hypothesis be rejected if the z -score is greater than 3.29, which corresponds with an alpha value of $p = 0.05$ (Kim, 2013). For the four conditions considered in this research study, the sample sizes were greater than 50, and the resulting z -scores were less than the prescribed 3.29 value. This results in the decision to retain the null hypothesis and further suggests the data can be considered to be normal.

Inferential Statistics

A three-way mixed ANOVA with two between-subjects factors with two levels each, and one within participants factor with five levels resulting in a 2x2x5 mixed factorial design was conducted in SPSS. As stated previously, the between subjects factors were UAS Integration Type and UAS Operation Type and the within subjects factor was Airspace Classification. The goal of the ANOVA analysis was to determine the main effects and interaction effects of the three independent variables on the dependent variable, Willingness to Pilot an Aircraft. The mixed ANOVA analysis was conducted using IBM SPSS TM, and the output is shown in Table 11.

Table 11

Three-way Mixed ANOVA Output

Source	df	Sum of Squares	F	Sig.	Partial Eta Squared
Airspace	2.14	86.0	64.935	<0.001	0.2255
IntegrationType	1	5.60	0.72	0.40	0.0032
OperationType	1	0.13	0.02	0.90	0.0001
IntegrationType * OperationType	1	0.00	0.001	0.98	0.0000
Airspace * IntegrationType	2.14	3.9	2.968	0.049	0.0131
Airspace * OperationType	2.14	0.4	0.275	0.775	0.0012
Airspace * IntegrationType * OperationType	2.14	1.4	1.082	0.343	0.0048

Results of the three-way mixed ANOVA indicated there was no three-way interaction between Airspace, UAS Operation Type, and UAS Integration Type, $F(2.143, 477.98) = 1.08$, $p = .343$, partial eta squared = .0048. There was no significant interaction between Airspace and UAS Operation Type, $F(2.143, 477.979) = 0.275$, $p = 0.775$, partial eta squared = 0.0012, and no two way interaction between UAS Integration Type and UAS Operation Type, $F(1, 223) = 0.001$, $p = 0.981$, partial eta squared = 0.0001. There was a statistically significant two-way interaction between Airspace and UAS Integration Type, $F(2.143, 477.979) = 2.968$, $p = 0.049$, partial eta squared = 0.0131. The simple main effects for all five levels of the within participant levels of airspace with type of UAS integration were not statistically significant at Bonferroni adjusted alpha level of $p = 0.01$, as shown in Table 12.

Table 12

Simple Main Effects for Two Way Interaction Between Levels of Airspace and Integration Type

Airspace	<i>F</i>	Sig.
Class B	1.24	0.27
Class C	2.36	0.13
Class D	1.65	0.20
Class E	0.02	0.89
Class G	0.02	0.89

The simple main effects for levels of integration type with Airspace were significant except for Class B and Class for segregated type and Class D and Class E for integrated type as shown in Table 13.

Table 13

Simple Main Effects for Levels of Integration Type with Airspace

Integration Type	(I) Airspace	(J) Airspace	Mean Difference (I-J)	Std. Error	Sig.
Segregated	Class B	Class C	0.1	0.051	0.050
		Class D	.326*	0.071	0.000
		Class E	.696*	0.091	0.000
		Class G	.865*	0.112	0.000
	Class C	Class B	-0.1	0.051	0.050
		Class D	.226*	0.056	0.000
		Class E	.596*	0.077	0.000
		Class G	.765*	0.091	0.000
	Class D	Class B	-.326*	0.071	0.000
		Class C	-.226*	0.056	0.000
		Class E	.370*	0.066	0.000
		Class G	.539*	0.082	0.000

Integration Type	(I) Airspace	(J) Airspace	Mean Difference (I-J)	Std. Error	Sig.
Integrated	<i>Class E</i>	<i>Class B</i>	-.696*	0.091	0.000
		<i>Class C</i>	-.596*	0.077	0.000
		<i>Class D</i>	-.370*	0.066	0.000
		<i>Class G</i>	.169*	0.058	0.004
	<i>Class G</i>	<i>Class B</i>	-.865*	0.112	0.000
		<i>Class C</i>	-.765*	0.091	0.000
		<i>Class D</i>	-.539*	0.082	0.000
		<i>Class E</i>	-.169*	0.058	0.004
	<i>Class B</i>	<i>Class C</i>	.165*	0.049	0.001
		<i>Class D</i>	.350*	0.068	0.000
		<i>Class E</i>	.466*	0.088	0.000
		<i>Class G</i>	.676*	0.108	0.000
	<i>Class C</i>	<i>Class B</i>	-.165*	0.049	0.001
		<i>Class D</i>	.185*	0.054	0.001
		<i>Class E</i>	.302*	0.074	0.000
		<i>Class G</i>	.511*	0.088	0.000
	<i>Class D</i>	<i>Class B</i>	-.350*	0.068	0.000
		<i>Class C</i>	-.185*	0.054	0.001
		<i>Class E</i>	0.116	0.064	0.069
		<i>Class G</i>	.326*	0.079	0.000
	<i>Class E</i>	<i>Class B</i>	-.466*	0.088	0.000
		<i>Class C</i>	-.302*	0.074	0.000
		<i>Class D</i>	-0.116	0.064	0.069
		<i>Class G</i>	.210*	0.056	0.000
	<i>Class G</i>	<i>Class B</i>	-.676*	0.108	0.000
		<i>Class C</i>	-.511*	0.088	0.000
		<i>Class D</i>	-.326*	0.079	0.000
		<i>Class E</i>	-.210*	0.056	0.000

All simple main effects were significant except for Class B and Class for segregated type of operations and Class D and Class E for integrated type of operations. The mean differences for the Class B compared to other airspace classes for segregated

operations are shown in Figure 5 and mean differences for Class D airspace compared to other airspace classes for integrated operations is shown in Figure 6.

Figure 5. Mean differences for Class B airspace with other airspace classes for segregated operations

Figure 6. Mean differences for Class D airspace compared to other airspace classes for integrated operations

There were no significant main effects for Integration Type, $F(1, 223) = 0.721$, $p = 0.397$, partial eta squared = 0.003 or for Operation Type, $F(1, 223) = 0.017$, $p = 0.897$, partial eta squared = <0.001. There was a significant main effect for Airspace, $F(2.1, 477.9) = 64.935$, $p < 0.001$, partial eta squared = 0.309. Pairwise comparisons for the five levels of airspace indicated that the mean difference was significant at $p < 0.01$ for all combinations with Bonferroni adjustment. The estimates for main effects of Airspace are shown in Table 14 and Figure 7.

Table 14

Estimates of Main Effect of Airspace

Airspace	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Class B	0.438	0.092	0.255	0.62
Class C	0.305	0.088	0.132	0.48
Class D	0.100	0.089	-0.076	0.28
Class E	-0.143	0.088	-0.318	0.03
Class G	-0.309	0.091	-0.487	-0.13

Figure 7. Main effects (with standard error bars) for the five airspace classes.

This suggests that irrespective of the UAS Operation Type and UAS Integration Type, there was a more positive effect on the pilot's willingness to pilot an aircraft in

Class B, Class C, and Class D airspace, and indicates that as the classification of airspace decreases, so does the willingness to pilot an aircraft score.

Hypothesis Testing

Four research questions and their associated null and alternate hypotheses guided this research, the purpose of which was to determine the effect Integration Type, Operation Type, and Airspace have on pilot willingness to operate an aircraft in UAS integrated airspace and airports. The first null hypothesis suggested that the Integration Type would not have an effect on pilot willingness to operate an aircraft. For research question 1 (RQ1), the null hypothesis was retained. There was no statistically significant result indicating that the integration type had no effect on pilot willingness to pilot an aircraft, $F(1, 223) = 0.721, p = 0.397$, partial eta squared = 0.0032.

The second null hypothesis suggested that Operation Type would not have an effect on pilot willingness to pilot an aircraft. For RQ2, the null hypothesis was retained. There was no statistically significant result indicating the operation type had an effect on pilot willingness to pilot an aircraft, $F(1, 223) = 0.017, p = 0.897$, partial eta squared = 0.0001.

The third null hypothesis suggested that Airspace would not have an effect on pilot willingness to pilot an aircraft. For RQ3, the null hypothesis was rejected. There was a statistically significant result indicating that Airspace had an effect on pilot willingness to pilot an aircraft, $F(2.1, 477.98) = 64.93, p < 0.001$, partial eta squared = 0.2255.

The next three null hypotheses suggested there would be no interaction between integration type and operation type, integration type and airspace, and operation type and airspace, while the last null hypothesis suggested there would be no three-way interaction between integration type, operation type, and airspace classification. For RQ4, all null hypotheses were retained, except for the interaction between integration type and airspace classification, which was rejected. A statistically significant interaction was observed for this interaction between integration type and airspace, $F(2.143, 477.98) = 2.168$, $p = 0.049$, partial eta squared = 0.0131. Although there were no significant simple main effects for levels of integration type by airspace class as shown in Table 12, there were significant simple main effects for levels of airspace by integration type as shown in Table 13. Differences were observed between Class B and Class C for segregated operations (Figure 5) and between Class D and Class for integrated operations (Figure 6).

Pilot Perspectives

Pilot perspectives were collected using a combination of closed and open-ended questions. The closed questions attempted to determine pilot awareness of UAS operations, previous encounters, and their opinions on operating with UAS under different meteorological conditions and different flight rules. The open-ended questions allowed participants to provide further opinions and concerns about operating with UAS. Forty-five percent of the pilots had previously flown a UAS and only 19% of the participants had previously encountered an UAS in flight and optionally took evasive maneuvers. The pilot opinions on flying in different meteorological conditions was as expected varied. About a third of the pilots were comfortable with flying with UAS in the

same airspace under either meteorological condition or flight rules, and about approximately a quarter of the pilots were uncomfortable with flying under either meteorological condition or flight rules.

The answers to open-ended questions provided further information on pilot perspectives for operating with UAS in the same airspace. It should be noted that the narratives, in part, were likely influenced by the personal experiences of the pilots such as past UAS encounters, awareness of the current thrust in small UAS operations such as for agricultural and package delivery uses, or the particular scenario presented to the participant in the questionnaire, among others. Typical pilot responses centered on the ability to see and avoid UAS and availability of ADS-B technology, communication, information sharing, and awareness concerns of UAS operations to both pilot and ATC, UAS airworthiness certification, operator experience, and ability of UAS operator to adhere to existing rules.

For example, a few pilots' perspectives stressed the need for airworthiness certification and ADS-B use for situation awareness:

“True integration requires UAV manufactures be held to the same Air Worthiness standards as all other aircraft manufacturers! If you want to regulate UAV pilots the same as manned pilots and regulate and require registration of UAV's similar to manned aircraft then the FAA MUST step up and demand full compliance including requiring ADSB compliance on all small and large UAV's to ensure awareness by all other pilots.”

A few pilot perspectives focused on the conditions presented in the questionnaire, for example:

“In the scenario you said “segregated”, how? Will the UAV also have ADS-B out? What data will that pilot have about me? Will they be on an IFR-like flight plan or just flying around? Too many unanswered questions.”

A few pilot perspectives focused on sUAS operating below 400 ft. for example agricultural surveillance in rural areas:

“I live in an area where agricultural UAS flights may become more a reality. As long as these UAS flights stay under the 400 ft. AGL limit I'm confident to operate my aircraft within the same airspace.”

Still others, worried about congestion, for example:

“The biggest safety threat to me is the potential proliferation of unmanned low-altitude VTOL transportation aircraft for intra-city transport, being proposed by Uber, Skyryse, and others.”

Safety was also a big factor in the narratives, for example:

“A friend of mine suffered a midair with a drone at 1800 agl in Class D airspace with his C170 in May 2018. I have firsthand knowledge — we are out there in our little airplanes and they are out there and they have little training about airspace and the peril they place us in.”

In order to gain an understanding of the key areas that were of importance to the participants, text mining techniques were used on the narratives. The pilot perspective narratives were first preprocessed to apply normalizing techniques such as lower casing and stemming. The text was first converted to lowercase and tokenized into words or text features. English stop words, white spaces, punctuation, and numbers were removed. In addition, similar words such as unmanned aircraft, UAS, UAV, drone, and the plural forms of these words were mapped to one word: UAS. Likewise, similar words such as manned aircraft, aircraft, plane, airplane, and their plural forms were mapped to aircraft. Finally, both UAS and aircraft words were removed from the tokenized words, and the word frequency cloud for the pilot perspectives was generated and is shown in Figure 8.

Figure 8. Word frequency cloud for pilot perspectives.

As already observed in the inferential testing, airspace was the biggest factor that was of particular importance to pilots for operating with UAS under the different UAS operation types and UAS integration types used in this study. Another trend observed in the above word cloud is concerns with see and avoid and ADS-B availability for safe operations.

Next, the pilot perspective narratives were further processed to understand pilots' emotions and sentiments for the different conditions by using the NRC Emotion Lexicon developed by Mohammad and Turney (2010, 2013) into the eight emotions: anger,

anticipation, disgust, fear, joy, sadness, surprise, and trust; and two sentiments: positive and negative. The processed narrative data used in the word frequency cloud was further processed to extract bigrams to determine context and processed with an emotion lexicon to determine the sentiment of the narratives. A summary of the results by emotion is presented in Figure 9.

Figure 9. Pilot perspectives by type of emotion and sentiment.

In general, the pilot perspectives were split almost evenly 50-50 between positive and negative sentiment. While there was trust and anticipation, there was also anger and fear expressed in the narratives. Next, the narrative was organized by condition, and the sentiments were compared for the four conditions as depicted in Figure 10.

Figure 10. Pilot perspectives by condition, and Type of Sentiment.

As observed previously, the sentiments expressed by the pilots is evenly spread between positive and negative emotions. Of the four conditions, the most positive emotion is observed for the condition where pilots were presented with a situation with autonomous UAS operations conducted in a segregated environment. Effective emotion

analysis can help identify trends and lead to a better understanding of pilot's perceptions. Like all opinions, sentiments are subjective (Liu, 2010; Mohammad & Turney, 2013). Further work and larger datasets are necessary in order to draw any reasonable conclusions on the changing pilot perceptions.

Summary

The purpose of this research study was to determine if integration type, operation type, and airspace classification would influence pilots willingness to operate an aircraft in UAS integrated airspace and airports. A mixed factorial ANOVA was conducted, and some significant results were identified. For the four research questions and seven associated hypotheses, all but two null hypothesis were retained. There was statistically significant main effect of airspace at all levels that influenced pilots' willingness to pilot an aircraft, which indicated that Class B, Class C, and Class D had a more positive effect on the pilots irrespective of the UAS operation type or UAS integration type. There was one statistically significant two way interaction between integration type and airspace, but there were no statistically significant simple main effects from this interaction. Pilot perspectives collected through open ended questions were also analyzed using word frequency and emotion analysis. The results from these analyses are in harmony with the ANOVA analysis highlighting airspace as the biggest factor that influences pilots willingness to pilot an aircraft. These results provide insights on pilot's perspectives and willingness to pilot an aircraft in UAS integrated airspace that could be beneficial to regulators. A discussion of these findings is presented in the following chapter.

CHAPTER V

DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

The purpose of this research study was to determine pilot's perceptions and willingness to operate an aircraft in UAS integrated airspace and airports. In this study, three independent variables: type of UAS integration, type of UAS operation, and airspace classification were used to determine what effect they had on pilot's willingness to operate an aircraft in UAS integrated environment. The two between participants variables type of UAS integration and type of UAS operation had two levels each, while the between participants variable had five levels. The two levels for type of UAS integration were segregated and integrated. The two levels for type of UAS operation were remotely piloted and autonomous. The five levels for the airspace classification were Class B, Class C, Class D, Class E, and Class G. The study also analyzed pilot's perspectives to determine emotions and sentiments expressed by pilots for such mixed operations.

The study conducted a factorial survey experiment of 316 participants and randomly presented them with a condition that included one of the two levels of each of the two between participant variables. Each participant was tasked to rate his or her willingness to pilot an aircraft scale created by Rice et al. (2020) for each of the five levels of the within participants variable. Once data were collected, they were preprocessed to test assumptions and validity and reliability of willingness to pilot an aircraft scale. A 3-way mixed ANOVA analysis was conducted using the complete data from 227 participants to answer the research questions that guided this study.

Discussion

Research has shown that the predictive power of intentions can be increased by clearly defining when, where, and how an action will be performed. Goals with clearly defined implementation intentions serve as a self-regulatory strategy helping people to effectively meet their goals in the face of problems such as tempting distractions, bad habits, and competing goals (Gollwitzer, 1999). Although, directly asking participants their intentions or willingness to perform an act has not been found to be a reliable method, a participant's willingness preferences can be measured indirectly via a systemic variation of key attributes in an experiment design (Green & Rao, 1971). Past research studies have effectively measured willingness behavior using surveys and choice experiments, among others.

Human judgment is believed to be driven by a small subset of characteristics when making decisions. Vignette experiments, also known as factorial surveys, embedded in surveys, have been effectively designed to study behavior and intentions (Rossi & Anderson, 1982). A vignette experiment consists of a collection of vignettes, or descriptions of subjects, objects, or situations in order to gather respondents' beliefs, attitudes, or intended behaviors with respect to the presented vignette. Willingness has been effectively used to measure people's attitudes toward paying for services, travelling in autonomous vehicles, and flying in autonomous vehicles, to name a few.

Vance and Malik (2015) conducted a study to investigate the main decisions that influence passenger's decisions to fly in fully autonomous airlines from the perspective of aviation and technology using eight factors in trust, safety and cost, such as automation

levels, safety records, liability guarantees, airline integrity, and service disruptions. Their study found that the three factors that had strong positive influence on the willingness to fly were service provider characteristics, automation sophistication, and system response to interruptions, and one factor that had a negative influence: contracts and guarantees provided by the airline.

In an analogous study conducted by Rice et al. (2015) to identify early adopters of autonomous aircraft, the researchers identified seven significant predictors of willingness to fly, namely, familiarity, fun factor, wariness, fear, happiness, age, and education. The factors that influence people's willingness to fly can vary based on different situations and circumstances. Technology infusion and global events can further influence people's behaviors and intentions in the short term.

In order to gather useful data about pilot's willingness to operate an aircraft in UAS integrated airspace and airports, a factorial survey experiment with three independent variables was used in the research model. Since the study was focused on human behavior and intention, i.e., pilot's willingness to operate an aircraft, three variables were selected to represent typical operational scenarios. The three independent variables: type of UAS operations, type of UAS integration, and airspace classification (along with their respective levels) represented potential operational scenarios in which mixed operations are possible in the future. The unmanned aircraft in each scenario could range from medium to large and there was no restriction on either the size or type of operation for manned aircraft or pilot experience and qualifications.

This research study used three independent variables: type of UAS integration, type of UAS operation, and airspace classification to determine pilot willingness to operate an aircraft in UAS integrated airspace and airports using a 3-way mixed ANOVA. The study was guided by four research questions, and the conclusions for each of the research questions are presented next.

Research Question 1: What type of UAS integration will affect pilot's willingness to pilot an aircraft?

The null hypothesis for this research question was that the type of UAS integration will not have any significant influence on pilot's willingness to operate an aircraft in UAS integrated airspace and airports. The alternate hypothesis was that the type of UAS integration will have a significant influence on pilot's willingness to operate an aircraft. The results of the mixed ANOVA indicated no main effect for type for UAS integration suggesting that the type of UAS integration has no effect on pilot's willingness to operate an aircraft in a mixed mode environment.

Research Question 2: What type of UAS operations will affect pilot willingness to pilot an aircraft?

The null hypothesis for this research question was that the type of UAS operation will not have any significant influence on pilot's willingness to operation an aircraft in UAS integrated airspace and airports. The alternate hypothesis was that the type of UAS operation will have a significant influence on pilot's willingness to operate an aircraft. The results of the mixed ANOVA indicated no main effect for type for UAS operation

suggesting that the type of UAS operation has no effect on pilot's willingness to operate an aircraft in a mixed mode environment.

Research Question 3: What airspace classification will affect pilot's willingness to pilot an aircraft?

The null hypothesis for this research question was that airspace classification will not have any significant influence on pilot's willingness to operate an aircraft in UAS integrated airspace and airports. The alternate hypothesis was that the airspace classification will have a significant influence on pilot's willingness to operate an aircraft. The results of the mixed ANOVA indicated a main effect for airspace classification suggesting that airspace indeed has a significant effect on pilot's willingness to operate an aircraft in a mixed mode environment. The average pilot's willingness to pilot an aircraft score differed for the different airspace classes, with the highest score being for Class B and decreasing scores with decreasing airspace classes, with the lowest for Class G.

Research Question 4: Will there be any significant interactions between the independent variables?

There were four hypothesis for this research question that explored the three two-way interactions between the three independent variables and one three-way interaction among the three variables. While each of the null hypothesis for this research question were that there would be no significant interaction between each of the two-way or three-way interaction, the alternate hypotheses were that there would be a significant interaction. The results of the mixed ANOVA indicated that there was one two-way

interaction between airspace classification and type of UAS integration. Differences in willingness to pilot an aircraft by airspace classification based on segregated and integrated operations were observed. No other two-way or three-way interaction were observed suggesting that neither of these combinations influenced pilot's willingness to operate an aircraft.

The study also compiled pilot perspectives on piloting an aircraft in mixed mode operations through open ended questions. These narratives were processed and analyzed using text mining techniques such as word frequency clouds and emotion and sentiment analysis. Results from this analysis were in harmony with the mixed ANOVA analysis. The most important factor on a pilot's mind was airspace irrespective of type of integration or type operations. The key elements of concern were situation awareness, risk and safety of operations, UAS aircraft certification and airworthiness, and UAS operator experience and regulatory conformance. The most favorable condition among the four conditions used in this study in terms of positive sentiment among the pilot participants was the fully autonomous UAS operations in segregated environment scenario.

The results of the current study, while partially in agreement with previous research conducted through surveys which had indicated that airspace was one of the key factors that influenced pilot's attitude, were also in sharp contrast to those studies based on the pilot demographics (Comstock et al, 2014; Richards & Edgell, 2018). For example, the majority of the participants in the study conducted by Comstock et al. (2014) were pilots operating out of major airports either for airlines, military, or the

business/corporate sector. In contrast, the majority of the pilots in the current study were general aviation pilots flying mostly for recreational purposes.

Comparing these two studies, while airspace was an important factor in both studies, results from the current study indicated that the pilots were more accepting of integrated UAS operations in controlled airspace such as Class B and Class C where separation services are provided by ATC to all aircraft. In contrast, a few pilots in Comstock et al.'s (2014) study indicated that UAS should be prohibited from Class B, Class C, and Class D airspace, while still others indicated rules should be more stringent for UAS operations in these airspaces. Results from Richards and Edgell's (2018) study also indicated that pilots of manned aircraft expressed moderate to extreme concern for integration into all classes of airspace with the lowest being into Class G, although no information was available on pilot demographics.

In terms of levels of automation in the UAS, pilots of manned aircraft were content with the prospect of full UAS automation, although a few indicated the necessity for sufficient redundancies or human intervention to override automation as needed to ensure safety of operations (Richards & Edgell, 2018). Although, the current study did not consider levels of automation or collect opinions from pilots about their attitudes on varying levels, two different conditions: remotely piloted, and fully autonomous were used in the hypothetical scenarios. Results from the mixed ANOVA analysis and narratives suggested that higher levels of autonomy were more acceptable to pilots of manned aircraft. This was largely influenced by skepticism on the remote pilot's lack of suitable qualifications and experience for operating in the NAS. The most positive

sentiment was expressed by pilots for the condition of a fully autonomous UAS operating segregated with other traffic.

There is considerable research on automation levels and human factors issues pertaining to human-automation interactions. Endsley (2017) rightfully identifies the automation conundrum that exists. Reliability and robustness of automation increases with increased automation, while situation awareness of human operators is reduced. The complexities of human-automation interaction between UAS, manned aircraft pilots, remote pilots, and ATC are expected to far exceed the traditional five levels as previously defined. There is a need to establish a shared situation awareness, and further research is necessary in understanding how these interactions will occur among human automation teams.

In addition, this research study considered two types of UAS integration: segregated and full integrated. Current aviation regulations are codified in 14 CFR Chapter I of the FAR to ensure that the aviation industry operates in a safe manner. To achieve the required safety of operations, there are several regulations that are imposed on manned aircraft such as airworthiness certification, aircraft categories, pilot certification, operation rules, flight rules, and airspace classes (Dalamagkidis, 2008). This traditional model is based on highly mature technologies for which standards have been developed and implemented. There are several challenges to UAS integration in the NAS, not the least since vehicle types, technologies, and tools are still evolving. Past research through surveys or analysis of NASA ASRS reports of UAS sightings have identified several human factors issues that highlight the challenges (Cardossi & Lennertz, 2017;

Yuan et al., 2014b). These research studies identified four primary human factors issues applicable that will play a vital role in the safe integration of UAS in the NAS, namely, training, communication, workload, and information sharing. This was evident in the current study as well, as was observed in the narratives analyzed from opinions submitted by pilots.

Altawy et al. (2016) conducted a survey of security, privacy, and safety aspects associated with the use of civilian drones. As the FAA continues to work on regulations to integrate UAS in the NAS, there is sparse research on how to cope with new and unforeseen threats that these new autonomous aircraft will pose. Altawy et al. (2016) address both physical and cyber threats and provide a discussion on the security properties required for their critical operational environment. They also identify the research challenges and future directions for civilian drone security, safety, and privacy.

Willingness has effectively been used to measure people's attitudes toward paying for services, travelling in autonomous vehicles, flying under different weather or other conditions, participating in noise or carbon offsetting programs, and other areas (Anania et al., 2017; Beringer & Ball, 2003; Herkimer, 2017; Jou & Chen, 2015; Hinnen, Hille, & Witmer, 2015; Knecht, Harris, & Shappell, 2005; Lu & Wang, 2018; Rice et al., 2015). Several of these studies had clearly identified that lack of awareness impacts participation or highlights ambivalence of participants (Lu & Wang, 2018; Kainz, 2016). Safety also plays a key role in participants' attitudes (Molin et al., 2017; Lee, Kim, & Sim, 2019). The more the technology infuses into society, it improves comfort level, although global events can change public opinion (Vance & Malik, 2015).

The results of this study indicated that airspace was the most important factor that influenced pilot's willingness to operate an aircraft and differences in willingness by airspace were based on segregated or integrated type. Neither type of UAS integration alone or type of UAS operation alone or other interactions between any two independent variables or among the three independent variables had any significant influence on willingness. Pilots typically operate either under VFR or IFR under well-established operational rules for communication, navigation, and surveillance that ensures safety of operations. These operating rules are defined by airspace classification, and hence pilot's perspectives for operation are guided predominantly by airspace classification. In busy congested airspace such as Class B and Class C airspace, separation services are provided by ATC irrespective of operating rules, and hence pilots were more amenable to operations in this mixed environment. In other airspace, separation services are provided for all IFR traffic and, time permitting, to VFR traffic. A combination of communication, navigation, and surveillance techniques are utilized for pilotage irrespective of equipage, type of operating rules, and nature of integration. Thus, type of integration and type of operation were of lesser importance to pilots compared to airspace classification. Further research is necessary to determine if this is true to the wider pilot population.

This study found some promising results to assess pilot willingness to operate an aircraft in UAS integrated airspace and airports. This research can be expanded upon using a similar type of methodology to study other constructs or conditions such as weather conditions or levels of automation or applied to other stakeholders such as UAS pilots or ATC to further the research and support UAS integration efforts in the NAS.

Conclusions

The current research study was aimed at understanding pilot willingness to operate an aircraft in UAS integrated airspace and airports. Three variables: type of UAS integration, type of UAS operation, and airspace classification were used to measure willingness to pilot an aircraft scale using a mixed ANOVA design. The study used the willingness to pilot an aircraft scale developed by Rice et al. (2020). Of the three independent variables that were used, airspace classification was the most important factor that influenced pilot's willingness to operate an aircraft in a mixed mode environment.

Pilot perspectives in the form of open-ended questions provided further information on their attitudes toward UAS integration. The results of the ANOVA analysis were further reinforced in the analysis of pilot emotions and sentiments expressed in narratives from open ended questions. Of the four conditions that were used in the study, pilots expressed the most positive sentiment toward the fully autonomous but segregated operations conditions. The narratives also identified other concerns that pilots of manned aircraft had toward operating in a UAS integrated environment such as risk, safety, communication, navigation, and surveillance (CNS) aspects.

This study provided a first attempt to garner pilot perceptions of operating in UAS integrated environment. The results from this study can be leveraged into future studies to better understand not only pilot perspectives but also perspectives from other stakeholders such as operators of unmanned aircraft that can lead to developing effective

integration solutions. The study can also be expanded to include other factors identified here such as CNS capabilities, risk perception, and safety related aspects.

Theoretical contributions. This study has built upon previous research on willingness to fly and willingness to pilot an aircraft model. It demonstrates that the model is valid and reliable and can be applied to measure willingness from the perspective of the pilot in manned aircraft and adds to the existing body of literature. It also demonstrates the utility of using a factorial survey experiment approach to garner pilot perspectives on specific factors that might influence behavior and willingness.

Additionally, the study provides insights on the influence of type of UAS integration, type of UAS operations, and airspace classification can have on pilot perspectives and willingness to operate an aircraft in UAS integrated airspace and airports. Although type of UAS integration and type of UAS operations are key factors that can influence integration design solutions for mixed mode operations, the biggest factor that was of concern to pilots was airspace classification. This result is in agreement with other research studies that identified airspace as one of the key factors that influenced stakeholder attitudes toward UAS integration (Comstock et al., 2014).

The study also provides insights on automation levels that might influence pilot's willingness to operate an aircraft. While the current study used only two levels: remotely piloted and fully autonomous, the findings from the study indicate pilots are more amenable to fully autonomous operations. Past research in automation has suggested that reliability and robustness increase with automation and hence trust in automation as well (Endsley, 2017).

Practical contributions. This study has contributed data-driven knowledge of how pilots' perceptions and willingness to operate an aircraft in UAS integrated airspace and airports. This is the first study to the author's knowledge to specifically seek pilot perspectives for operating a manned aircraft in such an integrated environment. The results from the study indicates that pilots of manned aircraft are more willing to pilot an aircraft in highly controlled airspace where separation services are provided by ATC to all aircraft. Though pilots expressed concerns about situation awareness, safety, and risk of UAS integrated operations, preliminary results suggest they were more amenable to fully autonomous UAS operations that are segregated from manned aircraft. This study demonstrates the importance of selecting the right combination of operations type, integration type, and airspace classification that would facilitate safety of operations among manned and unmanned aircraft in the NAS.

Limitations of the Findings

There are several limitations to the current study and its findings. The first limitation is on the sample size. Data were collected through voluntary participation from known pilot mailing lists and websites. Larger sample sizes might yield different results. Participants were recruited from Curt Lewis Safety Newsletter, Embry-Riddle pilots, General Aviation News, and local area pilots and mailing lists. A limitation of polling through such an approach was that while it enabled structured recruitment of participants, it restricted the generalizability of the study. It might not produce representativeness of pilots of all experience levels and operating environment. A similar study conducted with different demographics and experience level will yield different results. This study was

also limited by convenient and snowball sampling strategy to recruit participants, and the findings are limited to this sample population and cannot be generalized to the entire pilot population. Delimitation choices have an impact on the study. A delimitation of the study was that only three factors were considered: Type of UAS integration, Type of UAS operations, and Airspace Classification. Other delimitations of the study included the size of UAS, and assumption of operations occurring in VMC and conducted VFR, while there were no assumptions on the type of UAS applications or availability of technologies such as ADS-B (in/out) and DAA capabilities. This study did not make any assumptions on the type of missions the UAS was flying or the specific communication, navigation, and surveillance technologies that were necessary for UAS operations.

The willingness to pilot an aircraft scale, while demonstrated to be valid and reliable, could cause participant fatigue, especially when repetitively applied for the five different classes of airspace. Future research should explore other effective techniques for developing more concrete and complete hypothetical scenarios that might alleviate any fatigue among the participants, perhaps as a full between-participants study.

Recommendations

While the results of this research study are of interest and provide insights on pilot perspectives and willingness to operate an aircraft in UAS integrated airspace and airports, there is much to be explored to provide meaningful results that can be generalized to a wider population.

Recommendations for the Target Population.

This study examined pilots' perspectives and willingness to operate an aircraft in an UAS integrated environment. The responses were sought from pilots from the United States only. The majority of the responses were from general aviation pilots. A statistical significance was found to exist for Airspace Classification, and average pilot's willingness to pilot an aircraft score decreased as the classification decreased. Previous research studies have shown that pilot qualifications can influence pilot behavior, hence results from the study might not be applicable to the entire target population. Considerable differences were observed between well clear boundary perceptions between general aviation pilots and airline transport pilots and, also significant well clear boundary differences were observed between manned and unmanned intruder aircraft (Ott, 2014).

In the research surveys conducted to understand attitudes and information needs of ATC, remote pilots, and manned aircraft pilots, differences were observed among the different stakeholders (Comstock et al., 2014; Yuan & Histon, 2014a). In addition, the results from the current study which comprised predominantly of general aviation pilots was in contrast with the results from Comstock et al. (2014), which comprised primarily of airline transport pilots, regarding airspace classifications that pilots were amenable to UAS operations. Further research is necessary with broader pilot demographics and larger sample sizes to draw meaningful conclusions toward the target population and to expand the generalizability beyond the accessible population.

Further research with larger sample sizes and more diverse qualifications will provide opportunities to explore differences and commonalities among the disparate pilot

demographics to gain a better understanding of how UAS integration might impact the air traffic operations in the NAS. Exploring other factors such as communication, navigation and surveillance capabilities, perceived risk, weather conditions, levels of integration, and levels of automation might provide valuable inputs to regulators to develop solutions.

Finally, the focus of this study was predominantly on the pilot in the manned aircraft population only. To develop meaningful solutions, perspectives from all the stakeholders such as ATC, UAS operators, remote pilots, airports authority, and other stakeholders is essential. In addition, information needs for collaborative and symbiotic interactions among all the major stakeholders to ensure safe and efficient NAS are also essential to develop integration solutions. Past surveys of ATC, UAS pilots, and manned aircraft pilots have shown differences in attitudes and perceptions by the different stakeholders. Understanding these differences and drawing inferences from them will be vital to develop integration solutions.

Medium to large UAS will require infrastructure to operate such as airports and vertiports, among others, to operate. Demand, risks, safety, and cost are a few other factors that could influence geographical regions that might drive operations. Operations in urban areas can introduce issues such as noise and carbon pollution that will impact communities. Further research on these and other factors is necessary to develop safe and efficient UAS integration solutions in the NAS.

REFERENCES

- Aircraft Owners and Pilots Association [AOPA] (n.d.). What is general aviation?
Retrieved from https://www.aopa.org/-/media/files/aopa/home/advocacy/what_ga.pdf
- Anania, E. C., Mehta, R., Marte, D., Rice, S., & Winter, S. R. (2018a). Which factors predict consumer willingness to ride in driverless vehicles? In the Proceedings of the 62nd International Meeting of the Human Factors and Ergonomics Society, Philadelphia, PA.
- Anania, E., Rice, S., Winter, S., Milner, M., Walters, N., & Pierce, M. (2018b). Why people are not willing to let their children ride in driverless school buses: A gender and nationality comparison. *Social Sciences*, 7(3), 34.
- Anania, E. C., Rice, S., Walters, N. W., Pierce, M., Winter, S. R., & Milner, M. N. (2018c). The effects of positive and negative information on consumers' willingness to ride in a driverless vehicle. *Transport policy*, 72, 218-224.
- Altawy, R., & Youssef, A. M. (2016). Security, privacy, and safety aspects of civilian drones: A survey. *ACM Transactions on Cyber-Physical Systems*, 1(2), 7.
- Argrow, B., M. & Frew, E. W. (2017). UAS operations (White Paper). Retrieved from <https://www.eol.ucar.edu/system/files/Operations%20White%20Paper.pdf>
- Armitage, C. J., & Conner, M. (1999). The theory of planned behaviour: Assessment of predictive validity and perceived control. *British Journal of Social Psychology*, 38(1), 35-54.
- Armitage, C. J., & Conner, M. (2001). Efficacy of the theory of planned behaviour: A meta-analytic review. *British Journal of Social Psychology*, 40(4), 471-499
- Auspurg, K., & Hinz, T. (2014). *Factorial survey experiments* (Vol. 175). Sage Publications, Thousand Oaks, CA.
- Breidert, C., Hahsler, M., & Reutterer, T. (2006). A review of methods for measuring willingness-to-pay. *Innovative Marketing*, 2(4), 8-32.
- BBC News (2019). Drones 'endangered aircraft' 18 times in three months. Retrieved from <https://www.bbc.com/news/uk-46919876>
- Beringer, D. B., & Ball, J. D. (2003, October). Effects of NEXRAD graphical data resolution and direct weather viewing on pilot judgments of weather severity and willingness to continue flight. In *Proceedings of the Human Factors and*

Ergonomics Society Annual Meeting (Vol. 47, No. 1, pp. 26-30). Sage CA: Los Angeles, CA: SAGE Publications.

- Cardossi, K. & Lennertz, T. (2017). Human factors considerations for the integration of unmanned aerial vehicles in the National Airspace System: An analysis of reports submitted to the aviation safety reporting system (ASRS). DOT-VNTSC-FAA-17-11. Retrieved from <https://ntlrepository.blob.core.windows.net/lib/61000/61900/61977/DOTVNTSCFAA1711.pdf>
- Clothier, R. A., Greer, D. A., Greer, D. G., & Mehta, A. M. (2015). Risk perception and the public acceptance of drones. *Risk Analysis*, 35(6), 1167-1183. doi:10.1111/risa.12330
- Comstock, Jr, J. R., McAdaragh, R., Ghatas, R. W., Burdette, D. W., & Trujillo, A. C. (2014). UAS in the NAS: Survey responses by ATC, manned aircraft pilots, and UAS pilots. *Proceedings of the 17th International Symposium on Aviation Psychology* (pp. 383-388).
- Congress. (2012). Public Law 112-95. Retrieved from <https://www.congress.gov/112/plaws/publ95/PLAW-112publ95.pdf>
- Cook, T. D., Campbell, D. T., & Shadish, W. (2002). *Experimental and quasi-experimental designs for generalized causal inference*. Boston: Houghton Mifflin.
- Creswell, J. W. (2014). *Research design: qualitative, quantitative, and mixed methods approaches* (4th ed.). Thousand Oaks, CA: SAGE Publications.
- Duarte, C. M. (2008). Willingness to pay for noise reduction in residential areas affected by airport traffic: the case of Barcelona. In 15th Annual Congress of the European Real Estate Society.
- Dalamagkidis, K., Valavanis, K. P., & Piegl, L. A. (2008). On unmanned aircraft systems issues, challenges and operational restrictions preventing integration into the National Airspace System. *Progress in Aerospace Sciences*, 44(7-8), 503-519.
- Dalamagkidis, K. (2015a). Definitions and Terminology. In Valavanis, K. P., & Vachtsevanos G., T. (Eds.), *Handbook of Unmanned Aerial Vehicles* (pp. 43-55). <https://doi.org/10.1007/978-90-481-9707-1>
- Dalamagkidis, K. (2015b). Aviation history and unmanned flight. In Valavanis, K. P., & Vachtsevanos G., T. (Eds.), *Handbook of Unmanned Aerial Vehicles* (pp. 57-81). <https://doi.org/10.1007/978-90-481-9707-1>

- Dalamagkidis, K. (2015c). Classification of UAVs. In Valavanis, K. P., & Vachtsevanos G., T. (Eds.), *Handbook of Unmanned Aerial Vehicles*. (pp. 83-91).
<https://doi.org/10.1007/978-90-481-9707-1>
- de Winter, J., & Dodou, D. (2017). Human subject research for engineers: A practical guide. 10.1007/978-3-319-56964-2
- Drasch, K. (2017). Behavioral intentions, actual behavior and the role of personality traits. Evidence from a factorial survey among female labor market re-entrants. *Methods, Data, Analyses*, 13(1), (pp. 267-290).
- Drost, E. A. (2011). Validity and reliability in social science research. *Education Research and perspectives*, 38(1), 105.
- Endsley, M. R., & Kaber, D. B. (1999). Level of automation effects on performance, situation awareness and workload in a dynamic control task. *Ergonomics*, 42(3), 462-492.
- Endsley, M. R. (2017). From here to autonomy: Lessons learned from human–automation research. *Human factors*, 59(1), 5-27.
- Eyerman, J., Letterman, C., Pitts, W., Holloway, J., Hinkle, K., Schanzer, D., ... & Kaydos-Daniels, S. (2013). *Unmanned aircraft and the human element: Public perceptions and first responder concerns (Research brief)*. Research Triangle Park, NC: Institute for Homeland Security Solutions.
- Faul, F., Erdfelder, E., Lang, A. G., & Buchner, A. (2007). G* Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, 39(2), 175-191.
- Faul, F., Erdfelder, E., Buchner, A., & Lang, A. G. (2009). Statistical power analyses using G* Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods*, 41(4), 1149-1160.
- Federal Aviation Administration [FAA]. (n.d.-a). Appendix A: National Airspace System overview. Retrieved from
https://www.faa.gov/air_traffic/nas/nynjphl_redesign/documentation/feis/media/Appendix_A-National_Airspace_System_Overview.pdf
- Federal Aviation Administration [FAA]. (n.d.-a). Focus area Pathfinder program. Retrieved from https://www.faa.gov/uas/programs_partnerships/focus_area_pathfinder/

Federal Aviation Administration [FAA]. (n.d.-b). FAA UAS data exchange. Retrieved from https://www.faa.gov/uas/programs_partnerships/uas_data_exchange/

Federal Aviation Administration [FAA]. (n.d.-c). UAS facility maps. Retrieved from https://www.faa.gov/uas/request_waiver/uas_facility_maps/

Federal Aviation Administration [FAA]. (n.d.-d). UAS integration pilot program. Retrieved from https://www.faa.gov/uas/programs_partnerships/uas_integration_pilot_program/

Federal Aviation Administration [FAA]. (n.d.-e). Integration pilot program awardees. Retrieved from https://www.faa.gov/uas/programs_partnerships/uas_integration_pilot_program/awardees

Federal Aviation Administration [FAA]. (2013). Integration of civil unmanned aircraft systems (UAS) in the National Airspace System (NAS) roadmap. Retrieved from https://www.faa.gov/uas/media/UAS_Roadmap_2013.pdf

Federal Aviation Administration [FAA]. (2015). Amazon gets experimental airworthiness certificate. Retrieved from <https://www.faa.gov/news/updates/?newsId=82225>

Federal Aviation Administration [FAA]. (2016a). Advisory Circular 107-2. Small unmanned aircraft systems (sUAS). Retrieved from http://www.faa.gov/uas/media/AC_107-2_AFS-1_Signed.pdf

Federal Aviation Administration [FAA]. (2016b). Unmanned aircraft systems Order JO 7200.23. Retrieved from https://www.faa.gov/documentLibrary/media/Order/FAA_JO_7200_23_2.pdf

Federal Aviation Administration [FAA]. (2017a). Registration deletion. Retrieved from https://www.faa.gov/uas/getting_started/registration_deletion/

Federal Aviation Administration [FAA]. (2017b). Unmanned aircraft systems (UAS) frequently asked questions. Retrieved from <https://www.faa.gov/uas/faqs/>

Federal Aviation Administration [FAA]. (2017c). UAS traffic management (UTM) Research Transition Team (RTT) plan. Retrieved from https://www.faa.gov/uas/research/utm/media/FAA_NASA_UAS_Traffic_Management_Research_Plan.pdf

Federal Aviation Administration [FAA]. (2018a). Integration of civil unmanned aircraft systems (UAS) in the National Airspace System (NAS) roadmap. Retrieved from https://www.faa.gov/uas/resources/uas_regulations_policy/media/Second_Edition_Integration_of_Civil_UAS_NAS_Roadmap_July%202018.pdf

- Federal Aviation Administration [FAA]. (2018b). FAA Reauthorization bill establishes new conditions for recreational use of drones. Retrieved from <https://www.faa.gov/news/updates/?newsId=91844>
- Federal Aviation Administration [FAA]. (2018c). Concept of operations v1.0. Unmanned aircraft systems (UAS) traffic management (UTM). Retrieved from <https://utm.arc.nasa.gov/docs/2018-UTM-ConOps-v1.0.pdf>
- Federal Aviation Administration [FAA]. (2019a). Administrators fact book. Retrieved from https://www.faa.gov/news/media/2019_Administrators_Fact_Book.pdf
- Federal Aviation Administration [FAA]. (2019b). FAA releases 2019 to 2039 aerospace forecast. Retrieved from https://www.faa.gov/data_research/aviation/aerospace_forecasts/media/FY2019-39_FAA_Aerospace_Forecast.pdf
- Fishbein, M., & Ajzen, I. (2011). Predicting and changing behavior: The reasoned action approach. Psychology Press, New York, NY.
- Gettinger, D. (2018). Public safety drones: An update. Retrieved from <https://dronecenter.bard.edu/files/2018/05/CSD-Public-Safety-Drones-Update-1.pdf>
- Ghasemi, A., & Zahediasl, S. (2012). Normality tests for statistical analysis: a guide for non-statisticians. *International Journal of Endocrinology and Metabolism*, 10(2), 486.
- Gibbons, F. X., & Gerrard, M. (1995). Predicting young adults' health risk behavior. *Journal of Personality and Social Psychology*, 69(3), 505.
- Glaab, L. J., Dolph, C. V., Young, S. D., Coffey, N. C., McSwain, R. G., Logan M. J. and Harper, D. E. (2018). Small unmanned aerial system (UAS) flight testing of enabling vehicles technologies for the UAS traffic management project. NASA/TM-2018-219816. Retrieved from: https://utm.arc.nasa.gov/docs/2018-Glaab_NASA-TM-219816.pdf
- Gollwitzer, P. M. (1999). Implementation intentions: Strong effects of simple plans. *American Psychologist*, 54(7), 493.
- Green, P. E., & Rao, V. R. (1971). Conjoint measurement-for quantifying judgmental data. *Journal of Marketing Research*, 8(3), 355-363.
- Groves, R. M., Fowler, Jr, F. J., Couper, M. P., Lepkowski, J. M., Singer, E., & Tourangeau, R. (2011). *Survey Methodology* (Vol. 561). John Wiley & Sons, Hoboken, NJ.

- Gupta, S. G., Ghonge, M. M., & Jawandhiya, P. (2013). Review of unmanned aircraft system (UAS). *International Journal of Advanced Research in Computer Engineering & Technology (IJARCET)*, 2(4), 1647–1658.
- Hassanalian, M., and Abdelkefi A. (2017). Classifications, applications, and design challenges of drones: A review. *Progress in Aerospace Sciences*, 91, 91-131.
- Hayhurst, K. J., Maddalon, J. M., Morris, A. T., Neogi, N., Verstynen, H. A., & Llc, W. E. (2014). A review of current and prospective factors for classification of civil unmanned aircraft systems. NASA/TM-2014-218511. Retrieved from <https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20140011501.pdf>
- Herkimer, J. C. (2017). The psychological health of airline pilots: A flight deck crew's perceptions and willingness to fly (Order No. 10818001). Available from ProQuest Dissertations & Theses Global. (2026209682). Retrieved from <http://search.proquest.com.ezproxy.libproxy.db.erau.edu/docview/2026209682?accountid=27203>
- Hinnen, G., Hille, S. L., & Wittmer, A. (2017). Willingness to pay for green products in air travel: Ready for take-off?. *Business Strategy and the Environment*, 26(2), 197-208.
- Ivanova, G. A. (2013). Consumers' willingness to pay for electricity from renewable energy sources, Queensland, Australia. *International Journal of Renewable Energy Research (IJRER)*, 2(4), 758-766.
- Johnson, J., Rios, J., Mercer, J., Homola, J., Prevot, T., Mulfinger, D., and Kopardeker, P. (2017). Flight test evaluation of an unmanned aircraft system traffic management (UTM) concept for beyond-visual-line-of-sight operations. Twelfth USA/Europe Air Traffic Management Research and Development Seminar (ATM2017).
- Jou, R. C., & Chen, T. Y. (2015). Willingness to pay of air passengers for carbon-offset. *Sustainability*, 7(3), 3071-3085.
- Kainz, U. (2016). Consumers' willingness to pay for durable biobased plastic products: Findings from an experimental auction (Doctoral dissertation, Technische Universität München).
- Kamienski, J., & Semanek, J. (2015). ATC perspectives of UAS integration in controlled airspace. *Procedia Manufacturing*, 3, 1046–1051.
- Kao, L. S., & Green, C. E. (2008). Analysis of variance: Is there a difference in means and what does it mean? *Journal of Surgical Research*, 144(1), 158-170.

- Keane, J. F., & Carr, S. S. (2013). A brief history of early unmanned aircraft. *John Hopkins APL Technical Digest*, 32(3), 558–571.
- Kim, H. Y. (2013). Statistical notes for clinical researchers: Assessing normal distribution (2) using skewness and kurtosis. *Restorative Dentistry & Endodontics*, 38(1), 52-54.
- Knecht, W. R. (2005). Pilot willingness to take off into marginal weather. Part 2. Antecedent overfitting with forward stepwise logistic regression. Retrieved from <http://www.dtic.mil/dtic/tr/fulltext/u2/a460841.pdf>
- Knecht, W., Harris, H., & Shappell, S. (2005). The influence of visibility, cloud ceiling, financial incentive, and personality factors on general aviation pilots' willingness to take off into marginal weather, Part 1: The data and preliminary conclusions. Retrieved from <http://www.dtic.mil/dtic/tr/fulltext/u2/a460734.pdf>
- Kopardekar, P., Rios, J., Prevot, T., Johnson M., Jung, J., & Robinson, J., E. III. (2016). Unmanned aircraft system traffic management (UTM) concept of operations. 16th AIAA Aviation Technology, Integration, and Operations Conference, Washington DC.
- Kreps, S. (2014). Flying under the radar: A study of public attitudes towards unmanned aerial vehicles. *Research and Politics*, 1(1), (pp.1-7).
- Lascara, B., Spencer, T., DeGarmo, M., Lacher, A., Maroney, D., & Gutierrez, M. (2018). Urban air mobility landscape report: Initial examination of a new air transportation system. MITRE Case: 18-0154-14. Retrieved from: <https://www.mitre.org/sites/default/files/publications/pr-18-0154-4-urban-air-mobility-landscape-report.pdf>
- Lascara, B., Lacher, A., DeGarmo, M., Maroney, D., Niles, R., & Vempati, L. (2019). Urban air mobility airspace integration concepts. Retrieved from: <https://www.mitre.org/sites/default/files/publications/pr-19-00667-9-urban-air-mobility-airspace-integration.pdf>
- Lammers, W. J., & Badia, P. (2004). Fundamentals of behavioral research. Recording for the Blind & Dyslexic. Retrieved from <http://uca.edu/psychology/fundamentals-of-behavioral-research-textbook/>
- Lee, J. K., Kim, S. H., & Sim, G. R. (2019). Mode choice behavior analysis of air transport on the introduction of remotely piloted passenger aircraft. *Journal of Air Transport Management*, 76, 48-55.

- Le Gall-Ely, M. (2009). Definition, measurement and determinants of the consumer's willingness to pay: a critical synthesis and avenues for further research. *Recherche et Applications en Marketing (English Edition)*, 24(2), 91-112.
- Levin, A. (2019, Jan 22). Newark pilot says drone 'probably 20 feet, 30 feet' from wing. Bloomberg. Retrieved from <https://www.bloomberg.com/news/articles/2019-01-22/newark-airport-flights-are-halted-by-faa-after-reports-of-drones>
- Liu, B. (2010). Sentiment analysis and subjectivity. *Handbook of natural language processing*, 2(2010), 627-666.
- Lu, J. L., & Wang, C. Y. (2018). Investigating the impacts of air travelers' environmental knowledge on attitudes toward carbon offsetting and willingness to mitigate the environmental impacts of aviation. *Transportation Research Part D: Transport and Environment*, 59, 96-107.
- Maharana, S. (2017). Commercial drones. *International Journal of Management and Applied Science (IJMAS)*, 5(1), 96-101.
- Mathers, N., Fox, N., & Hunn, A. (2007). Surveys and questionnaires. The NIHR RDS for the East Midlands / Yorkshire & the Humber. Retrieved from https://www.rds-yh.nihr.ac.uk/wp-content/uploads/2013/05/12_Surveys_and_Questionnaires_Revision_2009.pdf
- McCarley, J., S. and Wickens, C. D. (2014). Human factors implications of UAVs in the national airspace. Retrieved from <http://aspheramedia.com/wp-content/uploads/2014/12/uavPlanFinal.pdf>
- Mehta, R., Rice, S., Winter, S. R., & Oyman, K. (2014, September). Consumers' perceptions about autopilots and remote-controlled commercial aircraft. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* (Vol. 58, No. 1, pp. 1834-1838). Sage CA: Los Angeles, CA: SAGE Publications.
- Mehta, R., Rice, S., Winter, S., & Eudy, M. (2017). Perceptions of cockpit configurations: A culture and gender analysis. *The International Journal of Aerospace Psychology*, 27(1-2), 57-63.
- Mohammad, S. M., & Turney, P. D. (2010, June). Emotions evoked by common words and phrases: Using mechanical turk to create an emotion lexicon. In *Proceedings of the NAACL HLT 2010 workshop on computational approaches to analysis and generation of emotion in text* (pp. 26-34).
- Mohammad, S. M., & Turney, P. D. (2013). Crowdsourcing a word-emotion association lexicon. *Computational Intelligence*, 29(3), 436-465.

- Molin, E., Blangé, J., Cats, O., & Chorus, C. (2017). Willingness to pay for safety improvements in passenger air travel. *Journal of Air Transport Management*, 62, 165-175.
- Mueller, E. R., Kopardekar, P. H., & Goodrich, K. H. (2017). Enabling airspace integration for high-density on-demand mobility operations. In 17th AIAA Aviation Technology, Integration, and Operations Conference (p. 3086).
- National Aeronautics and Space Administration [NASA] (2017). NASA embraces urban air mobility, calls for market study. Retrieved from <https://www.nasa.gov/aero/nasa-embraces-urban-air-mobility>
- Neubauer K., Fleet, D., Grosoli, F., Verstynen, H. (2015). Unmanned aircraft system (UAS) at airports: A primer. Airport Cooperative Research Program (ACRP) Report No. 144. Retrieved from http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_144.pdf
- Newcome, L. R. (2004). Unmanned aviation: A brief history of unmanned aerial vehicles. Reston, VA: American Institute of Aeronautics and Astronautics, Inc. doi:10.2514/4.868894
- Nisser, T., and Westin, C. (2006). Human factors challenges in unmanned aerial vehicles (UAVs): A literature review. Retrieved from: https://www.researchgate.net/publication/228768198_Human_factors_challenges_in_unmanned_aerial_vehicles_uavs_A_literature_review
- Ott, J. T. (2015). Well clear: General aviation and commercial pilots' perception of unmanned aerial vehicles in the national airspace system. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, 59(1), 60-64. doi:10.1177/1541931215591013
- Pereira, P. T., Almeida, A., de Menezes, A. G., & Vieira, J. C. (2009). Willingness to pay for airline services: A stated choice experiment. In *Advances in Tourism Economics* (pp. 165-173). Physica-Verlag, Heidelberg, Germany.
- Pestana M. E. (2011). Flying unmanned aircraft: A pilot's perspective. Infotech at Aerospace, St Louis, MO. Retrieved from: <https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20110011979.pdf>
- Petzold, K., & Moog, P. (2018). What shapes the intention to study abroad? An experimental approach. *Higher Education*, 75(1), 35-54.
- Polaczyk, N., Trombino, E., Wei, P., & Mitic . (2019). A review of current technology and research in urban on-demand air mobility applications. Vertical Flight Society Autonomous VTOL Technical Meeting and Electrical VTOL. Mesa, Arizona.

- Pomery, E. A., Gibbons, F. X., Reis-Bergan, M., & Gerrard, M. (2009). From willingness to intention: Experience moderates the shift from reactive to reasoned behavior. *Personality and Social Psychology Bulletin*, 35(7), 894-908.
- Porsche Consulting. (2018). The future of vertical mobility. Sizing the market for passenger, inspection, and goods services until 2035. A Porsche Consulting Study. Retrieved from <https://fedotov.co/wp-content/uploads/2018/03/Future-of-Vertical-Mobility.pdf>
- Qaisrani, I. H., Ali, L. A., Mirza, M. N., & Naqvi, A. A. (2016). Unmanned aerial vehicles: A revolution in the making. *South Asian Studies A Research Journal of South Asian Studies*, 31(2), 243–256. Retrieved from <http://web.a.ebscohost.com.salford.idm.oclc.org/ehost/pdfviewer/pdfviewer?sid=ab80ac3-a1d6-44bc-b34e-cd0120e514b2%40sessionmgr4008&vid=1&hid=4206>
- Rice, S., Dunbar, V., Ghosal, S., Mehta, R., Oni, M. A., Oni, M. D., & Oyman, K. (2015). A valid and reliable scale for consumer willingness to fly. *Proceedings of the 2015 Aviation, Aeronautics, and Aerospace International Research Conference*, 7, pp. 200-215
- Rice, S., Winter, S. R., Mehta, R., & Ragbir, N. K. (2019). What factors predict the type of person who is willing to fly in an autonomous commercial airplane? *Journal of Air Transport Management*, 75, 131-138.
- Rice, S., Winter, S. R., Capps, J., Trombley, J., Robbins, J. Milner, M. N., & Lamb, T. L. (2020). Creation of two valid scales: Willingness to fly in an aircraft and willingness to pilot an aircraft. *The International Journal of Aviation, Aeronautics, and Aerospace*, 7(1), 1-21.
- Richards, D., & Edgell, S. (2017). Attitudes toward UAV integration into the National Airspace System. In *17th AIAA Aviation Technology, Integration, and Operations Conference* (p. 3939).
- Rao, B., Gopi, A. G., & Maione, R. (2016). The societal impact of commercial drones. *Technology in Society*, 45, 83-90.
- Rossi, P. & Anderson, A. (1982) The Factorial Survey Approach: An Introduction. In Rossi, P. and Nock, S. (Eds.), *Measuring Social Judgments: The Factorial Survey Approach*, Sage, Beverly Hills, CA, (pp. 1-25).
- Sharma, R. and Mishra, R. (2014). A review of evolution of theories and models of technology adoption. *Indore Management Journal*, 6(2), pp. 17–29.

- Shaw, I. G. R. (n.d.). The history of U.S. drones. Retrieved from <https://understandingempire.wordpress.com/2-0-a-brief-history-of-u-s-drones/>
- Sheridan, T. B., & Parasuraman, R. (2006). Human-automation interaction. *Reviews of Human Factors and Ergonomics*, 1, 89–129
- Shibli, M. A. (2015). Towards global unification of UAS standardization: Regulations, systems, airworthiness, aerospace control, operation, crew licensing and training. *International Journal of Unmanned Systems Engineering*, 3(2), 32. doi:10.14323/ijuseng.2015.7
- Smith, C. J., & Taylor, N. W. (2013). Controlling UAS flight operations in a mixed-mode environment today. *Integrated Communications, Navigation and Surveillance Conference (ICNS)*, 2013. doi:10.1109/ICNSurv.2013.6548543
- Smith, J. C., Viken, J. K., Guerreiro, N. M., Dollyhigh, S. M., Fenbert, J. W., Hartman, C. L., ... & Moore, M. D. (2012, September). Projected demand and potential impacts to the national airspace system of autonomous, electric, on-demand small aircraft. In *12th AIAA Aviation Technology, Integration, and Operations (ATIO) Conference and 14th AIAA/ISSM, AIAA* (Vol. 5595).
- Suryanegara, M., Asvial, M., & Raharya, N. (2015). System engineering approach to the communications technology at unmanned aircraft system (UAS). In *2015 IEEE International Symposium on Systems Engineering (ISSE)* (pp. 475-480).
- Szondy, D. (2013, June). Beyond military UAS- the future of unmanned flight. *New Atlas*. Retrieved from <https://newatlas.com/uav-future-of-unmanned-flight/27478/>
- Taber, K. S. (2018). The use of Cronbach's alpha when developing and reporting research instruments in science education. *Research in Science Education*, 48(6), 1273-1296.
- Thipphavong, D. P., Apaza, R., Barmore, B., Battiste, V., Burian, B., Dao, Q., ... & Idris, H. R. (2018). Urban air mobility airspace integration concepts and considerations. In *2018 Aviation Technology, Integration, and Operations Conference* (p. 3676).
- Uber Elevate. (2016). Fast forwarding to a future of on-demand urban air transportation. Retrieved from <https://www.uber.com/elevate.pdf>
- U.S. Army. (n.d.). U.S. Army roadmap for UAS 2010-2035. Retrieved from <http://www.rucker.army.mil/usaace/uas/US Army UAS Roadmap 2010 2035.pdf>
- U.S. Department of Transportation [US DOT] (2014). FAA's progress and challenges in integrating unmanned aircraft systems into the National Airspace System. Statement of Mathew E. Hampton before the Committee on Transportation and

- Infrastructure Subcommittee on Aviation. Retrieved from https://www.oig.dot.gov/sites/default/files/UAS%20Statement_Master%20File_12-9-14_Final_508.pdf
- Vance, S. M., & Malik, A. S. (2015). Analysis of factors that may be essential in the decision to fly on fully autonomous passenger airliners. *Journal of Advanced Transportation*, 49(7), 829-854.
- Vogt, W. P., Gardner, D. C., & Haeffele, L. M. (2012). *When to use what research design*. New York: NY: Guilford Press.
- Wallace, R. J., Loffi, J. M., Vance, S. M., Jacob, J., Dunlap, J. C., & Mitchell, T. A. (2018). Pilot visual detection of small unmanned aircraft systems (sUAS) equipped with strobe lighting. *Journal of Aviation Technology and Engineering*, 7(2), 5.
- Wallander, L. (2009). 25 years of factorial surveys in sociology: A review. *Social Science Research*, 38(3), 505-520.
- Warshaw, P. R., & Davis, F. D. (1985). Disentangling behavioral intention and behavioral expectation. *Journal of Experimental Social Psychology*, 21(3), 213-228.
- Wallace, R. J., Kiernan, K. M., Haritos, T., Robbins, J., & Loffi, J. M. (2019). Evaluating small UAS operations and National Airspace System interference using AeroScope. *Journal of Aviation Technology and Engineering*, 8(2), 24.
- White House. (2017). Presidential memorandum for the Secretary of Transportation. Retrieved from <https://www.whitehouse.gov/the-press-office/2017/10/25/presidential-memorandum-secretary-transportation>
- Wiggins, M. W., & Stevens, C. (2016). *Aviation social science: Research methods in practice*. Routledge, New York, NY.
- Winter, S. R., Carryl, J., & Rice, S. (2015). Controlled rest in position (CRIP): Consumer perceptions in the United States. *Collegiate Aviation Review*, 33(1), (pp. 14-28).
- Winter, S. R., Rice, S., Tamilselvan, G., & Tokarski, R. (2016). Mission-based citizen views on UAV usage and privacy: an affective perspective. *Journal of Unmanned Vehicle Systems*, 4(2), 125–135.
- Winter, S. R., Keebler, J. R., Rice, S., Mehta, R., & Baugh, B. S. (2018a). Patient perceptions on the use of driverless ambulances: An affective perspective. *Transportation Research Part F: Traffic Psychology and Behaviour*, 58, 431-441.

- Winter, S. R., Rice, S., Mehta, R., Walters, N. W., Pierce, M. B., Anania, E. C., ... & Rao, N. (2018b). Do Americans differ in their willingness to ride in a driverless bus? *Journal of Unmanned Vehicle Systems*, 6(4), 267-278.
- Woo, G. S. (2017). Visual detection of small unmanned aircraft: Modeling the limits of human pilots. *Dissertations and Theses*. 350. <http://commons.erau.edu/edt/350>
- Yao, Y., Xia, H., Huang, Y., & Wang, Y. (2017, May). Free to fly in public spaces: Drone controllers' privacy perceptions and practices. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems* (pp. 6789-6793).
- Yuan, X. & Histon, J. M. (2014a). Survey of air traffic controller and pilot's experience with unmanned aircraft systems. Technical Report No. HCOM – 2014 – 02. Retrieved from https://uwaterloo.ca/humans-complex-systems-lab/sites/ca.humans-complex-systems-lab/files/uploads/files/tech_report_yuan_x_histon_j_survey.pdf
- Yuan, X., Histon, J. M., & Waslander, S. (2014b). Survey of operators' unmanned aircraft systems experience. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, 58(1), 31-35. 10.1177/1541931214581007
- Zhang, J., & Lyu, J. (2014). Reliability, validity and preliminary hypothesis tests for the English version of the Psychological Strain Scales (PSS). *Journal of affective disorders*, 164, 69–75. doi:10.1016/j.jad.2014.04.011

APPENDIX A

ERAU Internal Review Board (IRB) Application Form

Campus: World Wide

College: Aeronautics – World Wide

Applicant: Student

Degree Level: PhD

Project Title: Pilots' Willingness to Pilot an Aircraft in UAS Integrated Airports based on Integration, Operation Type, and Airspace Classification: An Experimental Analysis

Principal Investigator: Lakshmi Vempati

List all Other Investigators: Dr. Scott Winter

Submission Date: 03/31/2019

Beginning Date: 05/07/2019

Expected End Date: 04/31/2020

Type of Project: Survey

Type of Funding Support (if any): None

Other Explain:

Please answer the following questions and provide a brief explanation of the answer for each.

- 1. Background and Purpose: Briefly describe the background and purpose of the research including your hypothesis or primary objective and its rationale.**

The purpose of this research is to collect data on pilot perceptions and willingness to pilot an aircraft from an UAS integrated airport and to examine factors such as UAS integration type, UAS operations, airspace classification, and other demographical factors that influence pilots' choices. The collected data will present descriptive information that will be used to facilitate safe integration of UAS in the National Airspace System.

Please describe briefly how this study will contribute to existing knowledge in the field

The existing knowledge in the field is focused on identifying public perspectives on privacy and commercial uses of UAS in the NAS. There is little research focused on pilot perceptions and willingness to operate in an UAS integrated environment. This research will contribute to the existing field by assisting in the development of pilot perceptions and willingness to operate in UAS integrated airspace and airports and hence facilitate their safe and efficient integration.

- 2. Design, Procedures, Materials and Methods: Describe the details of the procedure to be used and the type of data that will be collected.**

An electronic questionnaire will be used to collect the data for this research project. A cross-sectional design will be used to design the questionnaire since time is of no essence

and the participants will be polled only once. The electronic questionnaire will include a combination of Likert scale, semantic differential scaling and free listing questions. A web-based tool, Survey Monkey, will be used to host the questionnaire and to collect attitudinal data from participants.

3. Measures and Observations: What measures or observations will be taken in the study? If any questionnaires, tests, or other instruments are used, provide a brief description and include a copy for review (computer programs may require demonstration at the request of the IRB).

During the study, participants will be asked about their willingness to pilot an aircraft in an UAS integrated airport and airspace. Demographic questions such as age, gender, flight experience, and aircraft ratings will also be asked. Participants will be asked their perspectives of what conditions such as UAS integration type, UAS operations types and class of airspace might influence their perspectives and willingness to pilot an aircraft. A copy of the instrument is attached for review.

4. Risks and Benefits: Describe any potential risks to the dignity, rights, health or welfare of the human subjects. Assess the potential benefits to be gained by the subjects as well as to society in general as a result of this project. Briefly assess the risk-benefit ratio.

The risks by taking part in this study are not anticipated to pose any greater risk than normal daily activities. The risk includes the possibility that the participants may be offended by some of the questions in the electronic questionnaire. While there is a possibility to participate and win in the drawing for a drone, other than that, the study will not benefit the participants personally. This study is intended to benefit academicians, regulators and technology developers, specifically contributing to integration of unmanned aircraft systems into the national airspace.

5. Informed Consent: Describe the procedures you will use to obtain informed consent of the subjects and the debrief/feedback that will be provided to participants. See Informed Consent Guidelines for more information on Informed Consent requirements. (The consent document must be submitted with this application for review.)

The questionnaire will include a detailed introductory section that outlines the study leadership, purpose, eligibility, participation, risks, benefits, compensation, voluntary participation, confidentiality, further information and consent. See the attached documents for details. The study will be conducted with an electronic questionnaire. The participants will have an opportunity to provide informed consent before beginning the questionnaire. Additionally, they can choose not to answer any questions or opt out of the questionnaire at any time.

6. Anonymity: Will participant information be: (Check appropriate box.)

Confidential. Names or any other identifying demographics can be matched, but only members of the research team will have access to that information. Publication of the data will not include any identifying information.

Justify the classification and describe how privacy will be ensured/protected.

The study will use an electronic questionnaire and will be completely anonymous, if the participant wishes. At the time of taking the questionnaire, participants will have the opportunity to enroll in a drawing to win a drone. If enrolled, any information provided by the participant will be confidential and once the drawing has been completed, all identifying information will be safely disposed. Names and any identifying demographics will not be released to the public or be able to be matched to any data after the study and drawing for a free drone is complete

7. Privacy: Describe the safeguards (including confidentiality safeguards) you will use to minimize the risks. If video/audio recordings are part of the research, please describe how that data will be stored or destroyed.

SurveyMonkey uses industry-standard security methods to protect data transmission and storage. Questionnaire data will be de-identified and will be stored on a password-protected computer. Any information retained to identify the winner of the drone, will be safely disposed once the winner has been selected. All individual answers will be presented in summary form in any papers, books, talks, posts, or stories resulting from this study. If participants withdraw from the study prior to completion of the task(s), their data will be destroyed immediately.

8. Participant Population and Recruitment Procedures: Who will be recruited to be participants and how will they be recruited. Note that participants must be at least 18 years of age to participate. Participants under 18 years of age must have a parent or guardian sign the informed consent document.

Participants will be contacted primarily through Curt Lewis Flight Safety Newsletter as well as Embry-Riddle pilots, and other local chapters, or as referred by other pilots. When the participants receive the e-mail invitation for the SurveyMonkey link, they will be prompted to "After you complete this survey, please forward this survey to any other pilots that you think would like to participate." The consent question in the survey provides the participants an opportunity to verify that they are over 18 years old, current pilots of any qualification who have flown within the last six months and would like to participate. Support letters and email notices are attached for review.

9. Economic Considerations: Are participants going to be paid for their participation? If yes, describe your policy for dealing with participants who 1) Show up for research, but refuse informed consent; 2) Start but fail to complete research.

Participants will not be paid but will be eligible to participate in the drawing to win a drone.

10. Time: Approximately how much time will be required of each participant?

The electronic questionnaire can be completed in approximately 13 minutes.

By signing below and returning this application, you are signing that as the Principal Investigator as well as any other investigators certify the following:

- 1) The information in this application is accurate and complete
- 2) All procedures performed during this project will be conducted by individuals legally and responsibly entitled to do so
- 3) I/we will comply with all federal, state, and institutional policies and procedures to protect human subjects in research
- 4) I/we will assure that the consent process and research procedures as described herein are followed with every participant in the research
- 5) That any significant systematic deviation from the submitted protocol (for example, a change in the principal investigator, sponsorship, research purposes, participant recruitment procedures, research methodology, risks and benefits, or consent procedures) will be submitted to the IRB for approval prior to its implementation 6) I/we will promptly report any adverse events to the IRB.

Signature of Principal Investigator

Date

Signature of Faculty Advisor

Date

Embry-Riddle Aeronautical University
Application for IRB Approval
EXEMPT Determination Form

Principal Investigator: Lakshmi Vempati

Other Investigators: Scott Winter

Role: Student **Campus:** Worldwide **College:** Aviation/Aeronautics

Project Title: Pilots' Willingness to Pilot an Aircraft in UAS Integrated Airports based on Integration, Operation Type, and Airspace Classification: An Experimental Analysis

Review Board Use Only

Initial Reviewer: Teri Gabriel **Date:** 02/19/2019 **Approval #:** 19-099

Determination: Exempt

Dr. Michael Wiggins Michael E. Wiggins
 IRB Chair Signature: Ed.D.

Digitally signed by Michael E. Wiggins, Ed.D.
 DN: cn=Michael E. Wiggins, Ed.D., o=Embry-Riddle
 Aeronautical University, ou=Aeronautical Science
 Department, email=wigginsm@erau.edu, c=US
 Date: 2019.02.22 16:24:03 -0500

Date: 02/22/2019

Brief Description:

The purpose of this research is to collect data on pilot perceptions and willingness to pilot an aircraft from a UAS integrated airport and to examine factors such as UAS integration type, type of UAS operations, airspace classification, and other demographical factors that influence pilots' choices. This will be accomplished using a survey through SurveyMonkey.

This research falls under the **EXEMPT** category as per 45 CFR 46.104:

- ☒ (2) Research that only includes interactions involving educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior (including visual or auditory recording) if at least one of the following criteria is met: (Applies to Subpart B [Pregnant Women, Human Fetuses and Neonates] and does not apply for Subpart C [Prisoners] except for research aimed at involving a broader subject population that only incidentally includes prisoners.)

APPENDIX B

Approval Notes from pilot groups and mailing list owners

Curt Lewis Flight Safety Newsletter Request:

Good Afternoon Dr Lewis,

I am currently a graduate student at Embry-Riddle Aeronautical University (ERAU) working on my PhD in Aviation. As part of my dissertation, I am going to be conducting a survey and as per the academic program I am preparing all the material that has to be approved by the University Institutional Review board (IRB).

As part of our IRB submission at ERAU, they request we obtain permission to post surveys via sources such as your Flight Safety Newsletter. If you could reply to this email that you approve of this request, we can include it with our IRB submission for review. You will obviously have final say and review of what you post in your newsletter.

Thank you for your consideration,

Lakshmi Vempati
PhD in Aviation, Candidate
Embry-Riddle Aeronautical University

Response:

I would be happy to publish your survey.

Regards,

Curt Lewis, PhD, CSP, FRAeS, FISASI
President
Curt Lewis & Associates, LLC
Targeting Safety & Risk Management

San Luis Obispo Ninety Nines (SLO99s) Request:

Hi Kathy,

As I might have mentioned I am working on my PhD at Embry Riddle Aeronautical University. As part of my dissertation, I am going to be conducting a survey sometime next year. As per the academic program, I am preparing all the material this semester and once my committee approves my proposal, my survey questionnaire has to

be approved by the University Internal Review board. I need to submit all the material to them.

I will be collecting data from pilots and I was wondering if the San Luis Obispo Ninety Nines (SLO99s) would be willing to share a link in the Slipstream and with the mailing list? If the group is willing I will need formal approval from the group (email is fine) which will be enclosed with my application to review board.

Can you check with the group if it is something you can/will be interested in?

Thanks,
Lakshmi

Response:

Hi Lakshmi,

As I expected, the SLO 99s are happy to provide a link to your survey on our website and to our mailing list. In addition, the group was willing to approach other 99s chapters and other pilots' groups to do the same, if you would like us to do that.

We are happy to support a fellow 99 in pursuit of your degree!

Keep us posted on your progress!

Kathy

Virginia Flyout Group (FOG) Request:

Hi Lanny,

I am working on my PhD at Embry Riddle Aeronautical University. As part of my dissertation, I am going to be conducting a survey sometime next year. As per the academic program, I am preparing all the material this semester and once my committee approves my proposal, my survey questionnaire has to be approved by the University Internal Review board. I need to submit all the material to them.

I will be collecting data from pilots and I was wondering if you would be willing to share a link of the questionnaire with the Flyout Group (FOG) mailing list? If willing I will need formal approval (email is fine) which will be enclosed with my application to review board.

Is this something you can/will be interested in?

Thanks Lakshmi

Response

I understand that you are requesting to send your questionnaire link to the flyout group using our emailer. I do not see any problem with this. Therefore, feel free to use: fly@embdocserv.com

Good luck and best wishes with your PHD.

E. Lanny Nass

AviatrixAerogram e-zine Request:

Hi Laura,

As I mentioned, I am working on my PhD in Aviation at Embry-Riddle Aeronautical University. As part of my dissertation, I am going to be conducting a survey sometime next year. As per the academic program I am preparing all the material this semester and once my committee approves my proposal my survey questionnaire has to be approved by the University Internal Review board. I need to submit all the material to them.

I will be collecting data from pilots and I was wondering if you will be willing to share a link of the questionnaire with the subscribers of AviatrixAerogram? If willing I will need formal approval (email is fine) which will be enclosed with my application to review board.

Is this something you can/will be interested in? If not no hard feelings.

Thanks very much,
Lakshmi Vempati

Response

Hello Lakshmi,

I will be happy to send your survey link to the Aviatrix Aerogram ezine email list.

Good luck!

Laura

APPENDIX C

Questionnaire Recruitment Notice

Dear Pilots,

My name is Lakshmi Vempati. I am a doctoral candidate in the Embry-Riddle Aeronautical University PhD in Aviation program, and I am working on my dissertation under the guidance of Dr. Scott Winter. We are interested in understanding pilot perspectives for operating in unmanned aircraft system (UAS) integrated airspace and airports. You can help this research by participating in this electronic questionnaire. The study is anticipated to take approximately 13 minutes to complete.

In order to participate, you must be 18 years of age, and a current pilot with any rating, and experience level who has flown within the last six months. Participants will have an opportunity to participate in the drawing to win a DJI Tello Quadcopter Drone. If you have any questions regarding the study, or the questionnaire in particular, please contact the researcher, Lakshmi Vempati, at vempatil@my.erau.edu or the dissertation committee chair, Dr. Scott Winter, at winte25e@erau.edu.

Please find the electronic questionnaire at: <Web Link>

Please feel free to forward the link to other pilots who you think might be interested in participating.

Sincerely,
Lakshmi Vempati,
Doctoral Candidate
ERAU PhD in Aviation

APPENDIX D

Consent Form and Questionnaire

Pilot Survey

1. RESEARCH PARTICIPANT CONSENT FORM

Lakshmi Vempati
Embry-Riddle Aeronautical University
Ph.D. in Aviation Program

Purpose of Research

The purpose of this research will be to assess your willingness to pilot an aircraft in Unmanned Aircraft System integrated Airspace and Airports

Specific Procedures

You will be presented with some scenarios and then you will then be asked some questions about those scenarios. In addition, you will be asked some demographics questions. The data collection process is anonymous and your responses will remain confidential. If you no longer wish to participate in the research, you may withdraw at any time and your data will be deleted from the dataset.

Duration of Participation

The duration of this is anticipated to take less than 15 minutes.

Risks

It is anticipated that this study will pose no greater risk than you would experience through normal daily activities.

Benefits

There are no known benefits to your participation other than knowing you have contributed to the advancement of scientific knowledge.

Compensation

There is no additional compensation awarded for participation in this research. There is an optional drawing to win a DJI Tele Pro drone if you choose to participate.

Confidentiality

The data collected during this study will be anonymous and confidential. We have no way of learning your true identity.

Voluntary Nature of Participation

You do not have to participate in this research project. If you agree to participate, you can withdraw your participation at any time without penalty. Furthermore, if you withdraw from the study prior to its completion, your data will be removed from the dataset and destroyed.

Contact Information:

If you have any questions about this research project, you can contact Lakshmi Vempati at

vempatil@my.erau.edu. If you have concerns about the treatment of research participants, you can contact the IRB Administrator, Teri Gabriel at teri.gabriel@erau.edu or call 386-226-7179.

*** 1. I have had the opportunity to read this consent form and have the research study explained. I do hereby give consent to have the data collected through this questionnaire to be used for its designed research purposes.**

☐ Yes

☐ No

Pilot Survey

2. Eligibility

*** 2. Are you a certified pilot in any aircraft type, category and class, at least 18 years old, and have piloted an aircraft within the last six months?**

☐ Yes

☐ No

Pilot Survey

3. Background Information

The following page is designed to gather some basic background information from each participant. Afterwards, you will be presented with a scenario to which you will read and answer the following questions to the best of your ability. At any time you may discontinue the questionnaire and your information will be deleted from the dataset. If a resource is not specifically mentioned within the scenario as being available to you, please presume that it is not and answer the questions based on this presumption.

3. Please select the Federal Aviation Administration certificates or other qualifications that you hold (select all that apply)?

☐ Student Pilot	☐ Civilian Helicopter Pilot
☐ Private Pilot	☐ Military Aircraft Pilot
☐ Recreational Pilot	☐ Military Unmanned Aircraft System Pilot
☐ Sport Pilot	☐ Military Helicopter Pilot
☐ Commercial Pilot	☐ Remote Pilot (Part 107)
☐ Air Transport Pilot	☐ Balloon Pilot

4. Select the aircraft category you have rating in (select all that apply)

☐ Airplane	☐ Lighter than air
☐ Rotorcraft	☐ Powered Parachute
☐ Glider	☐ Weight shift control aircraft
☐ Powered Lift	

5. . Select the Federal Aviation Administration ratings that you hold (select all that apply)?

☐ Single engine land	☐ Single engine sea
☐ Multi engine land	☐ Multi engine sea

6. How many overall flight hours do you have in any aircraft?

7. What is the weight class of the aircraft that you have the most rated flight time in?

☐ Less than 2,500 lbs	☐ 5,000 - 7,500 lbs
☐ 2,500 - 5,000 lbs	☐ Greater than 7,500 lbs

8. What Federal Aviation Regulation (FAR) Part do you fly under normally?

☐ Part 121	☐ Part 91 (Business/Corporate)
☐ Part 135	☐ Part 91 (Recreational)

Pilot Survey**4. Scenarios**

You will be presented with a scenario and you will then be asked some questions about that scenario. Following that, you will be asked some demographics questions. The data collection process is anonymous and your responses will remain confidential. Please answer all scenario based questions as accurately as possible.

3. Please select the Federal Aviation Administration certificates or other qualifications that you hold (select all that apply)?

☐ Student Pilot	☐ Civilian Helicopter Pilot
☐ Private Pilot	☐ Military Aircraft Pilot
☐ Recreational Pilot	☐ Military Unmanned Aircraft System Pilot
☐ Sport Pilot	☐ Military Helicopter Pilot
☐ Commercial Pilot	☐ Remote Pilot (Part 107)
☐ Air Transport Pilot	☐ Balloon Pilot

4. Select the aircraft category you have rating in (select all that apply)

☐ Airplane	☐ Lighter than air
☐ Rotorcraft	☐ Powered Parachute
☐ Glider	☐ Weight shift control aircraft
☐ Powered Lift	

5. . Select the Federal Aviation Administration ratings that you hold (select all that apply)?

☐ Single engine land	☐ Single engine sea
☐ Multi engine land	☐ Multi engine sea

6. How many overall flight hours do you have in any aircraft?

7. What is the weight class of the aircraft that you have the most rated flight time in?

☐ Less than 2,500 lbs	☐ 5,000 - 7,500 lbs
☐ 2,500 - 5,000 lbs	☐ Greater than 7,500 lbs

8. What Federal Aviation Regulation (FAR) Part do you fly under normally?

☐ Part 121	☐ Part 91 (Business/Corporate)
☐ Part 135	☐ Part 91 (Recreational)

Pilot Survey

4. Scenarios

You will be presented with a scenario and you will then be asked some questions about that scenario. Following that, you will be asked some demographics questions. The data collection process is anonymous and your responses will remain confidential. Please answer all scenario based questions as accurately as possible.

- A 25.0% Imagine a scenario where you have rented a Cessna 172 equipped with a Garmin G1000 avionics suite. You are conducting your flight under visual meteorological conditions (VMC) and adhering to visual flight rules (VFR). The weather conditions are visibility at least 10 statute miles or better and the sky conditions are clear. On-board, you have both paper and electronic navigation charts for the associated portions of your flight route, and the aircraft is equipped with Automatic Dependent Surveillance Broadcast (ADS-B) In. For your route of flight, you learn that civilian, medium to large unmanned aircraft systems (UAS) will be operating below flight level 180. The UAS operations are controlled by remote pilot and segregated from manned flight operations.
- B 25.0% Imagine a scenario where you have rented a Cessna 172 equipped with a Garmin G1000 avionics suite. You are conducting your flight under visual meteorological conditions (VMC) and adhering to visual flight rules (VFR). The weather conditions are visibility at least 10 statute miles or better and the sky conditions are clear. On-board, you have both paper and electronic navigation charts for the associated portions of your flight route, and the aircraft is equipped with Automatic Dependent Surveillance Broadcast (ADS-B) In. For your route of flight, you learn that civilian, medium to large unmanned aircraft systems (UAS) will be operating below flight level 180. The UAS operations are controlled by remote pilot and integrated with manned flight operations.
- C 25.0% Imagine a scenario where you have rented a Cessna 172 equipped with a Garmin G1000 avionics suite. You are conducting your flight under visual meteorological conditions (VMC) and adhering to visual flight rules (VFR). The weather conditions are visibility at least 10 statute miles or better and the sky conditions are clear. On-board, you have both paper and electronic navigation charts for the associated portions of your flight route, and the aircraft is equipped with Automatic Dependent Surveillance Broadcast (ADS-B) In. For your route of flight, you learn that civilian, medium to large unmanned aircraft systems (UAS) will be operating below flight level 180. The UAS operations are autonomous and segregated from manned flight operations.
- D 25.0% Imagine a scenario where you have rented a Cessna 172 equipped with a Garmin G1000 avionics suite. You are conducting your flight under visual meteorological conditions (VMC) and adhering to visual flight rules (VFR). The weather conditions are visibility at least 10 statute miles or better and the sky conditions are clear. On-board, you have both paper and electronic navigation charts for the associated portions of your flight route, and the aircraft is equipped with Automatic Dependent Surveillance Broadcast (ADS-B) In. For your route of flight, you learn that civilian, medium to large unmanned aircraft systems (UAS) will be operating below flight level 180. The UAS operations are autonomous and integrated with manned flight operations.

Pilot Survey

5. Scenario related questions

Please answer the following questions based on the scenario presented

9. If this scenario occurred in Class B airspace, please respond to the following statements

	Strongly Disagree	Disagree	Neither Disagree or Agree	Agree	Strongly Agree
I would feel safe piloting an aircraft in this situation	☐	☐	☐	☐	☐
I would be willing to pilot an aircraft in this situation	☐	☐	☐	☐	☐
I have no fear of piloting an aircraft in this situation	☐	☐	☐	☐	☐
I have no problem piloting an aircraft in this situation	☐	☐	☐	☐	☐
I feel confident piloting an aircraft in this situation	☐	☐	☐	☐	☐
I would be confident piloting an aircraft in this situation	☐	☐	☐	☐	☐
I would be happy piloting an aircraft in this situation	☐	☐	☐	☐	☐

Pilot Survey

6. Scenario relation questions continued

10. If this scenario occurred in Class C airspace, please respond to the following statements

	Strongly Disagree	Disagree	Neither Disagree or Agree	Agree	Strongly Agree
I would feel safe piloting an aircraft in this situation	☐	☐	☐	☐	☐
I would be willing to pilot an aircraft in this situation	☐	☐	☐	☐	☐
I have no fear of piloting an aircraft in this situation	☐	☐	☐	☐	☐
I have no problem piloting an aircraft in this situation	☐	☐	☐	☐	☐
I feel confident piloting an aircraft in this situation	☐	☐	☐	☐	☐
I would be confident piloting an aircraft in this situation	☐	☐	☐	☐	☐
I would be happy piloting an aircraft in this situation	☐	☐	☐	☐	☐

Pilot Survey

7. Scenario related questions continued

11. If this scenario occurred in Class D airspace, please respond to the following statements

	Strongly Disagree	Disagree	Neither Disagree or Agree	Agree	Strongly Agree
I would feel safe piloting an aircraft in this situation	☐	☐	☐	☐	☐
I would be willing to pilot an aircraft in this situation	☐	☐	☐	☐	☐
I have no fear of piloting an aircraft in this situation	☐	☐	☐	☐	☐
I have no problem piloting an aircraft in this situation	☐	☐	☐	☐	☐
I feel confident piloting an aircraft in this situation	☐	☐	☐	☐	☐
I would be confident piloting an aircraft in this situation	☐	☐	☐	☐	☐
I would be happy piloting an aircraft in this situation	☐	☐	☐	☐	☐

Pilot Survey

8. Scenario related questions continued

12. If this scenario occurred in Class E airspace, please respond to the following statements

	Strongly Disagree	Disagree	Neither Disagree or Agree	Agree	Strongly Agree
I would feel safe piloting an aircraft in this situation	☐	☐	☐	☐	☐
I would be willing to pilot an aircraft in this situation	☐	☐	☐	☐	☐
I have no fear of piloting an aircraft in this situation	☐	☐	☐	☐	☐
I have no problem piloting an aircraft in this situation	☐	☐	☐	☐	☐
I feel confident piloting an aircraft in this situation	☐	☐	☐	☐	☐
I would be confident piloting an aircraft in this situation	☐	☐	☐	☐	☐
I would be happy piloting an aircraft in this situation	☐	☐	☐	☐	☐

Pilot Survey

9. Scenario related questions continued

13. If this scenario occurred in Class G airspace, please respond to the following statements

	Strongly Disagree	Disagree	Neither Disagree or Agree	Agree	Strongly Agree
I would feel safe piloting an aircraft in this situation	☐	☐	☐	☐	☐
I would be willing to pilot an aircraft in this situation	☐	☐	☐	☐	☐
I have no fear of piloting an aircraft in this situation	☐	☐	☐	☐	☐
I have no problem piloting an aircraft in this situation	☐	☐	☐	☐	☐
I feel confident piloting an aircraft in this situation	☐	☐	☐	☐	☐
I would be confident piloting an aircraft in this situation	☐	☐	☐	☐	☐
I would be happy piloting an aircraft in this situation	☐	☐	☐	☐	☐

Pilot Survey

10. Perspectives

The following page is designed to gather some perspectives from each participant. Please share your thoughts and comments of operating in an unmanned aircraft system integrated environment.

14. How do you perceive integrated unmanned aircraft system operations will impact your ability to operate in the same airspace?

15. Are there any other comments or concerns you have of operating with unmanned aircraft systems in the same airspace or airports you wish to share?

16. Have you ever flown an Unmanned Aircraft?

- ☐ Yes
- ☐ No

17. Select all that apply. I would be willing to pilot an aircraft in any airspace with unmanned aircraft operations:

- ☐ VMC ☐ Both
- ☐ IMC ☐ None

Other (please specify)

18. Select the statement that best applies.

- ☐ I HAVE experienced an encounter with an Unmanned aircraft, and optionally, took evasive maneuvers
- ☐ I HAVE NOT experienced an encounter with an Unmanned aircraft

19. Select all that apply. I would be willing to pilot an aircraft and in any airspace with unmanned aircraft operations:

- ☐ VFR ☐ Both
- ☐ IFR ☐ None

Other (please specify)

Pilot Survey

11. Demographics

We would like to collect a few demographics from you in order to better understand our audience

20. Geographical location within the United States

- ☐ New England Region ☐ South-West Region
- ☐ Mid Atlantic Region ☐ Rocky Mountain Region
- ☐ Southern Region ☐ Pacific Region
- ☐ Mid-West Region ☐ Other

21. Age

22. Gender

- ☐ Male
- ☐ Female
- ☐ Other

23. What is your ethnicity?

- ☐ White or Caucasian
- ☐ Black or African American
- ☐ Hispanic or Latino
- ☐ Asian or Asian American
- ☐ American Indian or Alaska Native
- ☐ Native Hawaiian or other Pacific Islander
- ☐ Another race

Pilot Survey

12. Additional Information for Prize Drawing

Please complete this section if you choose to participate in the drawing to win a DJI Quadcopter Tello drone. If you choose to participate, any information will be confidential and once the drawing has been completed, all identifying information will be safely disposed. Names and any identifying demographics will not be released to the public or be able to be matched to any data after the study and drawing for a free drone is complete

* 24. Would you like to participate in the drawing to win a DJI Tello Quadcopter Drone

- ☐ Yes
- ☐ No

Pilot Survey

13. Additional information on prize drawing

25. If you answered yes, please provide contact information so we can contact you, if you are the winner.

Name	<input type="text"/>
Company	<input type="text"/>
Address	<input type="text"/>
Address 2	<input type="text"/>
City/Town	<input type="text"/>
State/Province	<input type="text"/>
ZIP/Postal Code	<input type="text"/>
Country	<input type="text"/>
Email Address	<input type="text"/>
Phone Number	<input type="text"/>

Pilot Survey

14. Questionnaire Completion

26. Thank you for participating in this questionnaire. If you have any questions about this research project, you can contact Lakshmi Vempati at vempatil@my.erau.edu. If you have concerns about the treatment of research participants, please feel free to contact the Embry-Riddle Aeronautical University Institutional Review Board Director Teri Gabriel at teri.gabriel@erau.edu.

Before you go, please forward this survey to any other pilots that you think would like to participate. Add email addresses you would like to forward this Questionnaire to,

Pilot Survey

15. Disqualification Page

Thank you for your interest. However, you do not meet the criteria necessary to participate in this questionnaire.