General Aviation Pilot Acceptance and Adoption of Electronic Flight Bag Technology

Troy Ernest Techau

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GENERAL AVIATION PILOT ACCEPTANCE AND ADOPTION
OF ELECTRONIC FLIGHT BAG TECHNOLOGY

By

Troy Ernest Techau

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
July 2018
GENERAL AVIATION PILOT ACCEPTANCE AND ADOPTION OF ELECTRONIC FLIGHT BAG TECHNOLOGY

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Troy Ernest Techau

This dissertation was prepared under the direction of the candidate’s Dissertation Committee Chair, Dr. Steven Hampton, 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.

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ABSTRACT

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This research used an adapted version of the extended Unified Theory of Acceptance and Use of Technology (UTAUT2) to examine electronic flight bag (EFB) acceptance and adoption for general aviation (GA) pilots. EFBs are a common tool in almost all types of aviation and feature many useful capabilities such as the ability to display traffic, weather, and aviation charts. Despite their potential benefits, while some pilots choose to use EFBs in their flight operations, others continue to rely on traditional paper charts and reference materials. Determination of which factors explain differences in pilot acceptance and adoption of EFBs could influence EFB user interface design, impact development of training and education programs, inform EFB sales and marketing strategies, or have implications for the development of EFB regulation and certification guidelines.

The research design featured an online survey of GA pilots. 703 responses were collected, of which 589 were valid for analysis after data preparation and cleaning. Confirmatory factor analysis (CFA) revealed a lack of discriminant validity for three of the seven UTAUT2 exogenous constructs, so the full structural model was modified to remove those constructs. Structural equation modeling (SEM) of the modified full
structural model was conducted using the IBM Statistical Package for the Social Science (SPSS) Statistics 25 and the Analysis of Moment Structures (AMOS) plugin.

*Effort expectancy, hedonic motivation, and price value* had a significant effect on *behavioral intention* to use EFBs, however *social influence* was determined to not be a significant factor. *Age* had a small but significant moderating effect on the relationship of price value on behavioral intention to use EFBs but was not supported as a moderator of either effort expectancy or hedonic motivation. Similarly, *gender* was shown to have a small but significant moderating effect on the relationship of effort expectancy on behavioral intention but was not supported for price value or hedonic motivation.

In contrast to the limited effects of age and gender, *experience* using EFBs had a significant moderating influence on three of the four UTAUT2 constructs in the modified UTAUT2 model used. Experience using EFBs had a significant moderating effect on effort expectancy, price value, and hedonic motivation, while experience using EFBs did not moderate social influence.

This research fills a gap in the literature as it is the first scholarly research conducted to determine what factors affect pilot decisions to use EFB technology. The results contribute to an improved understanding of pilot acceptance and adoption of EFB technology in the general aviation context and show that the UTAUT2 theoretical model of technology acceptance and adoption has utility in the aviation context for voluntary-use technologies. The study also identified weaknesses in the UTAUT2 survey instrument and potential improvements that could be made to the UTAUT2 theoretical model.
DEDICATION

This work is dedicated to my brilliant and beautiful wife, Dana, without whom none of my accomplishments would be possible. She encourages me in everything I do, and supports me when I need it most. I thank her for her patience and know that I am a better person because of her.

Our daughters Zoie and Piper bring joy, fulfillment, and purpose to life every day with their smiles and love. I hope that this achievement inspires them to always chase their dreams, and to know that they have my unending support and love.
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As the saying goes, it takes a village. This dissertation is no exception to that adage, and would not have been completed without the support, guidance, and occasional push from many colleagues, instructors, and mentors.

Many thanks to Dr. Steven Hampton and the members of my dissertation committee for their time and thoughtful guidance as they led me through the dissertation process. I sincerely hope this work is worthy of your efforts.

My classmates in the Embry-Riddle Ph.D. in Aviation program have taught me as much as any other part of the Ph.D. experience, and I am confident and honored to have studied and learned with each of you. Jen Edwards was my study partner for all coursework, and I can’t thank her enough. Matt Grunenwald’s dry wit as we went through the trials and tribulations of the daily coursework grind were a constant source of amusement, and Scott Haeffelin consistently helped me keep the big picture in perspective.

Lastly, I thank my brother, sisters, and extended family for being part of this journey. The positive influences of my mother and father in my life has been profound, and without their teaching and love, I would be but a fraction of who I am today. My mother, who passed so long ago but will never be forgotten, provided me with much of the foundation upon which I’ve guided my life endeavors, and I strive to live up to her expectations. My father continues to provide me wise counsel and a strong life compass, and always provides steadfast support for all that I do. Lastly, to Tegan, I wish you could have shared this experience with me.
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CHAPTER I
INTRODUCTION

The focus of this quantitative non-experimental study was to examine general aviation (GA) pilot decisions to utilize or not utilize electronic flight bags (EFBs) during their flight planning and operations. The study examined seven extrinsic factors that influence an EFB user’s behavioral intentions to use the technology and actual use behavior.

Although the terms acceptance and adoption are frequently used in research on technology use and diffusion, the terms are not universally defined, and some researchers use the terms interchangeably. In general, however, acceptance is considered to be an individual behavior under the volitional control of an individual and relates to perceptions and attitudes toward a technology (Davis, 1986; Renaud & van Biljon, 2008). In contrast, adoption is described as a process involving decision-making and actions that relate to actual use behavior of the technology (Renaud & van Biljon, 2008; Rogers, 2004; Venkatesh, Morris, Davis, G., & Davis, F., 2003).

EFBs support a myriad of cockpit functions, ranging from replacing paper references and calculating aircraft performance information to presenting charts with locational, weather, and traffic data (Cahill & Donald, 2006). EFBs are also capable of communicating with installed avionics (Pschierer et al., 2011). Research and development is underway so that EFBs will likely soon be used as a platform for pilots to communicate collaboratively with air traffic control (ATC) (Moallemi, Castro-Pena, Towhidnejad, & Abraham, 2016). As GA pilots often bear the costs associated with EFBs themselves, perceptions related to the value received for the price of the technology
is important as are pilot perceptions related to other technology factors, including usefulness, how difficult it is to learn, the influence of other pilots, and several other factors. Understanding what factors affect pilot decisions as they consider acquisition and use of EFB technologies has implications across the aviation community, including in the design, guidance for use, training, maintenance, and safety management of how EFBs are used.

The use of specific aviation technologies is sometimes mandated by aviation regulators, or usage may be at the discretion of an aircraft operator or pilot. An example of a mandated technology is the Federal Aviation Administration (FAA) requirement that pilots use Automated Dependent Surveillance-Broadcast (ADS-B) Out technology in many parts of the National Air Space (NAS) after January 1st, 2020 (14 C.F.R. § 91.225).

In contrast, the use of other technologies is discretionary for many types of aviation operations, such as the use of EFBs or global positioning system (GPS) receivers. For discretionary technologies, utilization or non-utilization of the technology is often the decision of the aircraft owner, operator, or individual pilot concerned, although regulatory approval may still be required prior to voluntary implementation of the technologies in certain types of flight operations.

The value and utility of EFBs to aviation has grown such that it is estimated that by 2020, industry activity related to EFBs will have a value of over $5 billion annually (Ponnuswamy, 2016). Yet, to date, little research is available to provide insight into why pilots choose to voluntarily utilize EFBs in their flight operations. The FAA recognizes EFBs as a technology that has already begun to play a role in the transformation of the NAS as part of the Next Generation Air Transportation System (NextGen) program. In
particular, several currently available EFBs are able to receive and display data from NextGen’s system, providing in-cockpit weather and traffic information (Hiltunen, Chase, Kendra, & Young, 2015).

EFBs can be found in aircraft ranging from initial entry trainers to airliners. Figure 1 shows a general aviation pilot flying with two EFBs, with one displaying an airport diagram and the other displaying ADS-B In data that was received through a wireless connection to a panel-mounted avionic system. In addition to their other capabilities to provide useful information during flight operations, EFBs are also an important tool for distribution and utilization of ADS-B In data streams.

ADS-B is considered to be foundational to several future developments of aviation technology. The U.S. Department of Transportation (DOT) considers ADS-B to be one of NextGen’s “transformational programs” that will “allow FAA to transition from ground-based radar to a satellite-based system for managing air traffic” (Scovel, 2016, p. 2). The FAA-sponsored Aviation Rulemaking Committee (ARC) for ADS-B In technology notes that portable displays such as EFBs, coupled with ADS-B In receivers, can enhance situational awareness (Brown & Hendricks, 2011).

The present research was initiated as it was considered important to understand what factors affect pilot decisions to voluntarily adopt and use EFBs in flight operations. This objective was viewed as especially relevant given that EFBs may have a key role in NextGen yet remain optional for pilots to use in many flight operations.
No previous research was identified that studied the factors that affect pilot decisions to adopt EFBs using modern technology acceptance theory, thus there is a gap in the assessment of technology acceptance in the context of general aviation. The voluntary nature of EFB use in many GA flight operations is suggestive of a consumer-driven technology adoption cycle, so it follows that understanding EFB acceptance and adoption in the context of current theories of consumer-oriented technology acceptance and adoption will support explanation of pilot intention to use EFB technology and assist in understanding actual pilot use of EFB technology.

In voluntary-use situations, Venkatesh, Thong, and Xu (2012) theorized that behavioral intention to use and actual use behavior is determined in part by seven factors: (a) the expected effort to use a technology; (b) perceptions regarding the expected
performance impact from use of the technology; (c) pleasure derived from use; (d) price value, comparing cost to benefits; (e) social influences; (f) habit; and (g) facilitating conditions. Experience, age, and gender were believed to moderate the effects of those factors on behavioral intention to use and actual use behavior. Experience was defined as the opportunity the individual has to use the target technology and includes the extent to which prior occurrences using the technology have led the individual to form habits regarding the technology (Venkatesh et al., 2012).

Development of an improved understanding of why pilots choose to accept and adopt EFBs could inform five areas related to the use of EFBs in the aviation context: (a) EFB design and manufacture; (b) EFB usage and implementation guidance; (c) training; (d) regulation; and (e) inclusion of EFBs in safety management activities, including risk assessments related to their use. For example, if pilots are found to believe that EFBs are difficult to use, and that belief lowers their intention to acquire and use EFBs, manufacturers may wish to focus on software and hardware features that lower perceptions about the difficulty of use of EFBs as a means to encourage increased sales.

Similarly, such insights into EFB acceptance and adoption factors could affect regulatory decisions on EFB usage guidance. Endsley (1995) developed a model of SA that featured three levels including perception and comprehension of the current situation and projection of future status based on that perception and comprehension. Endsley noted that SA was important not only in pilot control of aircraft, but also in air traffic control and the management of tactical, strategic, and complex systems. Thus, if regulators wanted to increase pilot SA during cruise flight, training could be mandated that emphasized the benefits of in-cockpit EFB displays of weather and traffic, as such a
mandate might be expected to increase EFB use and subsequently have a positive effect on situation awareness (SA) during airborne flight operations.

The present study was grounded in the extended Unified Theory of Acceptance and Use of Technology (UTAUT2), which focused on evaluating seven extrinsic constructs that affect pilot behavioral intention to use and actual use behavior of a particular technology and was framed in a context where such use is voluntary (Venkatesh et al., 2012). In prior work, Venkatesh, Morris, Davis, G., and Davis, F. (2003) evaluated eight theoretical models from social science research to develop the original UTAUT model and theory. Four of those theoretical models are detailed to provide a foundation for the proposed study, including the Diffusion of Innovations Theory (DOI) (Rogers, 1983), the Theory of Reasoned Action (TRA) (Fishbein & Ajzen, 1975), the Theory of Planned Behavior (TPB) (Ajzen, 1991), and the Technology Acceptance Model (TAM) (Davis, 1986).

The present study applied the theoretical constructs of UTAUT2 to the acceptance of EFBs as a means to explain GA pilot behaviors related to EFB acquisition, implementation, and use in flight operations. Pilot survey responses were assessed with the purpose of determining the extent to which UTAUT2 factors explain GA pilot adoption of EFBs and to explore how a pilot’s age, gender, and previous experience using EFBs moderated the relationships between those UTAUT2 factors.

Significance of the Study

The present research improved understanding of the factors that affect pilot decisions when choosing to adopt EFBs. The main theoretical contribution was that the
research was among the first empirically based studies that applied technology acceptance theory to explain GA pilot use of EFBs.

Within the NextGen program, EFBs are likely to continue to play a prominent role, whether as receivers of ADS-B In and System-Wide Information Management (SWIM) data, communication devices to support Controller-Pilot Data Link Communications (CPDLC), displays of information to support pilot access to stored information, or as a means to support pilots and controllers to share an improved common operating picture (COP). The present study contributes to a better understanding of how technology acceptance factors identified in the literature explain GA pilot acceptance and adoption of EFBs, expanded the literature for technology acceptance research, and has practical applications for aviation use of EFBs. For example, the results of the research make a contribution to explaining how demographic differences in pilot age, gender, and experience using EFBs moderated the relationships of extrinsic technology acceptance factors to behavioral intentions to use EFBs. The knowledge developed could help developers better match EFB capabilities to individual pilots based on their age, gender, or experience.

Additionally, the study provided a trial in which the suitability of the UTAUT2 theoretical model of technology acceptance could be utilized for further research in the aviation context. While the UTAUT2 appeared to have some utility for evaluating factors affecting acceptance and adoption of EFBs, the research showed that the theoretical model and its adapted survey instrument requires further refinement to best provide useful insights into pilot adoption of other voluntary-use technologies. For example, in 2016 the FAA published a policy statement that standardized design and
production approval for Non-Required Safety Enhancing Equipment (NORSEE) in the general aviation and rotorcraft fleets as a means to “encourage the installation of new technology safety enhancements into all aircraft product types” (FAA, 2016b, p. 2). To the extent that the application of technology acceptance theory in the present research helped to explain pilot adoption of NORSEE devices into the GA fleet, the results may contribute to attainment of the FAA’s objective to encourage the use of NORSEE and other voluntary-use technologies.

**Statement of the Problem**

Two challenges exist in the application of theories of technology acceptance to GA pilot use of EFBs. First, no studies were identified in the literature that applied technology acceptance theory to the aviation domain. Secondly, the nature of how GA pilots utilize EFBs in aircraft operations may be different than how subjects utilized the technology in many of the studies identified in the literature that examined acceptance factors for other technologies.

While contemporary literature encompasses multiple research studies that examine acceptance factors for information technology in other domains (Venkatesh & Morris, 2000; Pavlou & Fygenson, 2006; Wu, Wang, & Lin, 2007), no studies were identified that examined technology acceptance factors influencing pilot use of EFB technology in the aviation domain. Study of technology acceptance in the context of aviation and GA pilot use of EFBs is warranted to help ensure that the existing body of technology acceptance theory remains applicable in the aviation domain.

The nature of how GA pilots use EFB technology may differ somewhat from how the information technology examined in previous studies was used. Specifically, many of
the information technologies studied in the literature reviewed seem to have been used in a workplace environment and were essential tools required for the worker to accomplish their primary task. For example, Hong, Thong, Chasalow, and Dhillon (2011) studied acceptance factors for software developers using a particular type of software application at their workplace. All of the individuals studied were employees in the same company and operated the software as a primary job task, thus use of the software was not voluntary.

In contrast, it can be argued that the primary task of a GA pilot is related to the actual control and command of their aircraft, and EFBs are used during ancillary tasks as a tool to support the pilot’s operation of the aircraft. In most GA flight operations, the use of an EFB is at the pilot’s discretion unless influenced by company rules or similar requirements. Thus, EFB use by GA pilots can be considered voluntary, both from the perspective that the pilot has the choice to utilize or not utilize an EFB, and from the perspective that the EFB is not a required part of the primary task the pilot is attempting to conduct. Research that accounts for the voluntary nature of GA pilot EFB use is needed to add to the literature and assist in explaining why GA pilots choose to use EFBs.

A study using UTAUT2 and other technology acceptance models and theory may help fill both the gap in the study of technology acceptance in the aviation context and in explanation of GA pilot acceptance and adoption of voluntary-use technologies. The lack of research into the specific factors that influence GA pilots as they make decisions regarding acceptance and adoption of EFBs presents a challenge for the EFB industry and those that regulate EFBs. Without a foundation of empirical support, present-day
decisions regarding EFBs are possibly being made without taking into account what factors best explain GA pilot use of EFBs, including decisions related to EFB design and manufacture, development of EFB implementation and training guidance, regulation, and the safety management of EFBs. Understanding the impacts of acceptance and adoption factors may be particularly useful given that many pilots have alternatives to using EFBs to accomplish their primary piloting duties, such as paper charts, calculators, reference manuals, and other aviation support technologies. Because EFB usage can be voluntary in nature, study of the factors that affect pilot adoption and use of EFB technology using a consumer-oriented theoretical basis can help fill a gap in the existing literature regarding which factors most affect pilot EFB acquisition and use.

**Purpose Statement**

The main purpose of the study was to investigate the extent that the factors posited in the UTAUT2 contributed to an explanation of pilot acceptance and adoption of EFB technology (e.g. *behavioral intention* to use (BI) and *use behavior* (UB) of EFBs). An adapted version of the UTAUT2 survey instrument was used to test the UTAUT2 structural model as it applies to EFBs. The UTAUT2 theoretical model was selected as it evaluated how seven theorized exogenous latent factors grounded in technology acceptance theory affected pilot BI and UB of EFBs.

**Research Questions**

The following research questions were developed as a means to evaluate whether the factors found in the UTAUT2 theoretical model are applicable to GA use of EFBs:

- Research Questions 1 (RQ1). To what extent do the exogenous UTAUT2 factors affect pilot acceptance and adoption of EFB technology?
• Research Question 2 (RQ2). To what extent do the demographic variables of age, gender, or experience using EFBs moderate the relationships between the factors in the UTAUT2 model?

The first research question is important because if the UTAUT2 factors are shown to influence pilot acceptance and adoption of EFB technology, that understanding could help bridge the gap from theory to practice in terms of EFB design, regulation, manufacture, acquisition, training, and maintenance, or similar aspects such as marketing. If some UTAUT2 factors were not supported in this study, the study results could be useful in subsequent research that might better tailor the model to the aviation context.

For the second research question, certain demographic factors may moderate the relationships between the factors affecting acceptance and adoption of EFBs. Such moderation could have implications on how well or how quickly different groups of pilots adopt EFBs. For example, if a particular demographic factor is found to significantly moderate some aspects of EFB acceptance and adoption behavior, understanding that moderation could shape EFB training, such as development of different training modules for different demographic groups.

Delimitations

The research was delimited to a target population of GA pilots with a pilot certificate issued under 14 CFR § 61.5 other than a Student Pilot certificate, and who had flown at least five hours in the previous year under 14 CFR § 91 other than subparts 91F and 91K. While the research was focused on the U.S., there was no means implemented to determine the extent of participation by pilots holding foreign pilot certificates. No distinction was made between fixed wing or rotorcraft flight time. This criterion was
intended to exclude nonpilots, inactive pilots, student pilots, and pilots that had not recently performed as pilot in command (PIC) while operating under the 14 CFR § 91 GA flight rules.

Student pilots were excluded under the rationale that student pilot use of EFBs could have been influenced or directed by flight instructors or by policies implemented by a flight school. Were such external influences present, student pilot responses to questions regarding EFB use factors could have limited generalizability of the results of the study to the intended population of inference – GA pilots. Similarly, remote pilots certificated under 14 CFR §107 Subpart C were excluded, as flight of small unmanned aircraft systems (sUAS) does not qualify as GA flight operation.

Inactive pilots were excluded, as were pilots who only reported having recent flight activity under other aviation rule categories, by requiring five hours of GA recent flight as PIC within the previous year. As an example, selecting a five-hour recent GA flight criterion served to exclude responses from a pilot who only flew for an air carrier. Such exclusion was appropriate since that pilot’s most recent utilization of EFBs was from an environment in which EFB use required approval from the FAA, as well as the operator’s certificate holder. Pilots that performed flight operations using several operating rules, such as an airline pilot that flew for an air carrier under 14 CFR § 121 on some days but also flew under 14 CFR § 91 in operations that were not influenced by company rules or similar requirements, were asked to consider only those flight operations in which they were free to choose the conditions and extent of their EFB usage as they responded to the survey.
Delimitation of the study to GA was purposive. AC 91-78 (2007) classified EFBs as portable electronic devices (PED), and 14 CFR § 91.21 states that PEDs may be used if “the operator of the aircraft has determined will not cause interference with the navigation or communication system of the aircraft on which it is to be used”. This set of circumstances provides GA pilots with significant freedom of choice regarding their EFB selection and usage, and thus GA represents the pilot population most likely to exhibit consumer behavior in terms of their decisions regarding EFB usage. Examination of a consumer-oriented population was of primary interest for several reasons. Developing a deeper knowledge of the factors affecting EFB-related decisions for the population of pilots who voluntarily choose to use EFBs could be of great use to the aviation community. EFB industry stakeholders would likely benefit from a better understanding of why pilots choose to adopt EFBs and insight into whether that adoption varies between pilots. Secondly, understanding pilot behavior in a consumer-oriented model could inform stakeholders interested in EFB design, manufacture, training, regulation, and safety management.

Limitations and Assumptions

Because this study was delimited to pilots participating in GA flight operations in which EFB use is voluntary under 14 CFR § 91 other than subparts 91F and 91K, the study’s findings can reasonably be generalized only to other flight operations in which EFB use is voluntary. Generalizability to air carrier, public use, or other flight operations in which EFB use is normally externally controlled is limited. According to 49 CFR § 40125, public use aircraft are operated to perform a governmental function such as national defense, law enforcement, government research, management of public
resources, or for intelligence purposes. Pilots that have recent flight activity under multiple flight regulations, such as 14 CFR § 121 at an air carrier but have also piloted GA flight operations under 14 CFR § 91 other than subparts 91F and 91K, were permitted to respond to the survey. It was assumed that those survey respondents would comply with instructions which asked them to consider only GA flight operations in which their use of EFBs was their voluntary choice as they completed the survey, even if they had recent flight activity as PIC operating under conditions in which their use of EFBs was not voluntary or was influenced by government or company rules. The research was limited to the exogenous factors in the UTAUT2 model, and no factors related to other external influences were evaluated, such as whether the conduct of flight operations in multiple types of aircraft or under multiple sets of aviation regulations influences EFB acceptance and adoption.

**Definitions of Terms**

Automated Dependent Surveillance Broadcast (ADS-B)  
“ADS–B is a data link system in which aircraft avionics broadcast the position and other information from the aircraft for ground-based receivers and other aircraft with receivers” (Brown and Hendricks, 2011, p. 4).

Automated Dependent Surveillance Broadcast (ADS-B) In  
“The ability to receive ADS–B signals from the ground and other aircraft, process those signals, and display traffic and information to flightcrews” (Brown and Hendricks, 2011, p. 6).
Automated Dependent Surveillance Broadcast (ADS-B) Out  “The ability to transmit ADS–B signals” which “allows for more accurate and timely ATC surveillance data as compared to existing primary and secondary radars, but does not provide flightcrews the ability to receive, display, or interpret ADS–B signals” (Brown and Hendricks, 2011, p. 5).


Commercial-Off-The-Shelf (COTS)  For the purposes of this study, COTS is an adjective to describe software and hardware packages that are preconfigured for general public sale and use, as compared to developmental or customized technology implementations.

Electronic Flight Bag (EFB)  For the purposes of this research, an EFB is defined as a portable electronic device that includes hardware and software designed to function as a source of information relevant to flight operations for the flight crew. This definition encompasses technology generally embodied as a mobile phone, tablet, laptop, or purpose-built electronic device with software useful to the flight crew, regardless of whether the software is customized to
aviation, and irrespective of whether the EFB is mounted in the aircraft, connected to aircraft power, or communicates with aircraft systems. Note that this definition is a hybrid of the FAA definition of an EFB, which has changed multiple times as EFB guidance has been revised, including once during the conduct of the present research. The definition used is relatively congruent with the EFB definition used by the European Aviation Safety Agency EASA.

**Next Generation Air Transportation System (NextGen)**

NextGen is a program that encompasses a broad variety of technological updates to the FAA’s management of the U.S. national airspace.

**Portable Electronic Device (PED)**

The Portable Electronic Devices Aviation Rulemaking Committee (PED ARC) defines PEDs as “any piece of lightweight, electrically-powered equipment” and states that PEDs “are typically consumer electronics devices functionally capable of communications, data processing and/or utility” (PED ARC, 2013, p. ix).

**Technology Acceptance**

An individual behavior under the volitional control of an individual which also relates to perceptions
and attitudes toward a technology (Davis, 1986; Renaud & van Biljon, 2008).

Technology Adoption A process involving decision-making and actions that relate to actual use behavior of the technology (Renaud & van Biljon, 2008; Rogers, 2004; Venkatesh, Morris, Davis, G., & Davis, F., 2003).

List of Acronyms

- AAtS: Aircraft Access to SWIM
- AC: Advisory Circular
- ACS: Airman Certification Standards
- ADS-B: Automatic Dependent Surveillance-Broadcast
- AMC: Acceptable Means of Compliance
- AMOS: Analysis of Moment Structures
- ATC: Air Traffic Control
- BI: Behavioral Intention (to Use)
- CFA: Confirmatory Factor Analysis
- CPDLC: Controller-Pilot Data Link Communications
- EASA: European Aviation Safety Agency
- EE: Effort Expectancy
- EFB: Electronic Flight Bag
- ERAM: En Route Automation Modernization
- EXP: Experience
- FAA: Federal Aviation Administration
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
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<tbody>
<tr>
<td>FC</td>
<td>Facilitating Conditions</td>
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<tr>
<td>GDR</td>
<td>Gender</td>
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<tr>
<td>GPS</td>
<td>Global Positioning System</td>
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<tr>
<td>HM</td>
<td>Hedonic Motivation</td>
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<td>HT</td>
<td>Habit</td>
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<tr>
<td>ICAO</td>
<td>International Civil Aviation Organization</td>
</tr>
<tr>
<td>IFR</td>
<td>Instrument Flight Rules</td>
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<tr>
<td>JPDO</td>
<td>Joint Planning and Development Office</td>
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<tr>
<td>NAS</td>
<td>National Airspace System</td>
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<tr>
<td>NextGen</td>
<td>Next Generation Air Transportation System</td>
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<tr>
<td>NORSEE</td>
<td>Non-Required Safety Enhancing Equipment</td>
</tr>
<tr>
<td>NOTAM</td>
<td>Notice to Airmen</td>
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<tr>
<td>NVS</td>
<td>NAS Voice System</td>
</tr>
<tr>
<td>PE</td>
<td>Performance Expectancy</td>
</tr>
<tr>
<td>PED</td>
<td>Portable Electronic Device</td>
</tr>
<tr>
<td>PEOU</td>
<td>Perceived Ease of Use</td>
</tr>
<tr>
<td>PU</td>
<td>Perceived Usefulness</td>
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<tr>
<td>PV</td>
<td>Price Value</td>
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<tr>
<td>SEM</td>
<td>Structural Equation Modeling</td>
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<td>SI</td>
<td>Social Influence</td>
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<tr>
<td>SWIM</td>
<td>System Wide Information Management</td>
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<tr>
<td>SPSS</td>
<td>Statistical Package for the Social Sciences</td>
</tr>
<tr>
<td>TAM</td>
<td>Technology Acceptance Model</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Full Form</td>
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<tr>
<td>--------------</td>
<td>-----------</td>
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<tr>
<td>TAMR</td>
<td>Terminal Automation Modernization and Replacement</td>
</tr>
<tr>
<td>TBO</td>
<td>Trajectory Based Operations</td>
</tr>
<tr>
<td>TPB</td>
<td>Theory of Planned Behavior</td>
</tr>
<tr>
<td>TRACON</td>
<td>Terminal Radar Approach Control</td>
</tr>
<tr>
<td>UAS</td>
<td>Unmanned Aircraft System</td>
</tr>
<tr>
<td>UB</td>
<td>Use Behavior</td>
</tr>
<tr>
<td>UTAUT</td>
<td>Unified Theory of Acceptance and Use of Technology</td>
</tr>
<tr>
<td>VFR</td>
<td>Visual Flight Rules</td>
</tr>
<tr>
<td>VOU</td>
<td>Voluntariness of Use</td>
</tr>
<tr>
<td>VMC</td>
<td>Visual Meteorological Conditions</td>
</tr>
</tbody>
</table>
CHAPTER II

Review of the Relevant Literature

Chapter II is organized to provide an exposition on EFBs and their role in general aviation, an overview of theories of technology acceptance, and how those theories come together to explain pilot acceptance of EFBs. In the first sections, EFBs are defined, their role in general aviation is explored, and information on the FAA’s NextGen program provides a context for how EFBs are now and will soon be used as part of the FAA’s modernization plans. Next, information on the theories that form the foundation for technology acceptance research is explored, culminating in a discussion of the UTAUT2 model used in this research. Lastly, the UTAUT2 theoretical model is evaluated to provide rationale for the hypotheses tested in this research based on a foundation explaining how EFBs are used and an overview of research in technology acceptance.

EFB Overview

In this section, a short discussion on the emergence of EFBs provides context for the research project. The overview, although brief, focuses on the role that EFBs have begun to play in GA flight operations.

As noted in the Definition of Terms section in Chapter 1, for the purposes of this research, an EFB is defined as a portable electronic device that includes hardware and software designed to function as a source of information relevant to flight operations for the flight crew. This definition is intended to encompass technology generally embodied as a phone, tablet, laptop, or purpose-built electronic device with software useful to the flight crew.
The EFB definition used in the present research is consistent with FAA guidance of EFBs and relies on guidance from both the FAA and European Aviation Safety Agency (EASA). EASA guidance related to EFBs can be found in Acceptable Means of Compliance (AMC) 20-25 (EASA, 2014, p. 3), which defines an EFB as “an information system for flight deck crew members which allows storing, updating, delivering, displaying, and/or computing digital data to support flight operations or duties.” In Advisory Circular (AC) 120-76D (FAA, 2017a), the FAA defines an EFB in part as “any device, or combination of devices, actively displaying EFB applications.” AC 120-76D is the fifth revision of the FAA’s guidance on EFBs, which began with the publication of AC 120-76 in 2002.

**EFB software applications.** AC 120-76D (FAA, 2017a) provides for two classes of EFB software. Table 1 shows the general characteristics of each type of software.
### Table 1

**FAA EFB Software Types**

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition</th>
<th>Example Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Are listed in Appendix A of AC 120-76D; have a failure condition classification considered to be no safety effect; do not substitute or replace any paper, system, or equipment required by airworthiness or operational regulations; and do not require specific authorization for use.</td>
<td>Aircraft Parts Manuals, Minimum Equipment Lists, Chart Supplements, Pilot Duty Logs, Aeronautical Information Manual</td>
</tr>
<tr>
<td>B</td>
<td>Are listed in Appendix B of AC 120-76D; have a failure condition classification considered minor; may substitute or replace paper products of information required by airworthiness or operating regulations; and require specific authorization for operational authorization for use.</td>
<td>Flight Manuals, Maintenance Manuals, Weight and Balance Calculations, Power Settings, Aircraft Performance Manuals</td>
</tr>
</tbody>
</table>

Note. Table developed from AC 120-76D, retrieved from [http://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_120-76D.pdf](http://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_120-76D.pdf)

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**Emergence of EFBs.** Electronic flight bags began appearing in aviation cockpits in the early 1990s. Federal Express (FEDEX) developed an Airport Performance Laptop Computer (APLC) that pilots used to perform cockpit calculations of data related to aircraft performance (Jensen, 2006). Early EFBs were viewed as a tool to display information regarding aircraft performance, perform basic calculations, and tasks like viewing an aircraft’s Pilot Operating Handbook. That such a view existed is reinforced by the first published FAA guidance on EFBs (FAA, 2002), which envisioned EFBs as a replacement for paper references used in flight operations and imposed an approval requirement for EFBs to have data connectivity.

A major motivator for early EFB development was to speed and simplify the task of retrieving information relevant to the current flight operation and relieve pilots of the burden of manual calculations of data. EFBs were also viewed as a potential source of
cost savings. First, pilots no longer needed to carry heavy manuals and charts onto the flight deck. Chandra (2002) notes that research from that era showed concern for a potential relationship between pilot injuries and the necessity for pilots to carry heavy cases filled with paper charts and manuals. Secondly, additional savings were anticipated as EFBs weighed significantly less than the paper manuals and charts they replaced, reducing the fuel consumption required for aircraft operation.

Boeing was an early innovator of the concept of providing a moving map display to pilots with the installation of the Airport Moving Map (AMM) in the Boeing 777 in 2003 (Pschierer et al., 2011). As it was installed in the aircraft permanently, use of an AMM required formal incorporation of the hardware specifications into the aircraft’s approved type design. Jeppesen, a Boeing company, installed EFB technology into Boeing 777 aircraft by 2003 which had the capability to perform calculations, display charts, provide access to digital reference documents, and could also display video from cabin surveillance cameras (Allen, 2003, pp. 17-19). Figure 2 shows a Jeppesen Electronic Flight Bag in its installed location in the cockpit.

When the iPad was introduced in 2010, EFB use expanded so quickly that within 18 months of its introduction, 53% of readers reported using an iPad in the cockpit in a survey administered by the Aircraft Owners and Pilots Association (AOPA) daily email newsletter, Aviation eBrief (Barstow, 2012). As technology has evolved and increased the capability of computing devices, particularly with the advent of practical and powerful tablet computing platforms, applications for EFBs have also evolved. In an interview with executives from the EFB industry, Daly (2009) observed that EFBs enabled other cost savings for airline operations, as EFBs could be used in applications
relating to tracking aircraft loads, crew duty hours, fuel purchase and use, as well as maintenance tracking.

**Regulation on EFB Adoption and Use**

The choice to use an EFB during flight operations is governed by Title 14 of the U.S. Code of Federal Regulations (CFR). For a pilot who wishes to use an EFB, the flight rules and type of operation are important factors for consideration. For example, for a flight under Instrument Flight Rules (IFR), the pilot or certificate holder must comply with 14 CFR § 91.21, which requires that the portable electronic devices (PED) will not cause communication or interference with navigation or communication systems on the aircraft to be used in the flight operation. Additional guidance on how an operator can comply with that regulation is provided in AC 91.21-1D (FAA, 2017d).

Regarding type of operation, Table 2 provides six general groupings of flight operations. In general, for GA flight operations conducted under 14 CFR § 91, the final decision of whether or not to use EFBs is the responsibility of operators and pilots, and AC 91-78 (2007) provides information regarding applicable regulations. For flight operations under 14 CFR § 91K, 121, 125, and 135, the FAA normally requires approval to use EFBs. AC 120-76D (FAA, 2017) and FAA OpSpec/MSpec/LOA A061, Electronic Flight Bag (EFB) Program (FAA, 2017c) provide information on compliance with applicable regulations. Lastly, for flight operations under 14 CFR § 91F, whether approval is required or not for the use of EFBs depends on the specific aircraft and flight operations to be conducted.
Of importance for this study, the regulatory environment for aviation in the U.S. leaves GA pilots free to make their own decisions regarding the utility, safety, and value of EFBs for their flight operations. With the possible exception of primary flight students in ab initio training, who may be required to follow requirements regarding EFB use set by their flight instructors or flight schools, most GA pilots are not obligated to follow a company or other policy regarding EFB use. However, GA pilots retain the responsibility under AC 91-21-1D to evaluate the safety implications of integrating EFBs into their flight deck (FAA, 2017d).

### Table 2

**FAA Supplemental Guidance Regarding EFB Adoption**

<table>
<thead>
<tr>
<th>Flight Operations</th>
<th>Applicable FAA Publications</th>
<th>Approval Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>14 CFR § 91 (General Aviation)</td>
<td>AC 91-78, AC 91.21-1D</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>AC 20-164A, AC 20-173</td>
<td></td>
</tr>
<tr>
<td>14 CFR § 91F (Large &amp; Turbine Multiengine/Fractional)</td>
<td>AC 120-76D, AC 91.21-1D</td>
<td>No&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>AC 20-164A, AC 20-173</td>
<td></td>
</tr>
<tr>
<td>14 CFR § 91K (Fractional)</td>
<td>AC 120-76D, AC 91.21-1C</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>AC 20-164A, AC 20-173</td>
<td></td>
</tr>
<tr>
<td>14 CFR § 121 (Domestic, Flag, and Supplemental Operations)</td>
<td>AC 120-76D, AC 91.21-1D</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>AC 20-164A, AC 20-173</td>
<td></td>
</tr>
<tr>
<td>14 CFR § 125 (Airplanes Seating &gt;20 or capacity 6,000 pounds)</td>
<td>AC 120-76D AC 91.21-1D</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>AC 20-164, AC 20-173</td>
<td></td>
</tr>
<tr>
<td>14 CFR § 135 (Commuter and On Demand Operations)</td>
<td>AC 120-76D, AC 91.21-1D</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>AC 20-164A, AC 20-173</td>
<td></td>
</tr>
</tbody>
</table>

<sup>Note</sup>. Table developed from Federal Aviation regulations and advisory circulars as listed above.

<sup>a</sup>Dependent on Aircraft Type
**EFBs in General Aviation**

Precise estimates are difficult to obtain, but some studies indicate increasing usage of EFBs in GA. Although Ohme (2014) used a small convenience sample to study GA use of EFBs, his results indicated that 78% of the pilots surveyed used an EFB for at least some phase of flight. Twombly (2015) notes that ForeFlight, a leading EFB software manufacturer, claims that their product can be found in over 1,000 corporate flight departments and is the EFB software used by seven out of 10 EFB users. While the actual use rate of EFBs in GA is unclear, it is certain that the form of EFBs, training for their use, and the objectives for their use in flight operations continues to change.

**EFB hardware forms.** Many early EFBs featured purpose-built hardware devices running customized operating systems and application software, with examples appearing in an early review of the EFB industry (Yeh & Chandra, 2007). By 2015, a survey of the EFB industry identified 46 EFB software manufacturers (Hiltunen, Chase, Kendra, & Young, 2015), and 37 of those manufacturers offered at least one EFB product operating on the Apple iPad. The research by Hiltunen et al. (2015) shows that some manufacturers continue to produce customized hardware for use as EFBs; however, it appears that the use of COTS tablet computers with a standardized operating system has become widespread. In addition to reducing the cost of EFBs and allowing tablet hardware to be used for non-aviation purposes, the use of standardized hardware has facilitated the development of companion hardware such as ADS-B In receivers and external GPS receivers that can take advantage of standardized interfaces featured in COTS computer designs. Luke, Bittorie, Cannon, and Haldeman (1998) advocated the use of COTS computers as a strategy for reductions of costs and increases in processor...
power in military applications, so the use of COTS hardware for EFBs follows best
dractices from other types of aviation.

Training. For GA pilots using an EFB under 14 CFR § 91 other than § 91F or
§ 91K, the FAA mandates few training requirements. The latest FAA guidance for
training pilots for the Private Pilot rating (FAA, 2018a) requires only that prospective
pilots demonstrate the ability to identify and manage the risks associated with PEDs. In
2017, the FAA also published a document that discussed how an EFB could be used as
part of pilot testing under the Private Pilot – Airplane Airman Certification Standards
(FAA, 2017b).

However, for pilots flying under 14 CFR § 91F, § 91K, § 121, § 125, and § 135,
AC 120-76D (FAA, 2017) includes recommendations on development of procedures for
training pilots and flight crew on the use of EFBs. Considerations include training on the
EFB software functions and operations, geographic areas or flight maneuvers when EFBs
may be used, what to do if the EFB fails, concerns about battery charging, and similar
training to enhance safe integration of EFBs into flight operations.

Functions of EFBs. While currently available EFBs can provide displays of
traffic, weather, terrain, obstacles, and perform advanced flight planning and monitoring
tools, Giusti (2016) opined that such capabilities are reflective of “yesterday’s problem.”
Giusti noted that successful EFBs in the future will be prepared for “tomorrow's
problem” and be fully integrated into flight operations and may include as yet
undeveloped features that assist in crew management, mission planning, aircraft dispatch,
and similar tasks not embodied in today’s available EFB software.
Schvaneveldt, Branaghan, Lamonica, and Beringer (2012) provided an example of Giusti’s (2016) vision for improved EFBs developed with a user-centered design approach. While studying delivery of weather information to pilots, Schvaneveldt et al. (2012) noted that due to the design of available weather information services and then-current EFB applications, available EFBs were suboptimal for pilots in terms of convenience and efficiency. Schvaneveldt et al. (2012) also commented that pilots often used different sources of weather for each phase of flight, such as a web page for preflight planning, digital weather and traffic displays while enroute, and VHF communications for destination weather reports. Schvaneveldt et al. (2012) recommended a single system that could be used during all phases of flight.

A 2017 review (Thurber, 2017) of available EFB software shows that modern EFBs have begun to fulfill the vision detailed by Schvaneveldt et al. (2012). Thurber’s review showed multiple EFB software products that appear to support the use of an EFB for preflight planning as well as provide the ability to obtain and display enroute and terminal weather using ADS–B In connectivity. Figure 3 shows some of the capabilities available using commercially available EFB software, as of 2017.
Figure 3. Screenshots of ForeFlight EFB as available in 2017. Screenshots of the ForeFlight EFB displaying an aeronautical chart, ownship position, course line to desired destination, simulated instrument display, and other elements of information related to calculations of speed, altitude, time of arrival, and similar information that pilots were required to calculate manually prior to the development of EFBs. Reprinted from “ForeFlight Connect Stratus ADS-B Receiver”, copyright 2017 by ForeFlight, Inc., https://foreflight.com/products/stratus/. Fair use.

EFBs and NextGen

The NextGen program encompasses a transformation of the NAS, and EFBs will play a role in that transformation as they enable new capabilities and serve as a platform for pilots to access and use information from NextGen innovations. The following section provides a brief overview of the NextGen program and the role that EFBs may play as NextGen continues to be implemented.
NextGen overview. The FAA characterizes the decades-long NextGen program as “a series of inter-linked programs, systems, and policies that implement advanced technologies and capabilities to dramatically change the way the current aviation system is operated” (FAA, 2011b, p. 1). NextGen was initiated in the Vision 100 – Century of Aviation Reauthorization Act (2003), which directed the goals of the NextGen program to utilization of emerging communication, navigation, and surveillance technologies to improve aviation safety, security, and efficiency. The Act directed establishment of the Joint Planning and Development Office (JPDO), an initiative involving the Departments of Transportation, Defense, Commerce, Homeland Security, the National Aeronautics and Space Administration (NASA), and the White House. The JPDO (2004) noted the key role that enhanced flight deck technologies would play in the transformation of the NAS, establishing a vision for the future in which pilots would collaborate with other aircraft, have improved situation awareness, and benefit from increased focus on proactive safety management. A corresponding NextGen concept of operations document (JPDO, 2007) captured the key capabilities that would be required to achieve the NextGen goals. Those capabilities, as shown in Table 3, demonstrate a vision of the NAS in which information access and management by all aviation stakeholders are key requirements for success.
Table 3

**JPDO Capabilities for NextGen**

<table>
<thead>
<tr>
<th>Capability</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network-Enabled Information Access</td>
<td>Establishment of a real-time, service-oriented information architecture that improves the speed, efficiency, and quality of aviation decisions and decision-making.</td>
</tr>
<tr>
<td>Performance-Based Operations and Services</td>
<td>A shift in philosophy such that aviation regulations and performance requirements are expressed in terms of performance expectations instead of technology or equipment.</td>
</tr>
<tr>
<td>Weather Assimilated into Decisionmaking</td>
<td>Using weather-related information as an enabler in aviation decision-making to optimize effective use of weather information and mitigate the effects of adverse weather.</td>
</tr>
<tr>
<td>Layered, Adaptive Security</td>
<td>Establishment of a layered security approach that adapts and adjust to changing risks and incidents.</td>
</tr>
<tr>
<td>Positioning, Navigation, and Timing (PNT)</td>
<td>Provision of services at the point of need without the limitations inherent in ground-based navigational aids.</td>
</tr>
<tr>
<td>Aircraft Trajectory-Based Operations (TBO)</td>
<td>Using projections of four-dimensional trajectories to manage aircraft operations to allow collaboration between service providers and aircraft operators to optimize aviation operations.</td>
</tr>
<tr>
<td>Equivalent Visual Operations (EVO)</td>
<td>Use of information to support flight operations in all visibility conditions, improving the predictability and efficiency of operations.</td>
</tr>
<tr>
<td>Super-Density Arrival/Departure Operations</td>
<td>Establishment of new procedures and technologies to improve management of air traffic flow in the most densely used airports and airspace.</td>
</tr>
</tbody>
</table>


To develop the capabilities in the JPDO vision of NextGen, the FAA translated the NextGen capability objectives into six technology programs. Each of the programs
provides a platform to provide services to aviation stakeholders, and by 2016, five of the programs were in operation, with the exception of the NAS Voice System (FAA, 2016a). Table 4 shows the name of each of the six NextGen programs and provides a brief description of what each program involves.

Table 4  

**NextGen Programs**

<table>
<thead>
<tr>
<th>Program</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automatic Dependent Surveillance-Broadcast (ADS-B)</td>
<td>Satellite-based successor to radar that uses GPS to determine an aircraft’s location, airspeed, and other data, which is broadcast to ground and nearby aircraft.</td>
</tr>
<tr>
<td>Data Communications (Data Comm)</td>
<td>Enables controllers and pilots to communicate with digital messaging (Controller-Pilot Data Link Communications) (CPDLC).</td>
</tr>
<tr>
<td>En Route Automation Modernization (ERAM)</td>
<td>Replaces legacy automation at FAA en route centers controlling high-altitude aircraft, automating ATC functions, as a baseline to support data-sharing, digital communication, and trajectory-based operations.</td>
</tr>
<tr>
<td>Terminal Automation Modernization and Replacement (TAMR)</td>
<td>Program to convert terminal ATC facilities to a common automation platform; enables capabilities that may improve ATC situational awareness (SA).</td>
</tr>
<tr>
<td>National Air Space (NAS) Voice System (NVS)</td>
<td>NVS enables nationwide digital communication within FAA air traffic controllers, pilots, and Unmanned Aircraft Systems (UAS) operators.</td>
</tr>
<tr>
<td>System-Wide Information Management (SWIM)</td>
<td>Provides data-sharing infrastructure that underlies much of NextGen. Enables data exchange capability across multiple systems as baseline for collaboration.</td>
</tr>
</tbody>
</table>

*Note: Adapted from Federal Aviation Administration NextGen Implementation Plan, 2016, available at https://www.faa.gov/nextgen/media/NextGen_Implementation_Plan-2016.pdf*
**EFBs in NextGen strategy.** EFBs have begun to play a role in the implementation of the NextGen program. Pschierer et al. (2011) envisioned an EFB application that would enable a paperless cockpit, providing supplemental aeronautical information to the pilot from the departure gate all the way to the arrival gate. Much of that vision has been realized in present EFBs. Using data stored on the EFB preflight, EFBs can provide interactive displays of information such as aviation charts and can use GPS inputs to provide ownship position and calculate information relating to aircraft performance and expected positional data such as estimated time of arrival at the destination. By accessing ADS-B data using special receivers, EFBs can also provide pilots with a display of information related to nearby aviation traffic and graphical weather, as well as textual information about weather at distant destinations and waypoints.

Recent research suggests that the role of EFBs in aviation flight operations is still emerging and expanding. Moallemi et al. (2014) note that EFBs will have a role in allowing aircraft access to SWIM data while in flight under an initiative called Aircraft Access to SWIM (AAAs). Still in development, AAAs EFBs will serve as an interactive display device for pilots to exchange and use real-time data related to other aviation traffic and weather and even communicate and collaborate with the air traffic control (ATC) system. Controller-Pilot Data Link Communications (CPDLC), which can replace often problematic voice communications protocols, may use EFBs as a system component. Research into CPDLC includes human factors aspects such as usability, display design, workload, and other considerations that would affect how well EFBs would serve in supporting two-way digital communications while in flight (Gallimore et
Table 5 provides a brief summary of how EFBs may be integral to each of the six main FAA NextGen programs.

Table 5

**Potential NextGen Programs Utilization of EFBs**

<table>
<thead>
<tr>
<th>Program</th>
<th>Potential Utilization of EFBs</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADS-B</td>
<td>Receipt of graphical weather, text-based advisories, NOTAMS, altitude, ground track, speed, and distance of nearby aircraft using ADS-B In.</td>
</tr>
<tr>
<td>Data Comm</td>
<td>Two-way communication of departure clearances, collaborative rerouting, frequency handoffs, altitude changes, and other air traffic control (ATC) communications.</td>
</tr>
<tr>
<td>ERAM</td>
<td>ERAM detects conflicts between aircraft, which could be digitally relayed to in-cockpit EFBs.</td>
</tr>
<tr>
<td>TAMR</td>
<td>TAMR upgrades to data systems at TRACON facilities will enable ATC to better share a common operational picture of airspace, traffic, and weather with EFB users.</td>
</tr>
<tr>
<td>NVS</td>
<td>NVS contributes to two-way communications with pilots by providing supporting infrastructure that could utilize EFBs as a cockpit communication device.</td>
</tr>
<tr>
<td>SWIM</td>
<td>EFB access to SWIM information sources including trajectory information, weather modeling, special activity airspace, en-route strategic planning, airport information, and flight conditions.</td>
</tr>
</tbody>
</table>


**Foundational Research on Acceptance and Adoption**

The previous sections of this chapter have shown the key role that EFBs have and may continue to play in aviation, both in terms of being a useful device for pilots during flight operations and by demonstrating that EFBs are likely to play an important role in
the FAA’s NextGen program. The section that follows provides an overview of key research over the past several decades that form a foundation for the UTAUT2 theory and research model used in the present proposed research.

The UTAUT2 model that underlies this study’s research is supported by decades of inquiry into the fundamental concepts of how individuals and groups accept and adopt technology and innovations into their activities and routines. Some of the key theories in early research includes Diffusion of Innovations Theory (DOI), the Theory of Reasoned Action (TRA), the Theory of Planned Behavior (TPB), and the Technology Acceptance Model (TAM). TRA and its extension, TPB, are focused on the determinants of intention in a general sense, specifically beliefs and attitudes. TAM, however, is more narrowly focused on the actual use and acceptance of technology and introduces the variables of perceived ease of use and perceived usefulness as determinants of behavioral intention. This section of the literature review explores each of these theories in order to highlight their contributions to the UTAUT2 model.

**Diffusion of innovations theory (DOI).** How innovations spread among individuals has long been a subject of research. Studying agricultural practices related to the planting of seed corn by Iowa farmers, Rogers developed the Diffusion of Innovations Theory (DOI) in 1962. Rogers (2004) sought to develop a generalizable model of the process of diffusion that was independent of the type of innovation being studied.

An *innovation*, argued Rogers (1983, p. 11), was an “idea, practice, or object that is perceived as new by an individual or other unit of adoption”, while *diffusion* was “the process by which an innovation is communicated through certain channels over time among the members of a social system” (1983, p. 5). The diffusion process had four key
elements: the *innovation* itself, which was shared via *channels of communication* over *time* among the members of a *social system*.

Rogers (1983) theorized that innovations had five general attributes that were consistently shown to have an influence on adoption. The five attributes are shown in Figure 4, and were:

- *relative advantage*, which addressed the degree to which an innovation was perceived to be better than an idea which preceded it,
- *compatibility*, which examined the degree to which an innovation was perceived to be compatible with the values, needs, and experiences of potential adopters of the innovation,
- *complexity*, which addressed the degree to which an innovation was perceived as being relatively difficult to use or understand,
- *trialability*, which addressed the degree to which an innovation could be trialed or tested before adoption, and
- *observability*, defined as the degree to which the results of implementation of an innovation were observable to others.
Figure 4. Diagram of the diffusion of innovations theory (DOI). Rogers theorized that each attribute of an innovation affected adoption of the innovation. Adapted from “Diffusion of Innovations,” by E. M. Rogers, 1983.

Moore and Benbasat (1991) developed and tested a scale to operationalize Rogers’ DOI concepts, settling on eight constructs that could be measured using a 25-item survey. Two additional constructs, image and voluntariness of use were added to more fully reflect concepts used in the decisions related to adoption of an innovation. Complexity was replaced by an existing scale for the related concept of ease of use (Davis, 1989), and Roger’s observability construct was split to better reflect the component dimensions, resulting in the new constructs result demonstrability and visibility. The trialability, relative advantage, and compatibility constructs remained unchanged.

Mahajan and Peterson (1995) observed that multiple studies have shown that when the cumulative adoption of an innovation is plotted against the passage of time, a characteristic sigmoid (S-shaped) curve emerges. In this view, the adoption rate of innovations begins slowly, increases as more people in the social system adopt the innovation, then levels off at a point short of universal adoption of the innovation. Rogers (2004), looking at the quantity of research articles available at the time of each
revision of his *Diffusion of Innovations* text, observed that research into diffusion of innovations had followed the same S-shaped curve and had not yet reached the point of leveling off, indicating a continuing interest in such research.

Rogers (2004) observed that as DOI had been studied for over 50 years of research, the theory had been applied across many social sciences and had been broadened to encompass additional concepts. An example was that innovations are changed as they are being adopted. In a review of DOI literature, Tornatzky and Klein (1982) noted that over 30 years of innovations research had developed a focus on *primary* and *secondary* attributes of innovations. Primary attributes were viewed as inherent characteristics of the innovation itself, such as the size or cost to implement an innovation and were thus invariant in appearance in various social settings. In contrast, secondary attributes of innovations were viewed as subjective attributes of the innovation, and thus varied by the perceptions of those adopting the innovation and the environment in which the innovation was perceived by the potential adopters.

In a more recent paper, Dutta and Omolayole (2016) observed that gender of the potential innovation adopter has been shown to play a role and suggested that an appreciation of gender-based differences in innovation adoption could have practical significance for supporters of new innovations. For the present research, it is clear that DOI helped define and operationalize several useful concepts that have been incorporated into the UTAUT2 model that was used during the study.

**Theory of reasoned action (TRA).** Fishbein and Ajzen (1975) believed that an individual’s beliefs about themselves, other people, institutions, events, and about behaviors were the “informational base” (p. 14) that led to development of the individuals
attitudes, intentions, and actual behaviors. TRA emerged as a conceptual framework whose primary purpose was to establish the relationship between beliefs, attitudes, intentions, and behaviors. Fishbein and Ajzen (1975) defined beliefs, attitudes, and behavioral intentions as:

- **belief**, which represented the information a person had about an object,
- **attitude**, which was precisely defined as “the amount of affect for or against some object” (p. 11),
- **behavioral intention**, a type of belief in which the person intends to perform a behavior, which could be measured as a subjective probability that the person would actually perform the behavior, and
- **behavior**, which was defined as acts of a subject that were observable.

In developing their belief, attitude, and behavioral intention constructs, Fishbein and Ajzen (1975, p. 12) used object and attribute as generic descriptors that referred to “any discriminable aspect,” so an object could be any property of a person, place, thing, or event perceived in an individual’s world definition. Fishbein and Ajzen (1975) also noted that some contemporary research defined attitude as the sum of affect, cognition, and conation, but argued that for the purposes of TRA, attitude was limited to affect, while belief related to cognition, and conation related to intentions.

Figure 5 represents the relationships of the TRA constructs. In TRA, then, a person’s beliefs and attitudes are combined with normative beliefs and subjective norms to determine behavioral intentions. An important concept in TRA was that changes in
behavioral intentions were thus preceded by changes in beliefs, which were initiated by exposure to new information.

Figure 5. Diagram of theory of reasoned action (TRA). Fishbein and Ajzen stated that in conditions where the behavior is volitional, actual behaviors are best predicted by behavioral intentions, which are influenced by an individual’s attitude toward the behavior and subjective norms concerning the behavior. Adapted from “Belief, Attitude, Intention, and Behavior: An Introduction to Theory and Research,” by M. Fishbein and I. Ajzen, 1975, p. 16.

**Theory of planned behavior (TPB).** Ajzen (1991) developed the TPB as a means to address the shortfalls in TRA, as TRA did not adequately account for a person’s perceptions regarding voluntary control of their behaviors. TPB retained the TRA constructs and relationships of attitude toward behavior, subjective norms, behavioral intentions, and actual behavior, but added the new construct of perceived behavior control. *Perceived behavioral control*, according to Ajzen, relates to a person’s perceptions of whether performing the behavior of interest would be easy or difficult.

Figure 6 shows the relationships of the variables in TRB. Of particular note is that perceived behavioral control is thought to have a direct relationship to both behavioral intention and actual behavior. Ajzen (1991) notes that in the instance of
complete volitional control of behavior, the presence of behavioral intentions alone should explain behavior, which is reflected in the arrow from perceived behavioral control to intentions. However, Ajzen (1991) notes, when behavioral intention is held constant, “the effort expended to bring a course of behavior to a successful conclusion is likely to increase with perceived behavioral control” (p. 184). Thus, an arrow is drawn from perceived behavioral control directly to behavioral intentions. Ajzen notes that a practical example of such a relationship would be: given two individuals of equally strong behavioral intentions to perform a behavior, if one had increased confidence in his ability to succeed at the activity, that person would be more likely to actually conduct the behavior.

*Figure 6. Diagram of the theory of planned behavior (TPB). Formulated as an extension of the TRA, the TPB added the construct of Perceived Behavioral Control to represent beliefs about influences on actions that are outside of the individual’s control. Adapted from “The Theory of Planned Behavior,” by I. Ajzen, 1991, *Organizational Behavior and Human Decision Processes*, 50(2), 179-211. Copyright 1991.*

In a comprehensive review of TPB literature, Connor and Armitage (1998, p. 1432) conclude that meta-analysis of TPB research supports the overall validity of TPB as an explanation of behavior but argued that TPB should be viewed as a theory of the
“proximal determinants of behavior.” They note that TPB is assumed to describe the causal relationships of the variables it contains but observe that most of the then-available research on TPB was of a correlational design and did not support definitive testing of causality.

TPB has been used in several areas of research that are useful in the aviation context. In the area of safety climate, several studies showed empirical support for the relationship of perceived behavioral control to actual behavior in a safety context (Avci & Yayli, 2014; Johnson & Hall, 2005). Raisinghani et al. (2005) concluded that TPB was useful in understanding pilot attitudes regarding online learning for business aviation concepts. Both the TRA and TPB provide components of interest for this study, in particular, the relationships of beliefs, attitudes, norms, and perceptions of behavioral control to behavioral intentions and actual behavior.

**Technology acceptance model (TAM).** Focusing on individual acceptance of information systems technology, Davis (1986) developed the Technology Acceptance Model (TAM) with the dual goals of refining “understanding of user acceptance processes” (p. 2), and to provide a methodology for applied “user acceptance testing” (p. 2). Taylor and Todd (1995) note that TAM is directly adapted from TRA, “with only two beliefs composing attitude and no role for subjective norm” (p. 148). Taylor and Todd also believed that TAM had practical significance for information system designers, as the two main beliefs responsible for influencing system use were somewhat under their control. Those two main beliefs were:

- *perceived ease of use* (PEOU), defined as “the degree to which a person believes that using a particular system would be free of effort” (Davis, 1989,
perceived usefulness (PU), which refers to the extent that a person believes a technology will help in job performance.

As shown in Figure 7, PEOU and PU are both viewed as having a direct effect on attitude toward using. PEOU was thought to influence attitude toward using by two means (Davis, Bagozzi, & Warshaw, 1989). First, an easier to use system was believed to increase a user’s feelings of self-efficacy, and secondly, an easy to use system could be instrumental, that is, could help the user increase performance. Because effort saved due to an increase in PEOU could increase performance, PEOU also was theorized to have an effect on PU, reflected in Figure 4 by an arrow from PEOU to PU. Thus PU = PEOU + External Variables, while PEOU is more simply expressed as PEOU = External Variables.

Figure 7. Diagram of the technology acceptance model (TAM). TAM theorized that perceived usefulness and perceived ease of use, two types of beliefs, had a primary effect on user attitude toward using and intention to use technology. Adapted from “User Acceptance of Computer Technology: A Comparison of Two Theoretical Models,” by F. Davis, R. Bagozzi, and P. Warshaw, 1989, Management Science, 35(8), p. 985. Copyright 1989.
Davis (1986) and Davis, Bagozzi, and Warshaw (1989) suggested that a wide variety of variables could act on PU and/or PEOU as external variables, such as system features, characteristics of the user, training, system documentation, or available support. External variables “provide the bridge between the internal beliefs, attitudes, and intentions represented in TAM and the various differences, situational constraints, and managerially controllable interventions impinging on behavior (Davis, Bagozzi, & Warshaw, p. 988).

Taylor and Todd (1995) noted that TAM had been empirically tested and showed a good ability to explain behavioral intention to use and system use, although much of the testing available at that time utilized self-reports of usage rather than measures of actual use. Legris, Ingram, and Collerette (2003) echoed the concern for measured observations of actual system and noted that the predictive capacity of TAM should incorporate organizational and social factors.

Davis (1986, 1989) conceived of TAM in a workplace environment, where information technology is often implemented by management, so Legris et al. suggested integration of organizational factors including change management could be important considerations. Reviewing TAM, TPB, and TRA, Taylor and Todd (1995, p. 145) observed that the practical utility of TAM “stems from the fact that ease of use and usefulness are factors over which a system designer has some degree of control.”

Unified Theory of Acceptance and Use of Technology

By the early 2000s, studies of how innovations diffuse among a population and what factors influence individuals in decisions to adopt technology had become plentiful, yet published research continued to use a mix of TAM, TPB, TRA, and other theoretical
frameworks to explain intentions about the use of technology. In this environment of widespread interest yet varied methodology, Venkatesh, Morris, Davis, and Davis (2003) joined forces to develop a unified theory of technology acceptance that would synthesize and improve explanations of information system adoption behavior.

Discussions of both the UTAUT model as originally developed in 2003 and a 2012 extension of the UTAUT model are presented to help explain technology acceptance in a voluntary-use environment. The extension of the UTAUT became known as UTAUT2.

UTAUT. Seeking to integrate elements of eight competing models, Venkatesh et al. (2003) developed the UTAUT model to unify the core concepts of those models, with usage as a dependent variable, and intention as behavioral predictor. The models tested included the TRA, TAM, motivational model (MM), TPB, model of PC utilization, DOI, social cognitive theory, and a hybrid model that combined TAM and TPB.

Venkatesh et al. (2003) tested the variables in those eight models and conducted field studies at four organizations that were introducing new technology to their workforces. Creating a hybrid survey instrument using questions previously validated in scales related to each theoretical model, Venkatesh et al. eventually selected four exogenous constructs that, along with four moderating variables, explained much of behavioral intention to use. Figure 8 shows the UTAUT model developed as well as the theorized relationships among the variables included.
Figure 8. Diagram of the UTAUT theoretical model. Drawing upon eight predominant theories of technology acceptance, Venkatesh et al. theorized four main exogenous variables that influenced behavioral intentions and use behavior as individuals considered adopting new technology. Adapted from “User Acceptance of Information Technology: Toward a Unified View,” by V. Venkatesh, M. Morris, G. Davis, and F. Davis, 2003, p. 447.

**UTAUT endogenous variables.** In the UTAUT model, behavioral intention to use and use behavior are endogenous variables. Byrne (2010) considers endogenous variables to be synonymous with dependent variables, noting that endogenous variables are directly or indirectly influenced by other variables in a model.

**Behavioral intention to use (BI).** At the heart of the UTAUT model, the variable BI is drawn directly from the TRA, which defined BI as representing a person’s intention to perform a behavior. Davis et al. (1989, p. 984) similarly identified BI as “a measure of the strength of one’s intentions to perform a specified behavior.” In the UTAUT model, four exogenous constructs were theorized to have value in explaining BI.

In a review of TRA, Sheppard, Hartwick, and Warshaw (1988) stated that “a behavioral intention measure will predict the performance of any voluntary act, unless intent changes prior to performance” (p. 325), noting the measure of intention should
correspond to the behavioral criterion and that the wording of the intention measure and timing of when it is measured were important.

*Use behavior (UB).* In the domain of research of technology acceptance, use behavior relates to the subject’s actual use of the technology being addressed. Measurement of a subject’s actual use of a system has been problematic in research of actual system users, in that system use is often reported by the user (Legris et al., 2003). Many studies ask users to report their use of a system, expressed as a response to a small number of questions relating to how often and for how long they use the system in question. The challenge with self-reporting, according to Legris et al. (p. 202) is that many studies do not include procedures to measure actual use behavior, with the result that research often measures variance in self-reported use as opposed to actual use behavior. In the UTAUT model, Venkatesh et al. (2003) measured actual use behavior by auditing system logs that enabled calculation of the amount of time a user actually used the studied technology system.

*UTAUT exogenous variables.* From their empirical evaluation of the eight competing theoretical models examined, Venkatesh et al. (2003) selected four main exogenous variables that explained BI and UB. Byrne (2010) described *exogenous variables* as latent variables found within a model that equated to independent variables and in some way had a causal relationship to the values of the endogenous variables found in a model. Byrne noted that the values of the exogenous variables were not explained by the model but were reflective of factors external to the model.

Performance expectancy, effort expectancy, and social influence were believed to directly influence BI, while facilitating conditions was expected to have a direct effect on
use behavior. Each of the theorized relationships was expected to be moderated to some extent by two or more moderating variables.

**Performance expectancy (PE).** Venkatesh et al. (2003) defined performance expectancy in the UTAUT model as “the degree to which an individual believes that using the system will help him or her to attain gains in job performance” (p. 447). In developing this construct and definition, Venkatesh et al. sought to combine five constructs found in TAM, TPB, DOI, and other theories, including perceived usefulness, extrinsic motivation, relative advantage, job-fit, and outcome expectations. Venkatesh et al. believed that the PE construct was the strongest predictor of behavioral intention and that PE retained predictive value in both mandatory and voluntary-use situations.

**Effort expectancy (EE).** Effort expectancy is defined as the “degree of ease associated with the use of the system” (Venkatesh et al., p. 450). The EE construct synthesized the constructs of perceived ease of use, complexity, and ease of use from previous theoretical models, and Venkatesh et al. believed EE to be most effective as a predictor of behavioral intention when a behavior is new.

**Social influence (SI).** Venkatesh et al. (2003, p. 451) defined social influence as “the degree to which an individual perceives that important others believe he or she should use the new system.” The SI construct sought to demonstrate that an individual’s behavior will be influenced by what that person thinks others will think about them because of their use of technology. Interestingly, Venkatesh et al. found that SI was an important predictor of behavioral intentions in mandatory-use settings but was of less utility in voluntary-use technology adoption settings.
**Facilitating conditions (FC).** Finally, for the fourth exogenous variable in the UTAUT model, facilitating conditions was defined as “the degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system (Venkatesh et al., 2003, p. 453). Conceived as a synthesis of perceived behavioral control, facilitating conditions, and compatibility, the FC construct is intended to reflect how the environment in which a technology is operated may remove barriers that users could face while using the technology. Venkatesh et al. commented that when the PE and EE constructs are present in a theoretical model, the effects of FC are fully moderated for BI, thus the UTAUT model does not posit a relationship between FC and BI. However, Venkatesh et al. note that FC can have an effect on UB that is not moderated by BI, thus FC is included in the UTAUT model as an exogenous variable with a direct effect on UB.

**UTAUT moderating variables.** In some theoretical models, certain variables like age or gender are believed to influence the effect of other latent exogenous variables specified within the model. Hayes (2014, p. 8) observes that “an association between two variables X and Y is said to be moderated when its size or sign depends on a third variable or set of variables M”. Restated, given it is found to be significant, a moderator variable could strengthen or weaken the relationship between X and Y.

Moderating variables generally fall in two types: demographic and background. Examples of demographic variables include age, gender, race, and similar variables. In contrast to demographic variables, background variables represent aspects under some degree of control by the subject, such as experience using the technology being studied. Although the moderating variables shown in the UTAUT and UTAUT2 theoretical
models in this paper can be considered a special form of exogenous variables, for enhanced clarity, for the remainder of this paper the following convention is adopted:

- **exogenous variables** are those latent variables that reflect external factors and are theorized to have an effect directly on one or more endogenous variables, and

- the **moderating variable** term is applied whether the variable is thought to be of the demographic or background subtype of exogenous variable, but it primarily influences the model by affecting the relationship of an exogenous variable to an endogenous variable.

In UTAUT, Venkatesh et al. (2003) selected age, gender, experience, and voluntariness of use as moderating variables. While Venkatesh et al. did not explicitly define each of these moderating variables, a working definition is provided in the following paragraphs as a means to operationalize each construct, based on review of UTAUT, TRA, and TPB literature.

**Age (AGE).** Biological age, coded in years as two digits.

**Gender (GDR).** Male or female.

**Experience (EXP).** Conceived as a continuous variable reflecting level of experience using EFBs, ranging from novice (inexperienced) to experienced users, measured by respondent estimate of hours using EFBs. This operationalization of experience differs to some degree from the definition used by Venkatesh, Thong, and Xu (2012), in that in their work experience was measured by noting the amount of time since the technology was implemented, such as post-training, one month after, or three months after training. Because pilots are trained to record and track hours spent operating
aircraft, the present research presumes that pilots will be able to answer a question regarding the number of hours spent using EFBs with a degree of accuracy that is more precise than simply tracking how long the pilot has owned or had access to an EFB. This operationalization is also more appropriate for a voluntary-use technology that is not imposed on the respondent, but rather is one that they adopt on their own volition.

**Voluntariness of use (VOU).** VOU was reflected as a continuous variable that ranged from totally voluntary to completely mandatory use of a system.

**UTAUT2.** UTAUT was conceived as a synthesis of eight existing models of technology acceptance but was focused on the context of technology as used in organizations. In organizations, the voluntariness of use of the system can range from completely voluntary to mandatory, as usage is affected by company policies, regulations, and similar external pressures that affect individual adoption behavior.

Looking to expand UTAUT to the consumer use context, Venkatesh, Thong, and Xu (2012) refined the UTAUT model, creating the UTAUT2. Venkatesh et al. (2012) believed that UTAUT2 would have a practical application in helping industry focused on consumer technology improve technology design, as well as facilitate a richer understanding of how consumer demographics affect technology adoption.

In UTAUT2, the endogenous constructs BI and UB were retained, as were the four exogenous variables EE, PE, SI, and FC. The UTAUT moderating variable VOU was dropped from UTAUT2, as the use of technology in the consumer context is most often thought of as a voluntary behavior, thus negating the utility of the VOU construct. The three other UTAUT moderating variables, AGE, GDR, and EXP, were retained in UTAUT2. For the present research, although the variables in the UTAUT2 model were
modified slightly to fit EFBs, the variable names remained as published by Venkatesh et al. (2012) in order to promote clear comparison to other studies utilizing UTAUT2.

In developing the UTAUT2 model, Venkatesh et al. (2012) had to change their methodology for the UB variable from the original UTAUT study. This was necessary in order to apply the construct to voluntary-use technology situations. Rather than measuring actual technology usage in mandatory-use situations as was done in the 2003 UTAUT research, UB in UTAUT2 was designed to measure the variety and frequency of voluntary-use of mobile internet technology. Venkatesh et al. (2012) collected self-reported frequency of use for six mobile internet tasks using a Likert scale with responses indicating the level of use but did not report how they aggregated the data used for construction of the variable.

Notwithstanding their incomplete reporting, by defining UB as a measure with six independent mobile internet tasks, it is likely that Venkatesh et al. (2012) conceptualized UB as a non-compensatory formative composite index. A formative composite index is designed by aggregation of a variety of indicators or sub-indices which are believed to be representative of some phenomena of interest. Thus, in formative indices, "the concept is defined by, or is a function of, the observed variables," and "causality is from the indicators to the concept" (Mazziotta & Pareto, 2016a, p. 2). This contrasts with the typical design of variables used in survey research that use a reflective model such that "causality is from the concept to the indicators and a change in the phenomenon causes variation in all its measures" (Mazziotta & Pareto, 2016a, p. 2). Indeed, almost all of the other UTAUT2 variables are reflective.
A non-compensatory composite index is one in which the indicators are assumed not to be substitutable, so all sub-indices have the same weight, and compensation among the sub-indices is not consistent with the theoretical logic upon which they are constructed (Mazziotta & Pareto, 2016c). Munda and Nardo (2009) argue that the aggregation convention used in the construction of a composite indicator is paramount, particularly as many composite indexes are calculated using a weighted linear aggregation method that often incorrectly assumes full compensability of the sub-indices used. Mazziotta and Pareto (2016b) argue that the use of the geometric mean or multi-criteria analysis (MCA) are appropriate for calculation of non-compensatory composite indices.

Potentially as a consequence of the incomplete reporting by Venkatesh et al. (2012) on how they aggregated and validated their UB variable, replication of UB appears to have been problematic in subsequent studies, as multiple later researchers used dissimilar versions of the UB construct. Lewis, Fretwell, Ryan, and Parham (2013) provided descriptive statistics on their use of a composite indicator of use behavior involving online learning platforms but provided no detail on how they aggregated the measures for evaluation for use in structural evaluation of the UTAUT2 model. Similarly, Alalwan, Dwivedi, and Rana (2017) utilized a construct adoption in their study that is nearly identical to UB. The variable appears to have been conceptualized as an aggregation of five indicators of use behavior for banking activities, thus was likely a formative composite index, but appears to have been incorrectly evaluated as a reflective index in a table presented on discriminant validity.
**Exogenous variables added in UTAUT2.** Venkatesh et al. (2012) noted that several studies had extended UTAUT with the addition of new constructs but criticized that many of those extensions lacked appropriate theoretical support. Thus Venkatesh et al. sought to expand the UTAUT model, providing theoretical support for three additional constructs. The new variables added were hedonic motivation, price value, and habit.

**Hedonic motivation (HM).** Venkatesh et al. (2012, p. 161) defined hedonic motivation as “the fun or pleasure derived from using a technology,” noting that past information system research had shown HM to directly influence user acceptance of technology. Lowry, Gaskin, Twyman, Hammer, and Roberts (2012) developed a model to explain adoption of information systems that were used primarily for hedonic reasons, differentiating those **hedonic-motivation systems** (HMS) from **utilitarian-motivation systems** (UMS). Example HMS systems included those used for video games, music, social networking, games, and pornography and tended to reflect systems that provided intrinsic rewards to users. In contrast, UMS systems provided the user with external benefits. Lowry et al. (2012) noted that this paradigm created a contrast in that HMS system users focused on the process of using the system, while users of UMS systems focused on the outcomes provided by using the system.

**Price value (PV).** Price value, according to Venkatesh et al. (2012) is significant in the consumer context because consumers are generally responsible for the costs associated with acquiring and using a system, while employees in an organizational context generally are not. This difference may affect consumer use of technology, and thus Venkatesh et al. define price value as the consumer’s “tradeoff between the perceived benefits” (2012, p. 161) and costs for using a technology, such that consumers
weigh the cost of using a system against the benefits gained from the system’s use. In this consumer-use context, PV is believed to be a predictor of that consumer’s behavioral intention to use the technology.

**Habit (HT).** Habit, according to Venkatesh et al. (2012) reflects people’s tendency to perform behaviors automatically based on learning and operationalize it as the extent to which a person believes the behavior is performed automatically. Noting previous research, Venkatesh et al. theorize that HT has a direct effect on UB in addition to how HT affects BI, noting that BI is less important when a technology is used because of an increasing habit.

An additional change in development of the UTAUT2 model from its basis in UTAUT is that Venkatesh et al. (2012) theorize a new, direct relationship for facilitating conditions (FC) to behavioral intention to use (BI). Venkatesh et al. reiterate the linkage of FC to use behavior (UB) as it appeared in UTAUT remains valid, but note that in a consumer-use context where widely varying levels of facilitating conditions are available, FC will influence both BI and UB in the same manner that perceived behavioral control in the theory of planned behavior affects both BI and UB.

**Moderating variables in UTAUT2.** In developing UTAUT2, Venkatesh et al. (2012) dropped the moderating variable of voluntariness of use (VOU). Venkatesh et al. reasoned that in a consumer context, VOU is less relevant than it would be in an organizational context, as consumer use is most often voluntary by its nature. Figure 9 shows the UTAUT2 model, including the relationships of each moderating variable to the relationships of the exogenous and endogenous variables.
Figure 9. Diagram of UTAUT2 theoretical model. In order to address technology adoption in a consumer context, Venkatesh, Thong, and Xu removed the moderator relating to voluntariness of use and added three additional constructs to UTAUT, while adding several additional theorized relationships among the variables. Adapted from “Consumer acceptance and use of information technology: Extending the unified theory of acceptance and use of technology,” by V. Venkatesh, J. Thong, and X. Xu, 2012, p. 160.

Appropriateness of Use of the UTAUT2 Theoretical Model

The UTAUT2 theoretical model was selected for the proposed research as it is a recent theoretical construct built upon decades of technology acceptance research and is focused on assessing acceptance of consumer-oriented technologies. Most other theories of technology acceptance were developed in the context of technology that had been implemented in non-voluntary circumstances, such as when companies purchased technology for use by their employees. In the study of aviation use of EFBs, pilots in the 14 CFR § 91 general aviation sector other than § 91F and § 91K generally have the ability to make their own decisions regarding EFBs and are voluntary consumers of the
technology, making GA use of EFBs a similar setting to the study of mobile use of the internet by Venkatesh, Thong, and Xu (2012) while developing UTAUT2.

**Recent research utilizing UTAUT2.** Despite the strengths of its design and basis in decades of research on technology adoption and acceptance, UTAUT2 is an imperfect theoretical model, as are likely all theoretical models of the complex workings of human cognition and motivation. Although it is grounded in many of the prominent theories of technology acceptance and use that have emerged in the past 40 years, studies have shown some limitations of the assertions made by Venkatesh et al. when they published the UTAUT2 theoretical model in 2012. Yet despite any shortcomings, UTAUT2 appears to have remained useful in examinations of why humans choose to use (or not use) information technology in a consumer-oriented context.

In a Spanish study on acceptance of online banking, the UTAUT2 model factors of habit, performance expectancy, price value, and effort expectancy each contributed to explaining the use of internet banking by people over age 55 (Arenas-Gaitán, Peral-Peral, & Ramón-Jerónimo, 2015). Arenas-Gaitán et al. (2015) reported that social influence, facilitating conditions, and hedonic motivation did not play a significant role. However, the UTAUT model was able to predict over 62% of the participant’s behavioral intention to use internet banking.

Morosan and DeFranco (2016) modified the UTAUT2 model in a study of consumer intentions to use near field communications (NFC) payment systems in hotels, adding factors related to general privacy, system privacy, and perceived security. The research validated the relationship of the exogenous factors and behavioral intentions in the UTAUT2 structural model, with the exception of effort expectancy. The strongest
relations were found in relating performance expectancy, hedonic motivation, and habit to behavioral intentions. Morosan and DeFranco (2016) postulated that the results indicated that effort expectancy did not play a role in predicting consumer use of NFC communications for mobile payments, possibly because either mobile payments have been designed to be so simple that effort expectancy no longer matters as a variable, or that consumer desire to use NFC is so great as to outweigh any consumer reticence to use a technology as long as it has high-performance expectancy.

UTAUT2 has appeared in multiple dissertation research studies. Nwosu (2013) studied the efficacy of government interventions related to solar energy technology, using only the performance expectancy, effort expectancy, social influence, and facilitating conditions factors from the UTAUT2 model. Nwosu (2013) found that all four of the studied relationships were significant and positively oriented. Devine (2015) found that all seven of the UTAUT2 exogenous factors positively related to behavioral intentions of nurses to use social media technology. Bryant (2016) found that only four of the seven UTAUT2 exogenous constructs applied in his study of graduate intentions to use multi-modal computer tablets.

**UTAUT2 in the aviation context.** The UTAUT2 is a straightforward model of technology acceptance and is well described by Venkatesh, Thong, and Xu (2012). Only minor modifications of the UTAUT2 survey instrument were required to conduct the present research in the aviation context, such that the scale questions were changed to reflect the respondents use of EFBs instead of mobile internet technology.

The theoretical model and its structural relationships can be utilized as presented by Venkatesh et al. (2012). However, careful attention to the term *experience* was
required, as that term is used as a moderating variable in UTAUT2, while experience is used in the aviation field with a different definition.

In UTAUT2, Venkatesh, Thong, and Xu (2012, p. 161) operationalized experience as “the passage of time from the initial use of a target technology.” Venkatesh et al. based that definition on prior research, much of which had been conducted in non-voluntary settings in which technology had been systematically implemented by employers. Measurement of the passage of time served as a useful proxy to estimate experience using the technology, as researchers could determine when a technology had been implemented, consider how much time had elapsed since that implementation, and arrive at a conclusion regarding a subject’s experience level.

For the voluntary-use context in which UTAUT2 was developed, such calculations of the experience levels of a subject or unit sample is more difficult to determine. Individual users that make their own decisions to adopt and use a technology could have widely varying levels of experience, making self-reporting of experience levels with a technology the most logical method to gather information related to experience levels. Although Venkatesh, Thong, and Xu (2012) defined how they operationalized experience, they did not report how they assessed the construct in their survey instrument. Other researchers (Devine, 2015; Bryant, 2016) derived experience levels by asking survey respondents to report the types of technology they used and how often they used it.

The aviation field, however, often uses the term experience as a term related to how much cumulative time a pilot has in terms of flying an aircraft. Pilots are trained to keep detailed logbooks in which they record their flights, weather conditions,
destinations, and specific flight activities like flight in instrument meteorological conditions (IMC) or takeoff and landings with an accuracy of 1/10th of an hour.

For the present research, experience was designated specifically as the amount of time that a pilot actively used an EFB during a flight operation or during flight planning. Although pilots are trained to log the amount of time spent doing aviation tasks, for simplicity, survey respondents were asked to estimate the number of months of experience they had using EFBs.

In aviation, flight experience is commonly recorded by pilots as a record of cumulative hours spent flying as a pilot, receiving instruction, or to describe experience in various weather and other flight conditions. While flight experience is not used within the UTAUT2 model, either as an exogenous or as a moderating variable, data regarding flight experience was collected from survey respondents for use as a demographic variable.

**Hypotheses: Applying UTAUT2 to EFBs.** The overview of technology acceptance research provides a sufficient theoretical basis for applying the UTAUT2 model to pilot adoption of EFBs. In the UTAUT2 model (Venkatesh, Thong, & Xu, 2012), seven exogenous variables (constructs), *performance expectancy* (PE), *effort expectancy* (EE), *social influence* (SI), *facilitating conditions* (FC), *hedonic motivation* (HM), *price value* (PV), and *habit* (HT) are theorized to have an effect on two endogenous variables, *behavioral intention* (BI) and *use behavior* (UB). The effects of the seven exogenous variables are theorized to moderate the three demographic variables, *age*, *gender*, and *experience*, as well as behavioral intention to use and use behavior.
**Hypotheses 1 to 10.** To investigate RQ1, “To what extent do the exogenous UTAUT2 factors affect pilot acceptance and adoption of EFB technology?”, the relationships of the seven exogenous variables PE, EE, SI, FC, HM, PV, and HT were assessed to determine the extent that they related to BI and UB. The theoretical justification for the hypotheses related to these relationships was based on the development of the UTAUT and UTAUT2 models.

As noted previously, Venkatesh, Morris, Davis, and Davis (2003) examined eight prior theories related to technology adoption and acceptance as they developed UTAUT. In the UTAUT research, they noted four constructs were likely to play a role as direct determinants of user acceptance of technology and their subsequent use behavior of the technology. The four exogenous determinant constructs PE, EE, SI, and FC were justified as follows:

**PE:** Some variables similar to PE were observed in five of the eight prior models examined in developing UTAUT, including TAM. In TAM (Davis, 1986), the variable perceived utility (PU) was defined as the extent that a person believed a technology would help in job performance and was operationalized in a similar fashion in four other models. Venkatesh et al. (2003) believed PE was the strongest predictor of behavioral intention found in the eight models.

**EE:** Described as the ease associated with use of a technology, EE was related to perceived ease of use (PEOU) in the TAM model (Davis, 1986) and two other models in prior technology acceptance research. EE has demonstrated a significant effect on BI in multiple studies (Alalwan, Dwivedi, & Rana, 2017; Devine, 2015; Venkatesh, Morris, Davis, G., & Davis, F., 2003; Venkatesh, Thong, & Xu, 2012).
SI: Related to perceptions that others believe the user should utilize a technology, SI was found to be included in six of the eight prior studies examined in UTAUT. Fishbein and Ajzen (1975) postulated that social norms were a strong component of the theory of reasoned action (TRA), such that a person’s perceptions about whether the people most important to them believe that the person should perform or not perform a behavior motivates that person to comply with those expectations. Venkatesh et al. (2003) theorized that SI would play a stronger role in mandatory use contexts than voluntary-use contexts, basing that contention on research by Venkatesh and Davis (2000) which showed that social norms did not affect intentions when use of a technology was voluntary, and had a direct effect on intentions when usage was mandatory. The research by Venkatesh et al. (2003) supported SI as a part of UTAUT, with results consistent with Venkatesh and Davis (2000), in that SI was shown to have a greater effect in mandatory usage situations. Researching mobile banking, a voluntary-use technology, Alalwan, Dwivedi, and Rana (2017) found that SI had no significant effect on BI. Despite the mixed results regarding SI in previous research, it was expected that SI would be found to have a positive effect on intentions.

FC: Facilitating conditions are “the degree to which an individual believes that an organizational and technical infrastructure exists to support use” of a system, serving to reduce barriers to using the system (Venkatesh, et al., 2003, p. 453). Studies by Venkatesh et al. (2012), Devine (2015), and Alalwan et al. (2017) all showed support for FC having an effect on BI.

Venkatesh et al. (2003) showed support that FC also had a direct effect as an antecedent for actual use behavior (UB) of a technology as an antecedent of usage and
found that FC was not fully mediated by BI. Therefore, it was expected that FC would have an effect on UB, which was supported in studies by Devine (2015) and Alalwan et al. (2017).

The UTAUT2 model added the constructs HM, PV, and HT to the UTAUT model. This provided a basis for justifying the hypotheses related to each of those constructs, and for BI.

HM: In adding hedonic motivation (HM) to UTAUT2, Venkatesh et al. (2012) noted multiple studies that showed HM to be a predictor of BI. It is logical to theorize that perceived enjoyment of using a technology would have a positive influence on behavioral intention to use the technology.

PV: Useful in a consumer context, price value (PV) is operationalized as the tradeoff between the perceived value of a technology and the costs required to acquire and use it. This construct was supported in research by Devine (2015).

HT: As a construct related to the extent to which a person believed a behavior to be automatic, Venkatesh et al. (2012) found that habit (HT) had a direct effect on both BI and UB. For the present research concerning EFBs, HT was expected to have a positive influence on both BI and UB.

BI: When operationalized as a reflective construct that captured the level that a respondent intended to use a technology, Venkatesh et al. (2012) found that BI had a direct effect on UB. For the present research, BI was expected to have a positive influence on UB.

Figure 10 shows a simplified diagram of the UTAUT2 model, graphically depicting the relationships described in Hypotheses 1 to 10. Each hypothesis is aligned
to the relationship it concerns and are collectively used to address RQ1. Based on the foregoing discussion of expectations of the relationships of the variables, the hypotheses were as follows:

H1: Performance expectancy (PE) positively affects behavioral intention (BI).
H2: Effort expectancy (EE) positively affects behavioral intention (BI).
H3: Social influence (SI) positively affects behavioral intention (BI).
H4: Facilitating conditions (FC) positively affects behavioral intention (BI).
H5: Hedonic motivation (HM) positively affects behavioral intention (BI).
H6: Price value (PV) positively affects behavioral intention (BI).
H7: Habit (HT) positively affects behavioral intention (BI).
H8: Facilitating conditions (FC) positively affects use behavior (UB).
H9: Habit (HT) positively affects use behavior (UB).
H10: Behavioral intent (BI) positively affects use behavior (UB).
Figure 10. Diagram – Hypotheses 1 to 10. Diagram showing each hypothesis next to the appropriate relationships in the model. Hypotheses 1 to 7 (H1-H7) relate to the theorized relationships between the exogenous variables in the UTAUT2 model and the endogenous variable behavioral intentions (BI). Hypotheses 8 and 9 relate to the theorized relationships between facilitating conditions (FC) and habit (HT) on use behavior (UB). Hypothesis 10 predicts that behavioral intention will have an effect on use behavior (BU).

Hypotheses 11 to 13. Hypotheses 11 to 13 were related to UTAUT2’s conceptualizations that age, gender, and experience using the technology act as moderators of the relationships between the constructs of PE, EE, SI, FC, HM, PV, and HT as they relate to BI. Venkatesh et al. (2003) theorized that both age (AGE) and gender (GDR) would moderate the relationships of all seven of the exogenous variables on BI. However, it was expected that experience (EXP) would moderate the relationships of only five of the exogenous constructs and would not moderate PE or PV.
In Figure 11, a simplified diagram of the UTAUT2 model graphically depicts the relationships described in Hypotheses 11 to 13. As described in the preceding discussion, the following hypotheses were formulated to assist in assessing RQ2:

H11: The demographic variable of age (AGE) moderates the effects of the exogenous variables PE, EE, SI, FC, HM, PV, and HT on behavioral intention (BI).

H12: The demographic variable of gender (GDR) moderates the effects of the exogenous variables PE, EE, SI, FC, HM, PV, and HT on behavioral intention (BI).

H13: The demographic variable of experience (EXP) moderates the effects of the exogenous variables EE, SI, FC, HM, and HT on behavioral intention (BI).

Figure 11. Diagram – Hypotheses 11, 12, and 13. Diagram showing the hypotheses related to the demographic variables of age, gender, and experience moderate the relationships of the exogenous variables in the UTAUT2 model to the variable behavioral intention (BI).
**Hypotheses 14 to 17.** Hypotheses 14 to 17 related to Venkatesh et al.’s (2013) belief that AGE, GDR, and EXP would moderate the relationships between the two exogenous variables FC and HT on UB. In addition, it was expected that EXP would moderate the relationship between BI and UB.

Figure 12 depicts the relationships described in Hypotheses 14 to 17. Based on the previous discussion, the following hypotheses were formulated to assist in assessing RQ2:

H14: The demographic variable of age (AGE) moderates the effects of the exogenous variables facilitating conditions (FC) and habit (HT) on use behavior (UB).

H15: The demographic variable of gender (GDR) moderates the effects of the exogenous variable habit (HT) on use behavior (UB).

H16: The demographic variable of experience (EXP) moderates the effects of the exogenous variables facilitating conditions (FC) and habit (HT) on use behavior (UB).

H17: The demographic variable of experience (EXP) moderates the effects of the variable behavioral intention (BI) on use behavior (UB).
Summary

The use of EFBs in modern aviation has expanded rapidly, particularly in the last eight years since the advent of the iPad and other lightweight COTS tablet hardware and advanced EFB software packages. EFBs are in use in nearly all types of aviation operations and have replaced paper references in many aircraft cockpits. Modern EFBs have the capability to display reference data, aviation charts, weather, and traffic, and many can automate various tasks that were formerly calculated by the pilot, such as time enroute, time to destination, and similar information of key importance to pilots.

Research on various aspects of technology acceptance has appeared in the literature for at least 30 years, and the model most closely related to technology acceptance in the consumer context is the UTAUT2 theoretical model. The preceding chapter identified that there exists a lack of research applying technology acceptance to
aviation. In the case of EFBs, no research was identified that has sought to determine what factors of acceptance and adoption most affect pilot actual use behavior of the technology. Understanding of the factors that affect pilot acceptance and adoption of EFB technology has the potential to support improvements in the development of guidance on the use of EFBs, development of the EFB technology hardware and software, and training on the use of EFB technology in flight operations.

Four theories related to technology acceptance were discussed, including Diffusion of Innovations (Rogers, 1983), the Theory of Reasoned Action (Fishbein and Ajzen, 1975), the Theory of Planned Behavior (Ajzen, 1991), and the Technology Acceptance Model (Davis, 1986). Each of these theories served as part of the foundation that Venkatesh et al. (2003) used as a basis for developing the Unified Theory of Acceptance and Use of Technology. UTAUT sought to integrate key concepts from the eight theories of technology acceptance into a comprehensive model with improved explanatory power for predicting factors that led to behavioral intention to use technology, as well as actual use behavior. The UTAUT theoretical model included four exogenous latent factors, as well as four variables thought to moderate the direct effects of the latent factors. UTAUT was explored in use contexts in which users were mandated to utilize the technology of interest, and in 2012 the theory was revised to extend UTAUT such that it included three new constructs and could be applied in voluntary-use contexts (Venkatesh, Thong, and Xu, 2012).
CHAPTER III

METHODOLOGY

The previous chapters detailed a rationale for conducting the research and presented a theoretical framework regarding technology acceptance and how pilot decisions regarding the use of EFBs in flight operations may be explained. Chapter III provides details of the survey methodology used in the present research to examine EFB acceptance factors using the UTAUT2 theoretical model and instrument.

Research Approach

The research approach used a quantitative non-experimental research design featuring survey data collection and structural equation modeling analysis. The UTAUT2 theoretical model developed by Venkatesh et al. (2012) was adapted for the proposed research. UTAUT2 is based on decades of previous research and is focused directly on the factors that affect technology use decisions in a consumer context. The research plan used the UTAUT2 theoretical model and survey instrument to examine the factors that affect pilot acceptance and adoption of EFBs during GA flight operations.

Fowler (2009) urged researchers to provide solid methodological descriptions of survey research, stating two primary reasons. First, a good description of the methodology used can help the reader estimate for themselves the generalizability of the survey results. Secondly, a full description of the methodology used will facilitate replication of the survey by later researchers. To that end, this chapter provides the research approach, the population addressed, how it was sampled, the method of data collection and testing, and an examination of analytical techniques used in the research.
At a high level, Vogt, Gardner, and Haeffele (2012, p. 29) suggest using a survey design when five conditions are met:

- the data is best obtained directly from the respondents;
- the data can be obtained by brief answers to structured questions;
- respondents can be expected to provide reliable information;
- the researcher knows how the answers will be used; and
- an adequate response rate is expected.

In the present study of pilot acceptance and adoption of EFB technology, each of these five conditions were satisfied. The data for the present research is best obtained directly from pilots, as pilot intentions to use EFBs are “subjective” and related to the “inner states of the subjects being studied” (Vogt et al., 2012, p. 16), while information regarding actual pilot use of EFBs is “objective” data that can be gathered directly from survey respondents. Using an adapted UTAUT2 survey instrument permitted gathering of data using simple answers to structured questions, and anonymous pilot responses to a survey were reasonably expected to be reliable. The data collected was analyzed using structured equation modeling, a well-accepted analytical technique. As the research used a wide variety of techniques to recruit survey responses, an acceptable response rate was predicted and obtained.

Fowler (2009) advocates total survey design, which involves careful attention to all aspects of the design of survey research, including sampling, question design, standardizing interview procedures, attention to the mode of collection, and other factors that could affect data quality. The present study used much of the research methodology detailed by Venkatesh et al. (2012) which established the UTAUT2 model while
retaining the flexibility to optimize the survey research design for use in the aviation context.

**Design and Procedures**

An application for research involving human subjects was submitted to the Embry-Riddle Aeronautical University (ERAU) Institutional Research Board (IRB). The application detailed the type of survey research to be conducted, safeguards for participants, and included the initial proposed survey instrument and informed consent statements used in the research. Following IRB approval, a pilot study was conducted to test the reliability and validity of the survey instrument, as well as to evaluate the analytical processes used in the main research study. Also, during the pilot study, the wording of the survey questions was refined, and data collection procedures were tested. Based on the results obtained during the pilot study, revisions were made to the survey instrument, survey instructions, or analytical methodology prior to conducting the large-scale survey.

The survey instrument was entered into SurveyMonkey, an online platform that hosts surveys and has features that support privacy, data security, and analysis. All survey responses were entered using the survey instrument as encoded in the SurveyMonkey software.

All survey participants were presented with the IRB-approved informed consent statement and were not permitted to proceed to the survey until consent was obtained. The survey was anonymous, and no personally identifiable information was collected. Upon completion of the survey, participants were provided a link where they could enter a drawing for a $100 Amazon gift card ($50 for the pilot study). For that optional
drawing entry, a participant was asked to provide their name, email, address, and phone number in order to be entered into the drawing. The survey link and the link for a gift card drawing were distinct, and the researcher had no ability to use any data in the drawing survey to infer or attribute any responses in the main research survey to any individual. All data collected was maintained online in the SurveyMonkey website using password protection, and data downloaded to the researcher’s computer was encrypted and password-protected.

As the wording of the questions related to each UTAUT2 model construct tended to be similar, the presentation of questions 8 to 33 in the questionnaire was randomized. This was accomplished utilizing a randomization feature within the SurveyMonkey software. Questions 1 to 7 collected demographic data so were not randomized.

The collected survey data was analyzed using a variety of statistical tools. IBM SPSS Statistics 25 (SPSS) was used for data preparation and calculation of descriptive statistics. IBM SPSS AMOS 25 (AMOS) was used to perform structural equation modeling of the data collected, using SEM to test the hypotheses presented in the adapted UTAUT2 theoretical model.

Population/Sample

The unit of analysis was individual pilots. The population of inference was general aviation pilots flying under 14 CFR § 91 other than subparts § 91F and § 91K. Fricker (2008, p. 198) notes that the population of inference is the part of the population that the researcher intends to draw conclusions about. The research focuses on factors that affect pilot decisions regarding EFBs in the consumer context. Pilots that fly under 14 CFR § 91 other than subparts § 91F and § 91K were a logical choice for the research,
as those pilots are generally free to make their own choices regarding EFB acceptance and adoption, which may then affect their use of EFBs.

The GA population was an appropriate choice for the present research, as the aviation rules under which most GA aircraft operate generally permits pilots to choose whether, when, and which EFB technology to adopt for their operations. There is FAA guidance regarding the permanent installation of EFB technology in an aircraft; however, many GA pilots have freedom of choice as to whether to select the use of EFB equipment that would be installed under that guidance, and even more latitude for EFBs not permanently installed in the aircraft.

Pilot decisions regarding EFB adoption and use while flying under other rules, such as 14 CFR § 91F, 91K, § 121, § 125, or § 135 may be subject to FAA approval and could also be governed by company rules. Those external influences could potentially have an effect on how those pilots perceive the utility of EFBs, remove their concern for the cost of the devices, or otherwise bias how they might conceptualize the core constructs of the UTAUT2 theoretical model central to this research. Pilots that operate exclusively under rules other than 14 CFR § 91 were excluded from participation in the research.

Fricker (2008, p. 198) also defines the target population as “the population of inference less various groups that the researcher has chosen to disregard.” For the current research, pilots without recent activity as PIC and student pilots were excluded from the target population.

Pilots without at least five hours of recent activity as PIC in the previous year were excluded from the target population in order to ensure survey respondents had at
least some awareness or potential exposure to EFBs. Pilots with recent activity as PIC could reasonably be expected to have at least some awareness or exposure to the current state of development of EFBs and were expected to respond to the survey using their recent activity as PIC as a frame of reference. EFB technology, capabilities, and the rules under which EFBs may be used have changed over the course of time, so pilots without at least some recent flight activity as PIC may have only been able to rely on recollections of long ago flights or outdated technology while answering the survey, potentially introducing unwanted bias into the survey results.

Student pilots, while part of the population of inference, may be influenced by instructor preferences regarding EFBs, as well as by rules from flight schools or other entities that influence student decision-making. Consequently, student pilots were also excluded from the target population.

Size of the target population was roughly estimated using a summary of the civil airmen statistics, published monthly by the FAA (FAA, 2018b). The FAA defines an active airman as “one who holds both an airman certificate and a valid medical certificate,” and includes airplane and rotorcraft pilots, flight navigators, and flight engineers in that definition. However, pilots do not require a medical certificate to exercise the privileges of a Sport certificate, and pilots holding a Private, Commercial, or Airline Transport Certificate (ATP) may also exercise the privileges of a Sport pilot certificate without a medical. The FAA statistics do not estimate the number of pilots that choose to operate under those provisions. Similarly, glider pilots do not require a medical certificate, but the FAA statistics only reflect glider pilots that for some reason have a valid medical certificate on file with the FAA. Thus, the FAA statistics provide
only a rough estimate of the number of pilots that may be eligible to exercise the privileges of their certificate and are not indicative of actual recent activity flying as PIC.

The FAA estimates the total of all active pilots as of May 1, 2018, was 577,232, not including foreign address totals (FAA, 2018b). When 145,755 student pilots are excluded, the approximate available pilots in the target population is 431,477. As the target population also excludes inactive pilots that have logged fewer than five hours in the previous calendar year, that total can reasonably be reduced further, perhaps by a significant number. Estimation of a precise value for the activity levels of pilots registered with the FAA is difficult, and no reliable estimations of how many pilots have flown more or less than five hours in a calendar year was located. The value of five hours was selected for this research as one that would ensure pilots had some minimal level of recent activity as PIC to guide answering the survey, and intentionally exclude inactive pilots.

**Sampling frame and sample size.** Currivan (2011) notes that a *sampling frame* is used to define the population of interest for a research project and is used to select a sample from the target population. Additionally, both the comprehensiveness and accuracy of the sample frame are important considerations to assess whether the sample frame adequately covers the population of interest and whether that sampling frame contains correct elements of information about the population of interest. For the present research, the sampling frame included pilots whose email addresses were available to the researcher from several aviation industry sources and time-space probability sampling of pilots that attend selected aviation events.
Use of a sampling frame that consists only of email lists that contain addressees that may belong to pilots may inaccurately cover the population of interest, as pilot email addresses may have changed, be entered into the list incorrectly, and may not be comprehensive as the list may simply not contain the email addresses of all pilots. As no comprehensive, verifiable list of pilot email addresses is known to exist, several large-scale lists were used in order to increase the chances that the sample population is adequately covered by the sample frame.

An additional challenge in using only lists of email addresses as a sampling frame is that it is possible some pilots do not use email or choose not to share their email addresses, creating hidden populations that would be inaccessible if survey invitations are sought by email alone. Wejnert and Heckathorn (2012) describe the use of time-space sampling as a two-stage method to address hidden populations. In the method, researchers assemble a list of unhidden venues or institutions at which members of the hidden population may be found, then use probability sampling to select specific events from the list. In the second step, researchers travel to the venue or institution in order to access the hidden population. Wejnert and Heckathorn note that “time-space sampling is biased in favor of frequent venue attendees because members of the target population who do not attend public venues are excluded from the sampling frame, and venue regulars have many more chances of being interviewed than occasional patrons” (p. v2-312).

Calculation of the sample size required for structural equation modeling (SEM) is a widely debated topic in current literature. Iacobucci (2009) supported several ad hoc rules for determining sample size, but other researchers (Fabrigar, Porter, & Norris, 2010;
Westland, 2010) noted the shortfalls of those methods due to the complexity of SEM. Wolf, Harrington, Clark, and Miller (2013) observed that the flexibility of SEM to examine complex relationships among various data types using multiple alternative models complicates the development of standardized calculation methods for sample in SEM.

Westland (2010) offered a complex *a priori* algorithm to calculate SEM sample size, then used the algorithm to conduct a meta-study of previous research. Westland found that a high percentage of the literature reviewed used samples that were too small to support robust conclusions relative to the research questions under investigation. Westland (p. 482) defined *a priori* analysis as “what sample size will be sufficient given the researcher’s prior beliefs on what the minimum effect is that the tests will need to detect.” Several years later, Westland (2012) reported that errors had been found in the software code that he had developed in his research. Westland recalculated his original findings, and the results remained valid.

Soper (2017) published a revised software tool that relied on the input of five parameters to calculate an acceptable sample size for SEM research, including anticipated effect size, statistical power level, number of latent (unobserved) and number of observed variables, and the probability level (alpha or α). Using Soper’s calculator with α = 0.05, effect size = 0.2, power = 0.8, four observed variables, and 28 latent variables yielded a minimum sample size of 460 recommended cases to detect effect. The value of 31 latent variables reflects latent variables calculated for use in analysis of the effects of the moderating variables. For the current research, a minimum of 483 survey responses was
sought to obtain sufficient sample for SEM analysis. This number was selected to provide for a 5% overage of responses in case some responses have missing data.

**Sampling method.** Babbie (2013, p. 132) defines *probability sampling* as “the general term for samples selected in accord with probability theory, typically involving some random-selection mechanism.” In probability sampling, the “probability with which every member of the frame population could have been selected into the sample is known (Fricker, 2008, p. 199). An FAA database of pilots containing the mailing address of the pilots in the target population for this research is available but not useful for the present research. The database is incomplete, as it does not contain pilots that choose to remove their names from public disclosure or glider pilots without a medical certificate. Survey response rates vary widely in the literature. Kaplowitz, Hadlock, and Levine (2004) reported a response rate of over 31% for a mail-based survey involving multiple mailings of the survey and reminder cards, at a cost of almost $11 for each survey response obtained. Given the desired sample size for this study and the consequent costs to obtain sufficient responses, probability sampling was not conducted for this research.

Babbie (2013, p. 128) defines *nonprobability sampling* as “any technique in which samples are selected in some way not suggested by probability theory.” Vogt, Gardner, and Haefele (2012) define three types of nonprobability samples, including convenience samples, quota samples, and judgment samples. *Convenience samples* are samples that are often selected because they are easy for the researchers to access but are often not representative of the population being studied and can compromise the generalizability of research results. According to Vogt et al., *quota sampling* is “essentially stratified convenience sampling” (p. 127) and involves the researcher seeking
out a quota of participants to fit certain categories believed to be represented in the target population. While quota sampling has advantages over convenience sampling, it still suffers from limitations but can be useful in certain situations, such as when the time available for conduct of a survey is very limited.

The last category of nonprobability sampling provided by Vogt et al. (2012) is judgment sampling, also known as purposive sampling. In some situations, such as when a researcher is working alone, has limited funds, or when other factors prevent probability sampling, judgment sampling is the only practical way to obtain sufficient survey responses.

Survey responses for the present research were sought using nonprobability email delivery of survey invitations to potential respondents and time-space probability sampling of pilots that attend selected aviation events. Use of both methods combined the strengths of using large email lists with the ability to access the hidden population of pilots without email addresses by using probabilistic data sampling at aviation events.

An email list maintained by Curt Lewis & Associates, LLC, and email to the followers of a popular aviation blog maintained by an airline pilot were used to attract survey responses. Together, those lists distributed survey invitations to over 100,000 email addresses. Little information was available regarding the demographics or accuracy of those emails appearing on the email lists. The individual email addresses to which the survey invitation was distributed were not made available to the researcher.

Additional survey responses were sought using time-space probability sampling of selected aviation events accessible by the researcher. A list of potential aviation events that were within a three-hour driving or flying range of the researcher was
assembled, and a simple random sampling was used to select which events the researcher would attend.

Table 6 provides a listing of aviation events initially considered for use during data collection, ordered using a random probability value assigned by Microsoft Excel. In the table, the events were marked as belonging to one of the following four types of aviation events or institutions, and the events selected appear above the dotted line:

- **FAA Sponsored Safety Events (FSSE).** This type of event includes safety seminars and other events promoted by the FAA Safety Team (FAAST).
- **Aviation Advocacy Group Events (AAGE).** This type of event includes events sponsored by private industry organizations, although some of the events may be cross-promoted by the FAA.
- **Private Organization Events (POE).** This type of event includes fly-in aviation breakfasts or other privately sponsored gathering that is open to the public. An example is the Experimental Aircraft Association (EAA).
- **Aviation Venue (AV).** This type of event represents a collection opportunity at an aviation-related business with consistent pilot attendance, such as a fixed base operator (FBO) or airport restaurant.
Table 6

Potential Aviation Events for In-Person Survey Collection

<table>
<thead>
<tr>
<th>Randomly Assigned Value</th>
<th>Event Type</th>
<th>Date</th>
<th>Location</th>
<th>Event Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1208</td>
<td>POE</td>
<td>2/24/18</td>
<td>KPCM</td>
<td>Plant City, Florida aviation community event</td>
</tr>
<tr>
<td>0.1401</td>
<td>FSSE</td>
<td>2/8/2018</td>
<td>KORL</td>
<td>Orlando, Florida FAA Safety Team Class</td>
</tr>
<tr>
<td>0.1582</td>
<td>AAGE</td>
<td>2/3/2018</td>
<td>KLAL</td>
<td>Lakeland, Florida EAA Aircraft Workshop</td>
</tr>
<tr>
<td>0.4822</td>
<td>AAGE</td>
<td>2/3/2018</td>
<td>KFMY</td>
<td>Fort Myers, Florida AOPA Rusty Pilots</td>
</tr>
<tr>
<td>0.5532</td>
<td>POE</td>
<td>2/10/2018</td>
<td>KTPF</td>
<td>Tampa, Florida FBO lunch event</td>
</tr>
<tr>
<td>0.5702</td>
<td>AAGE</td>
<td>1/20/2018</td>
<td>KPCM</td>
<td>Plant City, Florida EAA Chapter meeting</td>
</tr>
<tr>
<td>0.6579</td>
<td>AAGE</td>
<td>1/27/2018</td>
<td>X06</td>
<td>Arcadia, Florida AOPA President talk</td>
</tr>
<tr>
<td>0.6611</td>
<td>AAGE</td>
<td>2/15/2018</td>
<td>KORL</td>
<td>Orlando, FL Women in Aviation luncheon</td>
</tr>
<tr>
<td>0.7564</td>
<td>AAGE</td>
<td>2/10/2018</td>
<td>KSEF</td>
<td>Sebring, Florida EAA fly-in breakfast</td>
</tr>
<tr>
<td>0.8630</td>
<td>AAGE</td>
<td>1/20/2018</td>
<td>X06</td>
<td>Arcadia, Florida Friends of Arcadia breakfast</td>
</tr>
<tr>
<td>0.9350</td>
<td>AAGE</td>
<td>1/20/2018</td>
<td>KBOW</td>
<td>Bartow, Florida AOPA Rusty Pilots</td>
</tr>
<tr>
<td>0.9591</td>
<td>AAGE</td>
<td>2/17/2018</td>
<td>X06</td>
<td>Arcadia, Florida Friends of Arcadia breakfast</td>
</tr>
<tr>
<td>0.9755</td>
<td>AAGE</td>
<td>2/17/2018</td>
<td>KPCM</td>
<td>Plant City, Florida EAA Chapter meeting</td>
</tr>
<tr>
<td>0.9871</td>
<td>POE</td>
<td>1/27/2018</td>
<td>KSEF</td>
<td>Sebring, Florida US Sport Aviation Expo</td>
</tr>
</tbody>
</table>

*Note. Event types are: AAGE (Aviation Advocacy Group Event); FSSE (FAA Sponsored Safety Event); POE (Private Organization Event); and AV (Aviation Venue)*

**Sources of survey error.** In survey research, several types of errors can affect the generalizability of the survey results to the population of inference, including coverage error, sampling error, nonresponse error, and measurement error.

**Coverage error.** Fricker (2008, p. 199) defines *coverage error* as “the difference between the frame population and the population of inference.” Fricker notes the dangers inherent in online, internet-based survey sampling methods, observing that many surveys use convenience samples which limit the usefulness of analysis of the survey results. Convenience samples, Fricker states, are non-probability samples in which some participants in the sample population may choose to opt out of responding. Ison (2010) noted that online surveys could suffer from coverage bias, in which frame population
sampled using the survey differs from the population of inference. Fricker (2008) suggested that if a study is intended to be generalizable to a population of interest that contains members who do not have access to email or internet services, then mixed methods of contact are required to enable sampling of that portion of the population.

For the present research, practical limitations prevented the researcher from attempting to contact the entire available pilot population to offer a chance to participate in the research. The survey was distributed by email to several extensive email address lists; however, to overcome the limitation that some pilots in the target population were expected not to have regular email or internet access, additional survey responses were sought at aviation events as described in Table 7. Using both of these methods to obtain survey responses partially mitigated coverage error, although practical limitations, notably the vast geography of the U.S., limited in-person solicitation and collection of survey responses to Florida.

**Sampling error.** Sampling error reflects that data collected from a sample will have random variation that differs from the target population, with the result that different samples will produce different results. Sampling error can be reduced by increasing the sample size, so in the present research, survey responses were solicited until the sample size calculated was obtained, plus an overage allowance for incomplete or ineligible surveys.

**Nonresponse bias.** Nonresponse bias, also called nonresponse error, refers to the fact that some people in a sample frame may choose not to respond or are unable to answer the survey due to issues such as being unfamiliar with the language used on the survey. Groves et al. (2012) note that in the case where a person is not made aware or
chooses not to respond to the survey at all, the term used is \textit{unit nonresponse}, and when a person chooses or is unable to answer a specific item on the survey, the term \textit{item nonresponse} is used. Fricker (2008) observed that nonresponse error can create bias in survey results if there is some systematic difference in those who choose not to answer a survey from those who do choose to use a survey. Groves et al. (2012, p. 191) note that “nonresponse can affect both descriptive statistics and analytic statistics.”

Nonresponse error can be difficult to evaluate, given that in many cases the researcher does not have information available about those who choose not to complete the survey to make any attempts at evaluating the presence or extent of any nonresponse bias. Fricker (2008) suggests that if a list-based sampling frame is used, a researcher may be able to adjust for nonresponse effects if sufficient information about each unit in the sampling frame is available.

Fricker (2008) concludes that research regarding the effect of incentives on response rates is inconclusive; however, Groves et al. (2012) notes that without an incentive, survey responses tend to be from people interested in the topic of the survey, and that with an incentive, other potential respondents choose to participate, and unit nonresponse is reduced such that the respondent pool better matches the target population when an incentive is used. For the present research, a small incentive of an Amazon gift card was used as a means to potentially increase the response rate, decrease unit nonresponse, and potentially reduce nonresponse error.

Groves et al. (2012) also noted multiple methods are used by researchers in an effort to reduce nonresponse bias, including repeated exposure to the survey, long data collection periods, mode switches in delivery of the survey, and other methods, but such
efforts often contribute to increased costs for the survey research. For the present research, the survey invitation was provided in multiple emails over a period of several weeks, and multiple modes to invite survey participation were used at aviation events. One method that worked well was to hand interested persons a survey invitation with a Uniform Resource Locator (URL) (i.e. web address) printed on a small piece of paper.

Analytical results that indicate no or minimal bias exists can be used to infer that the survey sample is representative of the population of inference. Atif, Richards, and Bilgin (2012, p. 4) note that “evaluation of the bias is not always possible as the true value of the population or population characteristics are not always known,” and they detailed nine approaches available to estimate non-response bias. Atif et al. also observed that none of the approaches were conclusive and that researchers may choose to use one or more of the approaches to assess non-response bias.

Using the wave analysis method, the present research used Chi-square testing to evaluate the differences in six demographic variables for early and late responders to determine the presence of non-response error. In describing wave analysis, Atif et al. (2012) proposed that every subject in a sample falls somewhere on the continuum of always responding or choosing never to respond. Atif et al. (2012) propose using those that respond late to successive waves of survey invitations can serve as an analytical proxy for non-respondents. After dividing survey responses into two groups representing respondents and non-respondents, estimation of whether there is a difference in the response rate between the two groups was analyzed by calculation of a Chi-Square statistic, with $p < 0.05$ considered as statistically significant.
Measurement error. The last type of error noted by Fricker (2008), measurement error, is the error related to how well a survey response actually relates to what the survey question actually intends to measure. Survey participants may misread survey questions, survey questions can be ambiguously written or presented in a confusing way, or a particular question may be uncomfortable for a participant and cause them to intentionally bias their response. To minimize measurement error, survey questions and methods of providing the survey were carefully tested during the pilot study to help identify and reduce sources of measurement error by confirmatory factor analysis (CFA) as a part of the structural equation modeling.

To minimize error associated with any difference between surveys solicited online or in person and for survey responses solicited at in-person events, the researcher limited personal interaction in an effort to prevent influencing responses, and directed potential respondents to complete the survey online on the same website as used by respondents solicited via email.

Other types of error. Research methodologists caution consideration of mode effects and selection error when conducting survey research. Mixed mode surveys can suffer from mode effects in which “the type of survey affects how respondents answer questions” (Fricker, 2008, p. 207). Mixed mode surveys occur when the same survey questions are presented using multiple modes, such as internet-based surveys using visual digital presentations, telephonic surveys in which the questions are presented audibly, and traditional pen and paper surveys. Suh (2015) found that while differences in responses occurred fairly often, most differences were not large, with a median difference of about 5%, and varied by the type of question asked.
Vannieuwenhuyze, Loosveldt, and Molenberghs (2014) note that mixed mode surveys can have reduced selection error as compared to single mode surveys, defining selection error as error that occurs when only a subset of the target population is sampled. Vannieuwenhuyze et al. observe that evaluation of selection error can be difficult, as measurement error confounds selection error, complicating the estimation of error and evaluation of the utility of mixed mode research.

The mode of survey data collection in the present research was the same whether solicited via an email invitation or at an in-person aviation event. To minimize mode effects, all surveys were presented in digital format provided by SurveyMonkey. SurveyMonkey delivers the survey in much the same format whether in a web browser or in an app on a tablet or computer. Figures C1, C2, and C3 in Appendix C contain images demonstrating the similarity of a survey presented in multiple hardware platforms.

**Data Collection Device**

Data for the research was collected using a customized version of the UTAUT2 survey instrument, modified to fit the subject of EFBs. In addition to the consent form, the UTAUT2 survey instrument consisted of three sections. In the first section, general demographic data relating to age, gender, pilot flight experience, experience using EFBs, and pilot certificate and ratings was collected. The information from the first section of the survey provided demographic information and data related to the three moderating factors in the UTAUT2 theoretical model, which are age, gender, and experience using EFBs, and also established that the respondent was qualified to provide a response to the survey. In order to support responses from a diverse population of pilots, including those with pilot certificates obtained from other countries, the wording of the survey question
regarding pilot certificate held permitted responses from pilots holding foreign certificates. However, in an effort to streamline the survey, the respondents were not asked to note whether they held a foreign certificate, thus the present research cannot determine what percentage of the respondents held a foreign pilot certificate.

The second section of the survey featured 26 questions from the UTAUT2 survey instrument published by Venkatesh et al. (2012), each modified slightly to fit the aviation EFB context. These 26 questions corresponded to the exogenous (observed) variables in the UTAUT2 model. Those variables include performance expectancy, effort expectancy, social influence, facilitating conditions, hedonic motivation, price value, and habit.

In the third section, information was collected regarding pilot use of EFBs while serving as PIC during GA flight operations. Pilots reported their use of EFBs, which was evaluated as the use behavior (UB) construct in the UTAUT2 theoretical model. Five sub-indices of use behavior were collected, corresponding to the five phases of flight as defined in Table 8. For each of the sub-indices UB1 to UB5, respondents were asked to report how often they used an EFB for that particular phase of flight, with five responses available that ranged from non-use of EFBs to use during all flight operations. During early planning for the study, UB was to be represented as a formative composite index, aggregating UB1 to UB5 using a geometric mean, but the lack of clear acceptance in the literature of composite indexes and disagreement of how to calculate their reliability and validity were of concern. Consequently, for analysis of the full structural model, the UB4 item was selected to represent UB as an observed endogenous variable. UB4 characterizes the respondents self-reported usage of EFBs during airborne phases of
flight. Note that Table 7 shows the survey items grouped by UTAUT2 factor, while Appendix B shows the survey instrument in the format as it was shown to the survey respondents.
### Table 7

**Survey Items Grouped by UTAUT2 Factor**

<table>
<thead>
<tr>
<th>Construct</th>
<th>#</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Performance Expectancy</strong></td>
<td>PE1</td>
<td>I find electronic flight bags useful in my flight operations.</td>
</tr>
<tr>
<td></td>
<td>PE2</td>
<td>Using an electronic flight bag helps me accomplish things more quickly.</td>
</tr>
<tr>
<td></td>
<td>PE3</td>
<td>Using electronic flight bags increases my productivity.</td>
</tr>
<tr>
<td><strong>Effort Expectancy</strong></td>
<td>EE1</td>
<td>Learning how to use electronic flight bags is easy for me.</td>
</tr>
<tr>
<td></td>
<td>EE2</td>
<td>My interaction with electronic flight bags is clear and understandable.</td>
</tr>
<tr>
<td></td>
<td>EE3</td>
<td>I find electronic flight bags easy to use.</td>
</tr>
<tr>
<td></td>
<td>EE4</td>
<td>It is easy for me to become skillful at using electronic flight bags.</td>
</tr>
<tr>
<td><strong>Social Influence</strong></td>
<td>SI1</td>
<td>People who are important to me think that I should use an electronic flight bag.</td>
</tr>
<tr>
<td></td>
<td>SI2</td>
<td>People who influence my behavior think that I should use an electronic flight bag.</td>
</tr>
<tr>
<td></td>
<td>SI3</td>
<td>People whose opinions that I value prefer that I use an electronic flight bag.</td>
</tr>
<tr>
<td><strong>Facilitating Conditions</strong></td>
<td>FC1</td>
<td>I have the resources necessary to use an electronic flight bag.</td>
</tr>
<tr>
<td></td>
<td>FC2</td>
<td>I have the knowledge necessary to use an electronic flight bag.</td>
</tr>
<tr>
<td></td>
<td>FC3</td>
<td>Electronic flight bags are compatible with other technologies I use.</td>
</tr>
<tr>
<td></td>
<td>FC4</td>
<td>I can get help from others when I have difficulties using an electronic flight bag.</td>
</tr>
<tr>
<td><strong>Hedonic Motivation</strong></td>
<td>HM1</td>
<td>Using an electronic flight bag is fun.</td>
</tr>
<tr>
<td></td>
<td>HM2</td>
<td>Using an electronic flight bag is enjoyable.</td>
</tr>
<tr>
<td></td>
<td>HM3</td>
<td>Using electronic flight bags is very entertaining.</td>
</tr>
<tr>
<td><strong>Price Value</strong></td>
<td>PV1</td>
<td>Electronic flight bags are reasonably priced.</td>
</tr>
<tr>
<td></td>
<td>PV2</td>
<td>Electronic flight bags are a good value for the money.</td>
</tr>
<tr>
<td></td>
<td>PV3</td>
<td>At the current price, electronic flight bags provide a good value.</td>
</tr>
<tr>
<td><strong>Habit</strong></td>
<td>HT1</td>
<td>The use of an electronic flight bag has become a habit for me.</td>
</tr>
<tr>
<td></td>
<td>HT2</td>
<td>I am addicted to using an electronic flight bag.</td>
</tr>
<tr>
<td></td>
<td>HT3</td>
<td>I must use an electronic flight bag.</td>
</tr>
<tr>
<td><strong>Behavioral Intention</strong></td>
<td>BI1</td>
<td>I intend to continue using an electronic flight bag in the future.</td>
</tr>
<tr>
<td></td>
<td>BI2</td>
<td>I will always try to use an electronic flight bag in my flight operations.</td>
</tr>
<tr>
<td></td>
<td>BI3</td>
<td>I plan to continue to use an electronic flight bag frequently.</td>
</tr>
<tr>
<td><strong>Use Behavior</strong></td>
<td>UB1</td>
<td>Preflight planning (Weather, navigation, flight planning)</td>
</tr>
<tr>
<td></td>
<td>UB2</td>
<td>Preflight checks (aircraft inspection, checklists, weight and balance)</td>
</tr>
<tr>
<td></td>
<td>UB3</td>
<td>Ground operations (Taxi, both pre- and post-flight)</td>
</tr>
<tr>
<td></td>
<td>UB4</td>
<td>Airborne operations (Takeoff, Climb, Cruise, Descent, Landing)</td>
</tr>
<tr>
<td></td>
<td>UB5</td>
<td>Post-flight (aircraft checks, checklists, closing flight plans)</td>
</tr>
</tbody>
</table>
**Instrument reliability.** The customized UTAUT2 survey instrument used in the present research was assessed for reliability using the concepts described in the following paragraphs. Reliability was evaluated during the pilot study and during analysis of the survey used for the main body of the research.

Reliability in research can also be called consistency. Babbie (2013, p. 188) defines *reliability* as “a matter of whether a particular technique, applied repeatedly to the same object, yields the same result each time.” Hair, Black, Babin, and Anderson (2015, p. 8) said that reliability “is the degree to which the observed variable measures the ‘true’ value and is ‘error free’; thus, it is the opposite of measurement error.”

In multivariate research, Hair et al. (2015) note that researchers can use composite measures (summated scales) in which multiple items are combined, to better represent a core construct, and the combination of multiple responses is more accurate in representing a construct than are single item measures. By design, the UTAUT2 theoretical model uses multiple questions, each worded slightly differently, for each of the seven core constructs represented by the exogenous variables. In this multivariate usage, Hair et al. refine the definition of reliability to be “an assessment of the degree of consistency between multiple measurements of a variable” (p. 123) and provide several methods in which assessment of reliability is conducted.

In the first measure, correlations of each item in a summated scale to the summated scale score referred to as *item-to-total correlation* are considered, as are the correlations of each item to the other items in the summated scale, referred to as *inter-item correlations*. Hair et al. (2015) recommends inter-item correlations be larger than .30 and item-to-total correlations be larger than .50.
A second measure of reliability recommended by Hair et al. (2015) is Cronbach’s alpha, which is a reliability coefficient that assesses the reliability (consistency) of the entire scale. In most uses, values for Cronbach’s alpha should exceed .70. Hair et al. caution that an issue with Cronbach’s alpha is that it can increase with an increase in the number of items on a scale, so it should be used carefully in scales that have a large number of items. Lastly, Hair et al. (2015, p. 546) observes that construct reliability (CR) is a “measure of the degree to which a set of indicators of a latent construct is internally consistent in their measurements,” and that the indicators all appear to measure the same construct.

**Instrument validity.** The concepts described in the following paragraphs were used to assess the customized UTAUT2 survey instrument for validity. Validity was evaluated during the pilot study and during analysis of the survey used for the main body of the research.

Babbie (2013, p. 34) says that the term validity is used “to refer to the approximate truth of an inference,” while Hair et al. (2015, p. 124) defines validity as “the extent to which a scale or set of measures accurately represents the concept of interest.” Multiple aspects of validity are defined in the literature relevant to the present research, including construct validity, convergent and discriminant validity, and nomological validity.

**Construct validity.** Shadish, Cook, and Campbell (2002) define construct validity as the degree to which inferences based on observations included in a study relate to the constructs that those observations may represent. Byrne (2010) observes that construct
validity relates to some extent on how well data is shown to have convergent and
discriminant validity, or evidence of *method effects*, which represents bias.

**Convergent and discriminant validity.** *Convergent validity* assesses “the degree
to which two measures of the same concept are correlated,” while *discriminant validity*
assesses the “degree to which two conceptually similar concepts are distinct” (Hair et al,
2015, p. 124). To measure convergent validity, the average variance extracted (AVE)
should be 0.50 or higher, as that indicates that the latent variable explains greater than
half of the variance in the indicator (Hair, Ringle, & Sarstedt, 2011). Factor loadings for
each of the constructs should also be assessed to establish convergent validity, with
regression weights greater than 0.7 preferred and loadings greater than 0.5 remaining
acceptable (Truong & Jitbaipoon, 2016a).

Discriminant validity can be assessed in two ways. Hair et al. (2011) suggest that
discriminant validity is acceptable if an indicator’s cross loadings with the latent
construct it is associated with are higher than that indicator’s loadings with the other
latent constructs in the scale. Truong and Jitbaipoon (2016a) suggest that a construct is
unique if it captures some phenomena that is not captured in another construct, and thus
has discriminant validity if the *maximum shared variance* (MSV) for a factor is less than
the AVE for that factor.

**Nomological validity.** *Nomological validity* refers to the degree to which the
items in a scale are supported in existing theory or prior research (Hair et al., 2015).
Venkatesh et al. (2012) grounded the development of the UTAUT2 theoretical model in
multiple theories of technology acceptance and conducted detailed testing of candidate
scale items as they developed the UTAUT2 survey instrument. The nomological validity
of the UTAUT2 scale is assumed valid for the purposes of this research, and further
testing of the nomological validity of the UTAUT2 model was not conducted.

**Pilot Study**

For the present research, a pilot study was conducted with the objectives of
evaluating the survey instructions, informed consent statement, data handling procedures,
and data analysis methodology. Additionally, the pilot study supported testing of
confirmatory factor analysis (CFA) procedures of the survey instrument to assess the
reliability and validity of the items and UTAUT2 constructs as modified for the proposed
research. In order to protect the privacy of each participant, no personally identifiable
information was collected during the pilot study.

In general, there are often multiple reasons to conduct methodological testing
prior to conducting survey research. Collins (2003) notes that survey participants can
misread the wording in questions or misunderstand concepts represented by a question.
Survey tools such as online websites or applications can present human-computer
interaction issues, such as fonts that are too small, difficulty in scrolling or screen
navigation, or a host of other problems that result in survey error or increase the dropout
rate of those who start but do not complete the survey. Collins advocates that researchers
conduct interviews with survey participants using various techniques to gain insights into
the test instrument, procedures, and other aspects of the task. For the pilot study, a
comment section was included to permit the respondents to provide observations
regarding issues with the survey instructions, informed consent, survey instrument
wording, or survey software platform.
The pilot study was advertised to faculty and students at ERAU by means of posters posted on bulletin boards in the College of Aviation, as well as emails to flight students and instructors. Each participant in the pilot study was provided with a link to a non-public website on SurveyMonkey.

The survey instructions, informed consent statement, data collection methodology, data handling procedures, and data analysis methodology were evaluated and adjusted as necessary based on the results of the pilot study. Comments from the respondents contributed to assessing procedural, readability, and content reliability of the survey instrument. Data collected during the pilot study was analyzed in SPSS and AMOS. CFA of the proposed items and constructs, including calculation of measures of reliability and validity as detailed in the following section permitted evaluation of issues with the survey instrument that required correction. Results of the pilot study are documented in Chapter IV.

**Treatment of the Data**

SurveyMonkey, the online platform used to host the data collection for this survey research, featured a simple export utility that facilitated easy import of raw survey responses into SPSS. Additionally, SurveyMonkey provided some statistical information as to the survey information gathered. Once sufficient survey responses were gathered to meet the calculated requirements for statistical analysis, the survey was closed and data was downloaded and imported into SPSS. Minimal data transformation was required, such as recoding of gender responses such that female was equal to 0, and male was equal to 1.

Evaluation of the survey data collected was managed in four sequential steps:
1. Preparation of demographic and descriptive statistics

2. CFA of the factor analytic model

3. SEM of the full structural model

4. Hypothesis testing

**Demographics and descriptive statistics.** Profiles of the demographic values reported by the respondents, including age, gender, pilot flight experience, and pilot ratings were calculated. Profiling the demographic information of the survey respondents described the characteristics of the sample obtained during the survey and was compared against the pilot population data acquired from the FAA.

Preparation of descriptive statistics is a fundamental process in data analysis and is used to describe the basic characteristics of data available in the sample obtained. Descriptive statistics for each variable in the UTAUT2 model were prepared, including mean, standard deviation, and histograms as appropriate to the type of data represented by the construct.

**CFA of the factor analytic model.** AMOS was used to calculate estimates of the relationships of the constructs within the specified structural model. Among other outputs, AMOS supported tests for normality and outliers, degrees of freedom, modification indices, and factor loadings represented by regression weights.

Truong and Jitbaipoon (2016a) note that CFA is a theory-driven method, and the factor structure analyzed is based on the ground theory underlying the research being conducted. Truong and Jitbaipoon suggest a CFA process using AMOS analysis that begins with treatment of missing data, assessment of normality of the data, review of
outliers, examination of model fit, and review of factor reliability, validity, and factor loadings.

AMOS requires complete data. An initial analysis of the completed surveys revealed some missing values. Cheema (2014) notes that a researcher’s choice of a method to handle missing values varies greatly by circumstance but observes that many researchers choose pairwise or listwise deletion and mean imputation to address missing values. Cheema contends that those methods, while simple, are the most error prone, stating that some researchers opt to increase sample size in order to minimize the proportion of the dataset with missing values. Missing values were assessed and imputed using IBM SPSS Missing Values software.

Normality for each factor in the UTAUT2 model was assessed by examination of the skewness and kurtosis values calculated. Byrne (2010) observes that a key assumption for SEM is that the data to be assessed are multivariate normal, and although there is not consensus in the literature regarding acceptable values for kurtosis, values greater than seven “can be indicative of early departure from normality” (p. 103), and thus the maximum of seven can be used as a guide during analysis. Truong and Jitbaipoon (2016a) recommend kurtosis values of three are acceptable, and larger values may need transformation.

Byrne (2010) recommends examination of the squared Mahalanobis distance ($D^2$) for each observation in the data to test for outliers. AMOS provides a display of those observations farthest from the centroid. Outliers observed were assessed in consideration of deletion, with caution not to lose information by excessive removal of outlying observations.
To assess model fit, AMOS provides multiple indices of goodness of fit of the model. SPSS calculations to demonstrate that the model is overidentified and has sufficient degrees of freedom are examined. Table 8 provides the indices considered in this study and the recommended values for each.

Table 8

*SEM Goodness of Fit Indices*

<table>
<thead>
<tr>
<th>Goodness of Fit Measure</th>
<th>Recommended Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\chi^2/df$</td>
<td>$\leq 3.00$</td>
</tr>
<tr>
<td>GFI</td>
<td>$\geq 0.90$</td>
</tr>
<tr>
<td>AGFI</td>
<td>$\geq 0.90$</td>
</tr>
<tr>
<td>NFI</td>
<td>$\geq 0.90$</td>
</tr>
<tr>
<td>CFI</td>
<td>$\geq 0.90$</td>
</tr>
<tr>
<td>RMSEA</td>
<td>$\leq 0.05$</td>
</tr>
</tbody>
</table>


Truong and Jitbaipoon (2016a) note that if good model fit is not achieved, post hoc analysis is required or the results obtained in the research will not be conclusive. The model was respecified to achieve good fit by reevaluating the model and making modifications as required to improve model fit. Covariance or cross loadings between items and factors was examined, and those items exhibiting the highest modification indices were modified. Only one change to the model was made at a time, and the model fit was then recalculated and reassessed.

After a good model fit was achieved, construct reliability, validity, and factor loadings were assessed. Determination of construct reliability and validity are important
to ensure that the model can consistently measure the constructs under consideration and actually measures the concepts it is designed to assess.

To determine construct reliability, Truong and Jitbaipoon (2016a) and Hair et al. (2015) recommend a Cronbach’s alpha of greater than 0.7. Hair et al. (2015) states that factor loadings should be 0.5 or higher, and factor loadings higher than 0.7 are most desirable and an indicator of convergent validity. Truong and Jitbaipoon also recommend calculation of CR values as a measure of reliability, such that a CR value greater than or equal to 0.7 indicates good construct reliability. Truong and Jitbaipoon also recommend consideration of an AVE of 0.5 or higher as an additional measure of convergent validity, particularly for factors with low factor loadings. To assess discriminant validity, MSV was examined to determine if it is less than AVE.

**SEM of the full structural model.** Once good model fit was achieved during CFA, indicating a reliable and valid instrument, assessment of the full structural model was conducted on the full structural model. Hair et al. (2015) recommend beginning with assessment of the SEM model fit and then assessment of “whether the structural relationships are consistent with theoretical expectations” (p. 655).

As the structural model is grounded in theory, corresponding relationships between the variables are input into AMOS, and a process similar to the CFA process is conducted when the full structural model is run. Model fit indices are examined to assess the model’s overall fit, and factor loading estimates are examined to determine if the results are consistent with the ground theory and the CFA results.

Regression weights between the variables in the form of t-values and unstandardized and standardized structural path estimates are examined to determine if
they are significant and in the expected direction (Hair et al., 2015). For post hoc analysis, Truong and Jitbaipoon (2016a) state that it is important to examine modification indices (MI) to find high MI values for the covariance between error terms and high regression weights between an item and a factor, which represents a cross-loading situation. Truong and Jitbaipoon also advises assessing regression weights between factors, which could suggest relationships between the factors other than those considered in the ground theory.

**Hypothesis testing.** AMOS supports testing of the hypotheses by examination of standardized and unstandardized structural path estimates, \( t \)-values, and \( p \)-values. A \( t \)-value is obtained by dividing the unstandardized path estimate by the standard error, sometimes called the critical ratio. A \( t \)-value is “significant at the 0.05 level if the \( t \)-value exceeds 1.96 and at the 0.01 level if the \( t \)-value exceeds 2.56” (Suhr, 2006, p. 11). Hypotheses 1-10 were evaluated using this process.

Hypotheses 11 to 16, related to the moderating effects of age, gender, and experience using EFBs, requires use of a different method for evaluating how the moderators affect the relationships between other variables. Two methods that have been used in prior research to examine the extent of such moderation are potentially useful.

Venkatesh, Thong, and Xu (2012) used the interaction between constructs in multigroup analysis to test the effects of moderating variables. Hayes (2014) detailed a procedure path-analysis based analytical method that utilized regression analysis of the relationships between two variables \( X \) and \( Y \) as moderated by a third variable \( M \), which is theorized and tested to its affects as a moderator. Hayes developed a macro, PROCESS, which plugs into SPSS and supports a somewhat automated analysis of
moderating variables. PROCESS produces regression coefficients, standard errors, t and p-values, and model summary information, which are then used in the determination of which hypotheses are supported. PROCESS macro was used to evaluate the effects of the moderating variables age, gender, and experience using EFBs on the relationships between other variables in the UTAUT2 model, as detailed in Hypotheses 11 to 17.

**Ethical Considerations**

Researchers are obligated to protect the subjects of any research activities from suffering any harm from participation. ERAU manages a robust IRB review process for research with human participants. The first step involves the student completing an extensive online application that provides granular detail of the type of research to be accomplished, the conditions in which it will be conducted, and how the data will be used and protected. During the application phase, the student researcher must provide the survey instrument to be used, along with a description of how data will be protected. After the faculty advisor approves, the IRB office receives the application, and the application is iterated with the research advisor as needed. After acceptance by the IRB office, the research is submitted to IRB reviewers. A research project categorized as exempt is approved for conduct for one year after approval but may be extended. Informed consent is a critical piece of IRB protection, and survey participants in the present research were provided a detailed informed consent statement.

Eynon, Fry, and Schroeder (2011) published an extensive review of ethical concerns in internet research, concluding that the ethical concerns of internet research is most effectively considered in the context of which the research is designed. Eynon et al. suggest consideration of the use of data encryption, password protection of devices and
online data tools, and secure data transmission protocols, particularly if the survey allows
collection of personal or confidential information that the participant would not be
willing to share if meeting in person. For the present research, all data and analysis
collected was secured by password access to the computer, coinciding with automated
encryption of data stored for the project.

Summary

The purpose of the research outlined was to examine the factors that influence an
EFB user’s behavioral intentions to use the technology and to understand the role of age,
gender, and experience using EFBs during flight operations as moderators of those
factors. The research used a non-experimental research design utilizing an adapted
version of the previously validated UTAUT2 survey instrument.

Data was mainly collected by internet-based survey, with some responses
collected at in-person events attended by the researcher. To minimize introduction of any
methodological errors, surveys solicited at events were completed on a tablet computer
using the exact same URL as would have been used had the researcher contacted the
respondent by means of the internet. A pilot study was conducted to validate the
adaptations made to the UTAUT2 survey items such that they encompassed EFBs, and to
test and practice data collection and initial analysis procedures.

The research plan called for the data to be downloaded, cleaned, and assessed,
with procedures to address missing values and evaluate the collected responses for bias.
Structural equation modeling using SPSS software with the AMOS plugin was conducted
to analyze the results for the data collected.
CHAPTER IV
RESULTS

This study investigated the factors that influence general aviation pilot acceptance and adoption of EFBs using the extended Unified Theory of Acceptance and Use of Technology (UTAUT2). A survey using an adapted version of the UTAUT2 survey items garnered 703 responses, with 589 responses available for analysis after ineligible, incomplete, and outlier responses were removed during the data-cleaning process. Chapter IV presents the SEM results obtained during the conduct of the pilot study and the main study. The first section provides the findings obtained during the pilot study and the changes made to adapt the UTAUT2 theoretical model for the main study. Next, the results of the main study are presented in detail, including data preparation, descriptive statistics, and statistical analysis of the data, including factor analysis and SEM to determine the fit of the results to the adapted UTAUT2 model. Lastly, the outcome of the hypothesis testing conducted is presented.

Pilot Study Results

The pilot study was conducted to assess and refine the process planned to collect data. The pilot study supported assessment of the settings entered on the SurveyMonkey platform, procedures to clean and analyze the data collected, and served to test the survey instrument, including analysis of the factor loadings on the constructs adapted from the UTAUT2 theoretical model. Posters were placed around ERAU’s Daytona Beach College of Aviation, and an email was sent to faculty and students at the same campus to solicit survey participation.
Summary of the pilot study results. One hundred and fifty three students and faculty responded to the invitation to complete the pilot study survey. All of the respondents reported being active pilots with recent flight experience. The data was downloaded from SurveyMonkey in SPSS format, then prepared and analyzed in SPSS and AMOS. Fifty three cases, representing 34.6% of the cases collected, had one or more items with missing values. Thirty nine of those cases were deleted as they were missing responses for over 79% of the items. Missing values were calculated for the remaining 14 cases with the SPSS missing values tool. One hundred and fourteen cases were available for further analysis.

General demographics of responses to the pilot study. The gender of pilot study respondents generally corresponded to the demographics of the student body of ERAU. Twenty five point four percent of the pilot study respondents (n = 114) were female, which was consistent with the university’s 2016 published student demographics, which reported figures of 20% female for undergraduate students and 28% for graduate students (Embry-Riddle Aeronautical University, 2017). It is likely that a small number of faculty members responded; however, the university did not report faculty gender demographics for comparison.

The mean age of respondents was 20.9 years, with a range from 18 to 47. Just over two-thirds of the respondents held a Private Pilot certificate (n = 76), with the remaining 32.7% of respondents holding a Commercial Pilot certificate (n = 38). No pilots reported holding recreational, sport, or airline transport pilot certificates.

Approximately the same percentage of pilot study respondents held an instrument rating, with only 34.5% of the pilots responding reporting they did not have an instrument rating.
rating. For the respondents holding a Private Pilot certificate, 48.7% reported had an instrument rating, which was higher than the FAA’s published figure that 29% of the Private Pilots hold an instrument rating (FAA, 206b). Similarly, 100% of the respondents holding a Commercial Pilot certificate reported holding an instrument rating, while the FAA reports that only 91% of the overall population of Commercial Pilots held an instrument rating (FAA, 2017f). The higher percentage of instrument ratings may be related to the university having an embedded 14 CFR § 141 flight school operating on campus and integrated into much of the university’s educational operations. Table 9 summarizes the gender, age, pilot certificate, and instrument rating demographics of the respondents to the pilot study.

Table 9

Demographics of Pilot Study Respondents

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Private Pilots</th>
<th>Commercial Pilots</th>
<th>All Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n = 76</td>
<td>n = 38</td>
<td>n = 114</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>n</td>
<td>%</td>
<td>n</td>
</tr>
<tr>
<td>Male</td>
<td>55</td>
<td>72.4</td>
<td>30</td>
</tr>
<tr>
<td>Female</td>
<td>21</td>
<td>27.6</td>
<td>8</td>
</tr>
<tr>
<td>Age (Count in Years)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18 - 22</td>
<td>65</td>
<td>85.6</td>
<td>20</td>
</tr>
<tr>
<td>23 - 26</td>
<td>9</td>
<td>11.8</td>
<td>14</td>
</tr>
<tr>
<td>27 - 30</td>
<td>2</td>
<td>2.6</td>
<td>1</td>
</tr>
<tr>
<td>30 - 33</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>34 - 37</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>38 - 41</td>
<td>1</td>
<td>2.6</td>
<td>1</td>
</tr>
<tr>
<td>42 - 45</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>46 - 49</td>
<td>1</td>
<td>2.6</td>
<td>1</td>
</tr>
<tr>
<td>Missing</td>
<td>1</td>
<td>2.6</td>
<td>1</td>
</tr>
<tr>
<td>Instrument Rating</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>39</td>
<td>51.3</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>37</td>
<td>48.7</td>
<td>38</td>
</tr>
</tbody>
</table>
Pilot and EFB experience demographics in the responses to the pilot study. The mean pilot experience for survey respondents, reported as logged flight experience, was 195.9 hours and ranged from 60 to 880 hours. The reported hours of flight experience for Private Pilots ($M = 131.6, SD = 54.3$) was lower than that of Commercial Pilots ($M = 324.5, SD = 176.6$), as would be expected given the training requirements for the Commercial Pilot certificate.

Pilot experience using EFBs was also collected during the survey. EFB experience differed from logged flight experience for multiple likely reasons. Widespread adoption of EFBs is a relatively recent phenomenon, and not all pilots have adopted EFBs into their flight operations, and while pilot experience is gained during actual flight operations, EFB experience as defined for the present research included other uses of EFBs, including preflight planning and pre- or post-flight tasks such as reviewing checklists, filing flight plans, or calculating weight and balance. But as the Pilot Study population consisted primarily of ERAU flight students, and the ERAU Flight Department strongly encourages use of EFBs, it would be expected that EFB usage reported in the Pilot Study may differ from the wider population of all general aviation pilots in the primary research. The mean reported EFB experience for all respondents was 141.9 hours and ranged from 0 to 700 hours. As with pilot experience, Commercial Pilots reported greater experience using EFBs ($M = 226.1, SD = 172.3$) than did Private Pilots ($M = 112.5, SD = 107.5$). Table 10 shows how pilot experience and EFB experience differed for Private and Commercial Pilots, as well as for all pilot study respondents.
Table 10

**Pilot and EFB Experience of Pilot Study Respondents**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Private Pilots</th>
<th>Commercial Pilots</th>
<th>All Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
</tr>
<tr>
<td>Pilot Experience (Count in Hours)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-100</td>
<td>29</td>
<td>38.2</td>
<td>29</td>
</tr>
<tr>
<td>101-200</td>
<td>39</td>
<td>51.3</td>
<td>6</td>
</tr>
<tr>
<td>201-300</td>
<td>8</td>
<td>10.5</td>
<td>21</td>
</tr>
<tr>
<td>301-400</td>
<td>4</td>
<td>10.5</td>
<td>4</td>
</tr>
<tr>
<td>401-500</td>
<td>3</td>
<td>7.9</td>
<td>3</td>
</tr>
<tr>
<td>501-600</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>601-700</td>
<td>1</td>
<td>2.6</td>
<td>1</td>
</tr>
<tr>
<td>701-800</td>
<td>2</td>
<td>5.3</td>
<td>2</td>
</tr>
<tr>
<td>801-900</td>
<td>1</td>
<td>2.6</td>
<td>1</td>
</tr>
<tr>
<td>EFB Experience (Count in Hours)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-100</td>
<td>41</td>
<td>53.9</td>
<td>12</td>
</tr>
<tr>
<td>101-200</td>
<td>20</td>
<td>26.3</td>
<td>8</td>
</tr>
<tr>
<td>201-300</td>
<td>8</td>
<td>10.5</td>
<td>5</td>
</tr>
<tr>
<td>301-400</td>
<td>3</td>
<td>7.9</td>
<td>3</td>
</tr>
<tr>
<td>401-500</td>
<td>3</td>
<td>7.9</td>
<td>3</td>
</tr>
<tr>
<td>501-600</td>
<td>3</td>
<td>7.9</td>
<td>3</td>
</tr>
<tr>
<td>601-700</td>
<td>1</td>
<td>1.3</td>
<td>1</td>
</tr>
<tr>
<td>Missing</td>
<td>6</td>
<td>7.9</td>
<td>4</td>
</tr>
</tbody>
</table>

*Note.* Null values are left blank for ease of reading.

**Pilot study testing and instrument modifications.** Reliability and validity testing was conducted to assess the results of the pilot study survey responses. Hair, Black, Babin, and Anderson (2015, p. 618) observe that “evidence of construct validity provides confidence that item measures taken from a sample represent the actual true score that exists in a population, and that high construct reliability means that the measures in a scale “consistently represent the same latent construct” (p. 619). Hair et al. (2015) also note that squared multiple correlations (R²), sometimes referred to as _item reliability_, may suggest that an item should be considered for deletion from the model.
In the pilot study results presented in Table 11, FC, HM, and HT all have at least one item with low $R^2$ values. Although FC showed potential issues with item reliability, the values for construct reliability (CR) and Cronbach’s Alpha were acceptable. Although the AVE value for FC was slightly low, the standardized loadings indicated acceptable validity, so no changes were made to the FC survey items. Similarly, HM had one item with a low $R^2$ value, but had acceptable CR and Cronbach’s Alpha reliability values, as well as acceptable results on the measures of validity, so it was retained in the model and the survey instrument unchanged.

$R^2$, AVE, and Cronbach’s Alpha values were lower than desired for the Habit (HT) construct, indicating problems with the constructs’ reliability and validity. As used in the pilot study, the three items related to HT were:

- HT1: The use of an electronic flight bag has become a habit for me.
- HT2: I am addicted to using an electronic flight bag.
- HT3: I must use an electronic flight bag.

Careful review of Venkatesh, Thong, and Xu (2012) revealed that the survey items developed in the original UTAUT2 model did not appear to fully align with the primary research the authors cited. Given that the factor loading of HT2 was lower than the recommended value of 0.5 or higher, and as the wording of HT3 did not seem to have a strong foundation in the literature reviewed, both HT2 and HT3 were replaced as follows:

- HT2A: Using an electronic flight bag feels automatic to me.
- HT3A: It is efficient and automatic for me to use an electronic flight bag.
The revised wording of HT2A and HT3A drew upon the assertion that “Habit has been defined as the extent to which people tend to perform behaviors automatically because of learning” (Venkatesh, Thong, & Xu, 2012), as well as the term automaticity. Kim, Malhotra, and Narasimhan (2005, p. 419) assert that information technology use “occurs automatically” and does not require conscious processing. HT2A and HT3A were designed to more directly solicit responses to the automaticity construct as a component of habit.
### Table 11

**Pilot Study Reliability and Validity**

<table>
<thead>
<tr>
<th>UTAUT2 Construct</th>
<th>Item/ Factor</th>
<th>Reliability (R²)</th>
<th>Construct Reliability (CR) (≧0.70)</th>
<th>Cronbach's Alpha (≧0.70)</th>
<th>Standardized Loadings (Acceptable ≧0.50 Ideal ≧0.70)</th>
<th>Average Variance Extracted (AVE) (≧0.50)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PE</td>
<td>PE1</td>
<td>0.73</td>
<td></td>
<td></td>
<td></td>
<td>0.85</td>
</tr>
<tr>
<td></td>
<td>PE2</td>
<td>0.59</td>
<td>0.904</td>
<td>0.838</td>
<td></td>
<td>0.77</td>
</tr>
<tr>
<td></td>
<td>PE3</td>
<td>0.61</td>
<td></td>
<td></td>
<td></td>
<td>0.78</td>
</tr>
<tr>
<td></td>
<td>EE1</td>
<td>0.64</td>
<td></td>
<td></td>
<td></td>
<td>0.80</td>
</tr>
<tr>
<td></td>
<td>EE2</td>
<td>0.63</td>
<td></td>
<td></td>
<td></td>
<td>0.80</td>
</tr>
<tr>
<td></td>
<td>EE3</td>
<td>0.70</td>
<td>0.921</td>
<td>0.88</td>
<td></td>
<td>0.84</td>
</tr>
<tr>
<td></td>
<td>EE4</td>
<td>0.61</td>
<td></td>
<td></td>
<td></td>
<td>0.78</td>
</tr>
<tr>
<td>SI</td>
<td>SI1</td>
<td>0.75</td>
<td></td>
<td></td>
<td></td>
<td>0.87</td>
</tr>
<tr>
<td></td>
<td>SI2</td>
<td>0.51</td>
<td>0.889</td>
<td>0.822</td>
<td></td>
<td>0.71</td>
</tr>
<tr>
<td></td>
<td>SI3</td>
<td>0.61</td>
<td></td>
<td></td>
<td></td>
<td>0.78</td>
</tr>
<tr>
<td>FC</td>
<td>FC1</td>
<td>0.54</td>
<td></td>
<td></td>
<td></td>
<td>0.74</td>
</tr>
<tr>
<td></td>
<td>FC2</td>
<td><strong>0.49</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>0.70</strong></td>
</tr>
<tr>
<td></td>
<td>FC3</td>
<td><strong>0.37</strong></td>
<td>0.826</td>
<td>0.779</td>
<td></td>
<td><strong>0.443</strong></td>
</tr>
<tr>
<td></td>
<td>FC4</td>
<td><strong>0.37</strong></td>
<td></td>
<td></td>
<td></td>
<td>0.61</td>
</tr>
<tr>
<td>HM</td>
<td>HM1</td>
<td>0.46</td>
<td></td>
<td></td>
<td></td>
<td>0.68</td>
</tr>
<tr>
<td></td>
<td>HM2</td>
<td>0.67</td>
<td>0.799</td>
<td>0.757</td>
<td></td>
<td>0.82</td>
</tr>
<tr>
<td></td>
<td>HM3</td>
<td><strong>0.38</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>0.503</strong></td>
</tr>
<tr>
<td>PV</td>
<td>PV1</td>
<td><strong>0.34</strong></td>
<td></td>
<td></td>
<td></td>
<td>0.58</td>
</tr>
<tr>
<td></td>
<td>PV2</td>
<td>0.61</td>
<td>0.787</td>
<td>0.772</td>
<td></td>
<td>0.78</td>
</tr>
<tr>
<td></td>
<td>PV3</td>
<td>0.74</td>
<td></td>
<td></td>
<td></td>
<td>0.86</td>
</tr>
<tr>
<td>HT</td>
<td>HT1</td>
<td><strong>0.46</strong></td>
<td></td>
<td></td>
<td></td>
<td>0.68</td>
</tr>
<tr>
<td></td>
<td>HT2</td>
<td><strong>0.22</strong></td>
<td><strong>0.567</strong></td>
<td><strong>0.629</strong></td>
<td></td>
<td><strong>0.47</strong></td>
</tr>
<tr>
<td></td>
<td>HT3</td>
<td><strong>0.37</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>0.349</strong></td>
</tr>
<tr>
<td>BI</td>
<td>BI1</td>
<td>0.55</td>
<td></td>
<td></td>
<td></td>
<td>0.74</td>
</tr>
<tr>
<td></td>
<td>BI2</td>
<td>0.58</td>
<td>0.892</td>
<td>0.848</td>
<td></td>
<td>0.76</td>
</tr>
<tr>
<td></td>
<td>BI3</td>
<td>0.84</td>
<td></td>
<td></td>
<td></td>
<td>0.92</td>
</tr>
</tbody>
</table>

*Note: PE = Performance Expectancy; EE = Effort Expectancy; SI = Social Influence; FC = Facilitating Conditions; HM = Hedonic Motivation; PV = Price Value; HT = Habit; and BI = Behavioral Intention.*
Other survey instrument modifications. Analysis of the results of the pilot study and review of comments from pilot study respondents also resulted in modification of the section of the survey that collected demographic data. The question relating to EFB experience was heavily revised.

The original question relating to EFB experience on the pilot study survey required pilots to think about the number of hours they used an EFB during preflight planning, preflight checks, during flight, and postflight, then provide an estimate of the total hours they had used an EFB. Ten of the 114 respondents did not submit a response for EFB experience, and several experienced pilots commented to the researcher that they felt the question was difficult to answer.

Venkatesh, Thong, and Xu (2012) operationalized experience as how much time had passed since a subject had initially used a technology under study, basing their method on previous research. The question on EFB experience was simplified and revised to use the passage of time using an EFB, with respondents choosing from five possible responses:

- I have less than 1-month experience using an electronic flight bag.
- I have 1 to 12 months experience using an electronic flight bag.
- I have 12 to 24 months experience using an electronic flight bag.
- I have 24 to 48 months experience using an electronic flight bag.
- I have more than 48 months experience using an electronic flight bag.

While using this revised survey item may be simpler for respondents to complete, the revised wording does not, however, account for differences in the frequency in which a pilot uses an EFB. For example, a pilot that uses an EFB on just a few flights each
year, but has done so for more than four years, would report greater EFB experience than a pilot that has only used an EFB for three years, but has used an EFB for hundreds of hours of flight for each of those three years.

**Large Scale (Main Study) Survey Results**

After revising the survey instrument subsequent to the pilot study, data for the main survey was collected for the main study. In the sections that follow, details of the results obtained are provided, including data collection, data preparation, descriptive statistics, testing procedures, and SEM modeling.

**Data Collection.** Collection using nonprobability email invitations went as planned, with responses collected by sending survey invitations by email to several mailing lists and solicitation of responses by the researcher at several aviation events. A large number of responses were collected within the first few weeks of emailing out the survey invitation. The survey SurveyMonkey supports establishment of a unique uniform resource locator (URL) for each collector in order to track which source a response came from and to support later analytical techniques, including testing for non-response bias. The five collectors used are detailed in Table 12.
Table 12

*Survey Collectors – Large Scale Survey (Main Study)*

<table>
<thead>
<tr>
<th>Collector Name</th>
<th>Type</th>
<th>Target Subpopulation</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - ERAU</td>
<td>Nonprobability Email</td>
<td>College students/faculty</td>
<td>133</td>
</tr>
<tr>
<td>2 – Airline Pilot Blog</td>
<td>Nonprobability Email</td>
<td>Aviation author blog followers / professional pilots</td>
<td>102</td>
</tr>
<tr>
<td>3 - Curt Lewis, LLC</td>
<td>Nonprobability Email</td>
<td>Aviation safety mailing list</td>
<td>314</td>
</tr>
<tr>
<td>4 - Researcher Invitations</td>
<td>Nonprobability Email</td>
<td>Researcher email invitations by researcher</td>
<td>134</td>
</tr>
<tr>
<td>5 - Aviation Events</td>
<td>Time-Space Probability Sampling</td>
<td>In-person collection at aviation events</td>
<td>20</td>
</tr>
</tbody>
</table>

Total: \( n = 703 \)

*Note.* The number of responses collected reflected is prior to removal of responses with systematic missing values or other issues.

The time-space probability sampling planned and detailed in Chapter 3 was problematic and resulted in collection of far fewer survey responses than anticipated. Inclement weather, transportation issues, and the lack of suitable aviation events in the time-frame in which the data collection occurred reduced the opportunity to collect responses as planned in Table 7, limiting collection to the events detailed in Table 13.
Table 13

*Aviation Events Attended for Survey Collection*

<table>
<thead>
<tr>
<th>Event Type</th>
<th>Date</th>
<th>Location</th>
<th>Event Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>AV</td>
<td>2/3/2018</td>
<td>KDED</td>
<td>Deland, Florida aviation restaurant</td>
</tr>
<tr>
<td>AV</td>
<td>2/3/2018</td>
<td>KBOW</td>
<td>Bartow, Florida FBO and aviation restaurant</td>
</tr>
<tr>
<td>AV</td>
<td>2/9/2018</td>
<td>KDAB</td>
<td>Daytona, Florida FBO</td>
</tr>
<tr>
<td>AAGE</td>
<td>2/10/2018</td>
<td>KSEF</td>
<td>Sebring, Florida EAA fly-in breakfast</td>
</tr>
<tr>
<td>POE</td>
<td>2/10/2018</td>
<td>KTPF</td>
<td>Tampa, Florida FBO lunch event</td>
</tr>
<tr>
<td>AV</td>
<td>2/17/2018</td>
<td>KCGC</td>
<td>Crystal River, Florida Flight School and FBO</td>
</tr>
</tbody>
</table>

*Note.* Event types are: AAGE (Aviation Advocacy Group Event); FSSE (FAA Sponsored Safety Event); POE (Private Organization Event); and AV (Aviation Venue).

If sufficient information is available, calculation of response rates is important to support evaluation of response bias and how the presence of sampling bias could affect the generalizability of the results of survey research. In the present research, such evaluation is difficult at best. For the ERAU mailing list, the researcher used a group mailing address and had no access to determine detailed information regarding the number of faculty and students included on that list. The owner of the airline pilot blog posted the survey invitation on her blog site and emailed the invitation to some of her followers, but there is no way to determine whether the responses to that SurveyMonkey collector were obtained due to the email invitations or due to the blog post. Similarly, Curt Lewis, LLC does not make information available about the number or makeup of the population that has opted in to their mailing list. Similarly, the researcher provided the survey invitation to leaders of several aviation organizations (The Ninety-Nines and
several EAA chapters), and due to privacy concerns, had no visibility regarding the number of email addresses the invitation was provided to by those leaders. As noted in Chapter 3, Groves et al. (2012) suggest employment of multiple methods to reduce sampling bias, including repeating exposure to the survey invitation and the use of long data collection periods, both of which were utilized in the present research. As an example, the Curt Lewis LLC survey invitation was sent each day for 21 days.

**Data preparation/missing value analysis.** The data collected was downloaded from SurveyMonkey in SPSS format. Variable names and descriptions assigned in SurveyMonkey were updated to reflect the variable names used in the UTAUT2 model. A nominal variable named Case ID was created for each case for identification purposes, and variable measures were adjusted to reflect the appropriate variable type.

Of the 703 cases initially downloaded from SurveyMonkey; 18 cases were identified as reflecting respondents were ineligible for the study as they held a Student Pilot certificate and were deleted. Using the SPSS Missing Values tool, and additional 82 cases were identified and deleted, as those cases had missing values for more than 75% of the items. Six additional cases had four to six items with missing values and were deleted as a separate variance $t$-test suggested that the missing values for those cases may not have been random.

AMOS requires that the dataset have no missing values. Missing values were imputed for the remaining cases that had missing values, using the expectation maximization (EM) method for all variables, except three nominal variables which were computed using the median of nearby points method. At the conclusion of the missing values analysis process, 597 cases were available for analysis with no missing values.
**Descriptive statistics.** The following two sections provide descriptive statistics about the respondents for the main study. The first section details demographics about the respondents' age, gender, pilot certificate held, instrument rating, pilot experience, EFB experience, and reported EFB usage. The demographic tables are organized by the pilot certificate held and the total of all pilots responding to the survey, and where possible compare the results obtained to the statistics for all pilots certificated by the FAA using information from the latest year for which detailed civil aviation pilot statistics were available. The second section provides statistics related to the responses provided by the respondents for the items on the UTAUT2 scale.

**Respondent demographics.** Table 14 provides data regarding both the pilot certificates and instrument ratings held by the main study respondents. Private Pilots comprised the largest number of respondents, followed by Commercial and Airline Transport Pilots. While eight Sport and Recreational pilots completed the survey, those two certificate levels made up only about 1.3% of the total respondents. The survey sample comprised a slightly higher percentage of Private and Commercial pilots as compared to the percentage of Private and Commercial pilots in the total population of pilots reported by the FAA (FAA, 2017f), while the number of Airline Transport pilots was slightly lower than the percentage reported by the FAA. Overall, while the sample population reported higher percentages of instrument ratings at the Private and Commercial certificates, the percentage of pilots with and instrument rating was consistent with the percentage of pilots in the overall pilot population reported by the FAA.
Table 14

Certificate and Instrument Rating of Main Study Respondents

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Sport</th>
<th>Recreational</th>
<th>Private</th>
<th>Commercial</th>
<th>Airline Transport</th>
<th>All Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pilot Certificate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( n )</td>
<td>5</td>
<td>3</td>
<td>273</td>
<td>185</td>
<td>131</td>
<td>597</td>
</tr>
<tr>
<td>% sample</td>
<td>0.8</td>
<td>0.5</td>
<td>45.8</td>
<td>31.0</td>
<td>21.9</td>
<td>100.0</td>
</tr>
<tr>
<td>% FAA total(^a)</td>
<td>1.43</td>
<td>0.04</td>
<td>38.1</td>
<td>23.1</td>
<td>37.4</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Instrument Ratings Held

<p>| | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( n )</td>
<td>2</td>
<td>1</td>
<td>121</td>
<td>180</td>
<td>131</td>
<td>435</td>
</tr>
<tr>
<td>% sample</td>
<td>40.0</td>
<td>33.3</td>
<td>44.3</td>
<td>97.3</td>
<td>100.0</td>
<td>72.9</td>
</tr>
<tr>
<td>% FAA total(^b)</td>
<td>n/a</td>
<td>n/a</td>
<td>29.2(^c)</td>
<td>91.0</td>
<td>100.0(^d)</td>
<td>69.5(^d)</td>
</tr>
</tbody>
</table>

Note. FAA population statistics adapted from 2017 Active Civil Airmen Statistics [XLS file]. Retrieved from https://www.faa.gov/data_research/aviation_data_statistics/civil_airmen_statistics/

\(^a\)The percentages listed for each category of pilot certificates under \% FAA total represents the percentage of all categories of pilot certificates issued by the FAA, including Student Pilots, Flight Instructors, Rotorcraft, and Glider Pilot certificates. 

\(^b\)FAA does not publish figures for the number of pilots holding a Sport or Recreational Pilot certificate that hold an instrument rating.

\(^c\)The percentages listed for \% FAA total under the Private, Commercial, and Airline Transport Pilot certificate headings represents the percentage of pilots holding an instrument rating at each certificate level.

\(^d\)The percentage for \% FAA total under All Respondents represents the percent of pilots holding an instrument rating at the included five pilot certificates only.

Table 15 provides information about the gender and age of the pilots responding to the survey. The percentage of female pilots in the sample is higher than that of the overall pilot population reported by the FAA for 2017. The sample collected had 18.4% female pilots, while the FAA reports that the overall pilot population had only 5.5% female pilots (FAA, 2017f). This over-representation of female pilots is consistent across all of the pilot certificates reported.

The mean age of the pilots represented in the sample is slightly lower than published FAA figures for all certificates except Airline Transport Pilot certificate. The
mean age of all survey respondents, however, was very consistent with the mean age reported by the FAA for the overall pilot population.

Table 15

*Gender and Age of Main Research Study Respondents*

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Sport</th>
<th>Recreational</th>
<th>Private</th>
<th>Commercial</th>
<th>Airline Transport</th>
<th>All Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( n = 5 )</td>
<td>( n = 3 )</td>
<td>( n = 273 )</td>
<td>( n = 185 )</td>
<td>( n = 131 )</td>
<td>( n = 597 )</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( n )</td>
<td>5</td>
<td>2</td>
<td>230</td>
<td>141</td>
<td>109</td>
<td>487</td>
</tr>
<tr>
<td>% sample</td>
<td>100.0</td>
<td>66.7</td>
<td>84.2</td>
<td>76.2</td>
<td>83.2</td>
<td>81.6</td>
</tr>
<tr>
<td>% FAA total</td>
<td>96.2</td>
<td>90.8</td>
<td>93.8</td>
<td>93.6</td>
<td>95.6</td>
<td>94.5</td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( n )</td>
<td>0</td>
<td>1</td>
<td>43</td>
<td>44</td>
<td>22</td>
<td>110</td>
</tr>
<tr>
<td>% sample</td>
<td>0.0</td>
<td>33.3</td>
<td>15.8</td>
<td>23.8</td>
<td>16.8</td>
<td>18.4</td>
</tr>
<tr>
<td>% FAA total</td>
<td>3.8</td>
<td>9.2</td>
<td>6.1</td>
<td>6.4</td>
<td>4.4</td>
<td>5.5</td>
</tr>
</tbody>
</table>

**Age**

\[ \text{M - sample} \]

<table>
<thead>
<tr>
<th></th>
<th>Sport</th>
<th>Recreational</th>
<th>Private</th>
<th>Commercial</th>
<th>Airline Transport</th>
<th>All Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>( M - \text{sample} )</td>
<td>51.2</td>
<td>32.3</td>
<td>44.6</td>
<td>43.6</td>
<td>55.0</td>
<td>46.5</td>
</tr>
<tr>
<td>( M - \text{FAA total} )</td>
<td>56.4</td>
<td>44.0</td>
<td>48.4</td>
<td>46.0</td>
<td>50.2</td>
<td>49.3*</td>
</tr>
</tbody>
</table>

*Note. FAA population statistics adapted from 2017 Active Civil Airmen Statistics [XLS file]. Retrieved from https://www.faa.gov/data_research/aviation_data_statistics/civil_airmen_statistics/*

*The published FAA mean age for the overall pilot population includes student pilots, flight instructors, and remote pilots, so a weighted average was calculated excluding those certificates.*

Table 16 provides additional data regarding age of survey respondents. Ages are grouped into brackets for each certificate. Figure 13 shows the same data as pie charts to facilitate comparison of the differences in ages of respondents for each certificate.
Table 16

*Bracketed Age Demographics of Main Research Study Respondents*

<table>
<thead>
<tr>
<th>Age Range</th>
<th>Sport</th>
<th>Recreational</th>
<th>Private</th>
<th>Commercial</th>
<th>Airline Transport</th>
<th>All Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n = 5</td>
<td>n = 3</td>
<td>n = 273</td>
<td>n = 185</td>
<td>n = 131</td>
<td>n = 597</td>
</tr>
<tr>
<td></td>
<td>n (%)</td>
<td>n (%)</td>
<td>n (%)</td>
<td>n (%)</td>
<td>n (%)</td>
<td>n (%)</td>
</tr>
<tr>
<td>18 - 24</td>
<td>0 (0.0%)</td>
<td>2 (66.7%)</td>
<td>74 (27.1%)</td>
<td>44 (23.8%)</td>
<td>1 (0.8%)</td>
<td>121 (20.2%)</td>
</tr>
<tr>
<td>25 - 34</td>
<td>1 (20.0%)</td>
<td>0 (0.0%)</td>
<td>20 (7.3%)</td>
<td>30 (16.2%)</td>
<td>15 (11.4%)</td>
<td>66 (11.1%)</td>
</tr>
<tr>
<td>35 - 44</td>
<td>1 (20.0%)</td>
<td>0 (0.0%)</td>
<td>28 (10.3%)</td>
<td>25 (13.5%)</td>
<td>14 (10.7%)</td>
<td>68 (11.4%)</td>
</tr>
<tr>
<td>45 - 54</td>
<td>2 (40.0%)</td>
<td>0 (0.0%)</td>
<td>45 (16.5%)</td>
<td>24 (13.0%)</td>
<td>22 (16.8%)</td>
<td>93 (15.6%)</td>
</tr>
<tr>
<td>55 - 64</td>
<td>0 (0.0%)</td>
<td>1 (33.3%)</td>
<td>65 (23.8%)</td>
<td>25 (13.5%)</td>
<td>42 (32.1%)</td>
<td>133 (22.3%)</td>
</tr>
<tr>
<td>65 - 74</td>
<td>0 (0.0%)</td>
<td>0 (0.0%)</td>
<td>36 (13.2%)</td>
<td>31 (16.8%)</td>
<td>35 (26.7%)</td>
<td>102 (17.1%)</td>
</tr>
<tr>
<td>75 +</td>
<td>1 (20.0%)</td>
<td>0 (0.0%)</td>
<td>5 (1.8%)</td>
<td>6 (3.2%)</td>
<td>2 (1.5%)</td>
<td>14 (2.3%)</td>
</tr>
</tbody>
</table>

Figure 13. Age Demographics of Survey Respondents. Pie charts showing the ages of pilots that responded for each type of certificate. Greater than 50% of Airline Transport pilots are between 55 and 74, while the distribution of the ages of pilots holding Private and Commercial certificates is much more even.
As might be expected, the amount of pilot experience, reported in flight hours logged, varied by level of pilot certificate held, with Airline Transport Pilots reporting the most flight hours, followed by Commercial and Private pilots. This result is logical, as pilots must obtain additional experience to obtain each certificate in sequential order. Table 17 provides statistics for pilot experience by pilot certificate, while Figure 14 shows that male respondents reported more flight hours than female respondents for all pilot certificates held.

Table 17

_Pilot Experience of Main Research Study Respondents_

<table>
<thead>
<tr>
<th>Pilot Experience</th>
<th>Sport</th>
<th>Recreational</th>
<th>Private</th>
<th>Commercial</th>
<th>Airline Transport</th>
<th>All Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$n = 5$</td>
<td>$n = 3$</td>
<td>$n = 273$</td>
<td>$n = 185$</td>
<td>$n = 131$</td>
<td>$n = 597$</td>
</tr>
<tr>
<td>$M$</td>
<td>176.0</td>
<td>130.0</td>
<td>612.7</td>
<td>2114.9</td>
<td>11406.6</td>
<td>3440.6</td>
</tr>
<tr>
<td>$Md$</td>
<td>110.0</td>
<td>140.0</td>
<td>280.0</td>
<td>1100.0</td>
<td>8600.0</td>
<td>850.0</td>
</tr>
<tr>
<td>$SD$</td>
<td>154.2</td>
<td>26.5</td>
<td>802.8</td>
<td>3146.1</td>
<td>8225.8</td>
<td>6034.0</td>
</tr>
</tbody>
</table>

*Note.* Pilot experience reported in flight hours in accordance with 14 CFR § 61.51.
Figure 14. Chart – Mean pilot experience by gender (Hours). Chart showing the mean pilot experience reported by gender for each pilot certificate. Sport and Recreational pilot certificates are not displayed due to small size of the samples collected for each.

Figure 15 shows reported EFB experience. Due to the very small sample size at those levels, Sport and Recreational certificates are not displayed. EFB Experience varied widely among pilots at all certificate levels. Airline Transport pilots reported the greatest EFB experience levels, with 79.4% reporting greater than 24 months experience, while only 66.0% of Commercial pilots and 47.8 of Private pilots reported similar experience. The mean for reported EFB experience for Private, Commercial, and Airline Transport pilots increased at each higher-level certificate, which is logical given the increased flight experience required to obtain the higher certificates.
Figure 15. Chart – EFB experience by pilot experience. Chart showing the mean pilot experience reported by gender for each pilot certificate. Sport and Recreational pilot certificates are not displayed due to small size of the samples collected for each.

**UTAUT2 model variable statistics.** Table 18 provides information regarding Use Behavior (UB). The aggregate mean of UB is not reported, as a composite index of UB was not utilized during the present research. While Table 19 shows that pilots reported using EFBs most for flight planning and airborne operations, it also shows that a similar number of pilots use EFBs during ground operations.
### Table 18

**Use Behavior (UB) Statistics**

<table>
<thead>
<tr>
<th>Factor</th>
<th>Mean</th>
<th>SD</th>
<th>Phase of Flight</th>
</tr>
</thead>
<tbody>
<tr>
<td>UB1</td>
<td>3.90</td>
<td>1.11</td>
<td>Preflight Planning</td>
</tr>
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<td>Preflight Checks</td>
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<td>Airborne Operations</td>
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<td>UB5</td>
<td>2.01</td>
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<td>Post-Flight</td>
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*Note.* UB = Use Behavior. UB4 used in evaluation of full structural model as an observed endogenous variable.

However, when the data is viewed as a histogram of percentages as in Figure 16, a clearer understanding of the results emerges. Use of EFBs during ground operations, which includes both pre- and post-flight taxi operations, is spread somewhat equally across all potential usage levels. In contrast, nearly 70% of pilots report significant use of EFBs during preflight planning and airborne operations, but 70% of pilots also report not using EFBs during most preflight checks and post-flight activities.
Figure 16. Chart – Self-reported EFB use behavior by phase of flight. Chart shows the distribution of responses for self-reports of use behavior of EFBs by percentage for each phase of flight.

Table 19 provides descriptive statistics for the survey items related to the constructs in the UTAUT2 model. For each of these constructs, users responded on a five-point Likert scale with responses ranging from Strongly Agree to Strongly Disagree. The mean and standard deviation is provided for each item factor, and it can be readily seen that for some items, the mean response was significantly higher for all items in some constructs as compared to others.
Table 19

**UTAUT2 Item Descriptive Statistics**

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<td>HT3</td>
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<td>0.798</td>
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*Note.* PE = Performance Expectancy; EE = Effort Expectancy; SI = Social Influence; FC = Facilitating Conditions; HM = Hedonic Motivation; PV = Price Value; HT = Habit; BI = Behavioral Intention; and UB = Use Behavior.
Performance Expectancy (PE), related to whether the individual believed that the technology would help in task performance, had a high mean near the potential maximum. All three items had a mean above 4.0, indicating that many of the survey respondents either agreed or strongly agreed that EFBs would help them in flight operations.

Effort Expectancy (EE), which in this study relates to the degree of ease the pilot expects in using EFBs, shared a similarly high mean score, with all four items having means slightly over 4.0. Many of the pilots agreed that learning to use EFBs was easy, the devices were clear and understandable, and that it was easy to become skilled at using an EFB. The means were lower than that found for PE, but the mean of 4.13 indicated that many pilots responded that they either agreed or strongly agreed with the items related to EE.

Social Influence (SI), which for this study relates to how much an individual perceives others think the pilot should use an EFB, did not score as highly as PE and EE. With a mean of 3.46, the lowest mean score of all of the UTAUT2 variables, there was not strong agreement among the sample population that the opinions of others were an important element that influenced their usage of EFBs.

Facilitating Conditions (FC), which relates to whether the respondent believed there would be sufficient resources available to support their use of the technology, scored well overall with a high mean, indicating that many pilots either agreed or strongly agreed that there was support available for using EFBs. The survey respondents reported a much lower average score on the FC4 item, which read “I can get help from others when I have difficulties using an electronic flight bag”. The frame of reference for
FC4 contrasted somewhat with the frame of reference utilized for FC1, FC2, and FC3. FC1, FC2, and FC3 requested the pilot respond while considering their own ability to help themselves with the technology. In contrast, FC4 asked the pilot to consider whether others would provide assistance on the technology if needed. Subsequent analysis of FC4 showed inadequate factor loading of FC4 on the FC construct.

Hedonic Motivation (HM), which relates to how much fun or enjoyment is derived from using a technology system, achieved a mean score in the range between “Neither Agree nor Disagree” and “Agree”. This result potentially indicates that the sample population surveyed did not have as strong feelings about the enjoyment derived from using EFBs as they did for many of the other UTAUT2 constructs.

Price Value (PV), related to the pilot’s view as a consumer of EFB technology and perceptions of how well the cost of an EFB weighs against the benefits of using the system scored relatively high, with the mean score near 4.0. Habit (HT), which relates to the habitual use and automaticity achieved in using a technology, also scored well, with many pilots agreeing that the use of EFBs was a habit and felt automatic for them as part of their flight operations. This result was an initial indicator that revision of the HT factors during the pilot study was successful.

Lastly, Behavioral Intention (BI) refers to the respondent’s belief they will use the technology in the future, and achieved the highest mean score of all of the constructs on the survey. This indicates that many of the pilots surveyed either agreed or strongly agreed that EFBs would be part of their future flight operations.

Tests of normality/outlier checks. After completion of missing value analysis, compilation of demographic data, and preparation of descriptive statistics, the data was
loaded into AMOS for factor analysis, assessment of normality, and outlier checks. Mahalanobis distance ($D^2$) values were examined. Eight cases had Mahalanobis distance values over the recommended value of 100 (Truong, 2016b) and were deleted, but the majority of the cases were well underneath that threshold. This left a total of 589 cases for continued analysis.

To assess for normality, skewness and kurtosis values were examined. Byrne notes that while skewness and kurtosis values may be under the guideline value of 7.0, indicating the distribution of the sample is univariate normal, the data may still be multivariate non-normal. Table 20 shows an assessment of normality for the 597 initial cases and after deletion of eight cases due to high Mahalanobis distances. Note that the $z$-value of the original 597 responses is 92.38, well over the maximum $z$-value of 5.0 recommended by Byrne (2010), and that after deletion of the eight cases with high Mahalanobis distances, the $z$-value only reduces to 71.7. In fact, after deletion of 100 additional cases, the $z$-value remained at just under 25, indicating that even a greatly reduced dataset was non-normally distributed.

Reviewing Table 19, non-normal distribution of the sample responses is not an unexpected result given that some of the UTAUT2 constructs (PE, EE, and BI) all had items showing scores above 4.0. Gao, Mokhtarian, and Johnston (2008) suggest consideration of deleting cases with high Mahalanobis distance values until the critical ratio of kurtosis for the highest individual measure is 1.96 or smaller. However, given that the minimum sample size suggested by Westland (2010) was 483, deletion of several hundred cases from the sample was deemed unacceptable for the present research, particularly as the reason the data is not normally distrusted is readily apparent.
### Table 20

**Assessment of Normality**

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<tr>
<th>UTAUT2 Construct</th>
<th>Item</th>
<th>Skew</th>
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<th>Kurtosis</th>
<th>Critical Ratio of Kurtosis</th>
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<td>25.16</td>
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|          | 288.52 | 92.38                      | 225.68   | 71.77                     |

*Note.* PE = Performance Expectancy; EE = Effort Expectancy; SI = Social Influence; FC = Facilitating Conditions; HM = Hedonic Motivation; PV = Price Value; HT = Habit; and BI = Behavioral Intention.
Testing for non-response bias. Non-response bias was tested by comparison of the demographics of early and late responders, with late responders serving as a proxy for non-responders. The rationale for considering late responders as a proxy for non-responders is that those responders likely had the earliest survey invitations sent but refused to respond until provided the invitation again at a later date. Responses from survey participants that acted on the survey invitation in the Curt Lewis emails were selected, as that survey invitation was active for almost four consecutive weeks. The first 25% of the Lewis responses were considered early responders, and the last 25% of response were deemed late responders, as suggested by Atif, Richards, and Bilgin (2012). Chi-square values were calculated and are reported in Table 21. None of the six demographic variables examined showed significant differences for early and late responders, indicating non-response bias was not detected in the sample.

Table 21

<table>
<thead>
<tr>
<th>Demographic</th>
<th>Chi-Square (χ²)</th>
<th>Probability (p)</th>
<th>Significant</th>
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</thead>
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<td>Age</td>
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<tr>
<td>Gender</td>
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<td>No</td>
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<td>Pilot Certificate</td>
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<td>Pilot Experience</td>
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<td>.538</td>
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</tr>
<tr>
<td>Instrument Rating</td>
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<tr>
<td>EFB Experience</td>
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<td>No</td>
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</table>

Note. p is significant at p < .05.
Confirmatory factor analysis. The model was estimated in AMOS, resulting in $df = 271$, $\chi^2 = 795.6$, $p = 0.00$. The model is overidentified. Kenny (2014) notes that $\chi^2$ is normally significant when sample sizes are greater than 400, so this finding was deemed not to be of concern. Figure 17 shows the UTAUT theoretical model as it appeared in AMOS at the initiation of CFA.
Figure 17. UTAUT2 CFA Model. This figure shows the CFA model as input into AMOS before confirmatory factor analysis.

Model fit was assessed for the specified model using the measures of fit displayed in Table 22. Note that in the first iteration of the model, five of the six model fit indices
used were at good levels, with only AGFI being too low at 0.87. Based on model fit indices, three covariances were sequentially introduced to the model during three subsequent iterations. After the fourth iteration, AGFI was 0.89. Although the fit for AGFI was not good, it was acceptable, and further analysis showed that three more model modifications using relatively weak modification indices would be required to incrementally bring the value for AGFI to the recommended good level of ≥ 0.9.

Table 22

*Model Fit and Post Hoc Analysis*

<table>
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<tr>
<th>Iteration</th>
<th>Modification</th>
<th>CFI (≧0.90)</th>
<th>GFI (≧0.90)</th>
<th>AGFI (≧0.90)</th>
<th>NFI (≧0.90)</th>
<th>CMIN/DF (≦3.00)</th>
<th>RMSEA (≦0.05)</th>
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<td>Original</td>
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<td>0.93</td>
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<tr>
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<td>0.93</td>
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<td>Covariance e15-e17</td>
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<tr>
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<td>Covariance e2 - e3</td>
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</tbody>
</table>

*Note.* CFI = , GFI = Goodness of Fit Index, AGFI = Adjusted Goodness of Fit Index, NFI = Bentler-Bonett Normed Fit Index, CMIN/DF = Chi Square/Degrees of Freedom, RMSEA = Root Mean Square Error of Approximation.

Byrne (2010) cautions that *overfitting* a model can result when using parameters that represent weak effects, and observes that decisions regarding the sufficiency of model fit should take into account both model fit indices and the researcher’s assessment of the model’s alignment with the theories that underlie it. As this model is grounded in theory and fit well on five of the six fit indices, the model was accepted after the three modifications, resulting in a model diagram as appears in Figure 18.
Figure 18. UTAUT2 Respecified CFA Model. This model shows the CFA model after respecification. Note the deletion of item FC4, and the addition of three covariance arrows as detailed in Table 20, which were added to obtain good model fit indices for five of the six indices utilized.
**Reliability and validity testing.** Following the initial adjustments to the structural model to increase model fit, testing of reliability and validity was conducted. Table 23 shows the standardized loadings, composite reliability (CR), and average variance extracted (AVE) for each of the variables in the structural model. All factor loadings were above the recommended value of 0.70, except for the loading for FC4, which was low at 0.43. While all CR ratings were above the recommended value of 0.70, the FC construct had an AVE value below the recommended value of $\geq 0.50$, at 0.39. After further testing, including dropping the FC4 item, the AVE for the FC construct remained below 0.50, so the FC construct was from the structural model.
Table 23

*Reliability and Consistency Assessment*

<table>
<thead>
<tr>
<th>UTAUT2 Construct</th>
<th>Item/ Factor</th>
<th>Item Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Standardized Loadings (≧ 0.70)</td>
</tr>
<tr>
<td>PE</td>
<td>PE1</td>
<td>0.85</td>
</tr>
<tr>
<td></td>
<td>PE2</td>
<td>0.78</td>
</tr>
<tr>
<td></td>
<td>PE3</td>
<td>0.76</td>
</tr>
<tr>
<td></td>
<td>EE1</td>
<td>0.79</td>
</tr>
<tr>
<td></td>
<td>EE2</td>
<td>0.82</td>
</tr>
<tr>
<td></td>
<td>EE3</td>
<td>0.85</td>
</tr>
<tr>
<td></td>
<td>EE4</td>
<td>0.79</td>
</tr>
<tr>
<td>SI</td>
<td>SI1</td>
<td>0.85</td>
</tr>
<tr>
<td></td>
<td>SI2</td>
<td>0.86</td>
</tr>
<tr>
<td></td>
<td>SI3</td>
<td>0.83</td>
</tr>
<tr>
<td></td>
<td>FC1</td>
<td>0.69</td>
</tr>
<tr>
<td></td>
<td>FC2</td>
<td>0.76</td>
</tr>
<tr>
<td></td>
<td>FC3</td>
<td>0.55</td>
</tr>
<tr>
<td></td>
<td>FC4</td>
<td>0.43</td>
</tr>
<tr>
<td>HM</td>
<td>HM1</td>
<td>0.76</td>
</tr>
<tr>
<td></td>
<td>HM2</td>
<td>0.95</td>
</tr>
<tr>
<td></td>
<td>HM3</td>
<td>0.55</td>
</tr>
<tr>
<td>PV</td>
<td>PV1</td>
<td>0.80</td>
</tr>
<tr>
<td></td>
<td>PV2</td>
<td>0.80</td>
</tr>
<tr>
<td></td>
<td>PV3</td>
<td>0.87</td>
</tr>
<tr>
<td>HT</td>
<td>HT1</td>
<td>0.84</td>
</tr>
<tr>
<td></td>
<td>HT2</td>
<td>0.84</td>
</tr>
<tr>
<td></td>
<td>HT3</td>
<td>0.88</td>
</tr>
<tr>
<td>BI</td>
<td>BI1</td>
<td>0.87</td>
</tr>
<tr>
<td></td>
<td>BI2</td>
<td>0.80</td>
</tr>
<tr>
<td></td>
<td>BI3</td>
<td>0.92</td>
</tr>
</tbody>
</table>

*Note.* PE = Performance Expectancy; EE = Effort Expectancy; SI = Social Influence; FC = Facilitating Conditions; HM = Hedonic Motivation; PV = Price Value; HT = Habit; and BI = Behavioral Intention.
Table 24 shows the Cronbach’s Alpha results for the structural model. All values were above the recommended value of 0.70 except for FC, which was just below that threshold at 0.69. These results indicated good overall internal consistency in the measurements and reinforced the decision to drop FC.
Table 24

Reliability and Consistency Assessment

<table>
<thead>
<tr>
<th>UTAUT2 Construct</th>
<th>Cronbach's Alpha (≧0.70)</th>
<th>Item/Factor</th>
<th>Corrected Item Total Correlation</th>
<th>Cronbach’s Alpha if Item Deleted</th>
</tr>
</thead>
<tbody>
<tr>
<td>PE</td>
<td>0.86</td>
<td>PE1</td>
<td>0.70</td>
<td>0.83</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PE2</td>
<td>0.75</td>
<td>0.78</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PE3</td>
<td>0.75</td>
<td>0.79</td>
</tr>
<tr>
<td>EE</td>
<td>0.90</td>
<td>EE1</td>
<td>0.78</td>
<td>0.86</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EE2</td>
<td>0.71</td>
<td>0.88</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EE3</td>
<td>0.78</td>
<td>0.86</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EE4</td>
<td>0.80</td>
<td>0.85</td>
</tr>
<tr>
<td>SI</td>
<td>0.88</td>
<td>SI1</td>
<td>0.76</td>
<td>0.85</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SI2</td>
<td>0.78</td>
<td>0.83</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SI3</td>
<td>0.78</td>
<td>0.83</td>
</tr>
<tr>
<td>FC</td>
<td>0.69</td>
<td>FC1</td>
<td>0.54</td>
<td>0.59</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FC2</td>
<td>0.54</td>
<td>0.59</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FC3</td>
<td>0.48</td>
<td>0.63</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FC4</td>
<td>0.37</td>
<td>0.70</td>
</tr>
<tr>
<td>HM</td>
<td>0.83</td>
<td>HM1</td>
<td>0.76</td>
<td>0.68</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HM2</td>
<td>0.70</td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HM3</td>
<td>0.60</td>
<td>0.84</td>
</tr>
<tr>
<td>PV</td>
<td>0.86</td>
<td>PV1</td>
<td>0.73</td>
<td>0.81</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PV2</td>
<td>0.70</td>
<td>0.84</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PV3</td>
<td>0.78</td>
<td>0.77</td>
</tr>
<tr>
<td>HT</td>
<td>0.88</td>
<td>HT1</td>
<td>0.74</td>
<td>0.86</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HT2</td>
<td>0.78</td>
<td>0.83</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HT3</td>
<td>0.80</td>
<td>0.82</td>
</tr>
<tr>
<td>BI</td>
<td>0.88</td>
<td>BI1</td>
<td>0.79</td>
<td>0.82</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BI2</td>
<td>0.73</td>
<td>0.90</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BI3</td>
<td>0.83</td>
<td>0.78</td>
</tr>
</tbody>
</table>

Note. PE = Performance Expectancy; EE = Effort Expectancy; SI = Social Influence; FC = Facilitating Conditions; HM = Hedonic Motivation; PV = Price Value; HT = Habit; and BI = Behavioral Intention.

Table 25 provides results for the calculation of discriminant validity for all of the reflective constructs in the model. On the left side, the maximum shared variance (MSV)
is shown alongside the AVE. The bold MSV values indicate a lack of discriminant validity, as the MSV is higher than the AVE, for PE, EE, FC, HT, and BI. The right side displays the correlations of each construct to the other constructs, with the square root of the AVE positioned on the diagonal. The values with an asterisk correspond with the bolded MSV values, as both are merely different computations related to the same underlying factor loadings.

Table 25

*Discriminant Validity – All Constructs*

<table>
<thead>
<tr>
<th></th>
<th>AVE</th>
<th>MSV</th>
<th>PE</th>
<th>EE</th>
<th>SI</th>
<th>FC</th>
<th>HM</th>
<th>PV</th>
<th>HT</th>
<th>BI</th>
</tr>
</thead>
<tbody>
<tr>
<td>PE</td>
<td>0.63</td>
<td>0.91</td>
<td>0.795*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EE</td>
<td>0.66</td>
<td>0.93</td>
<td></td>
<td>0.827</td>
<td>0.811*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SI</td>
<td>0.72</td>
<td>0.15</td>
<td>0.393</td>
<td>0.329</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FC</td>
<td>0.39</td>
<td>0.93</td>
<td>0.878</td>
<td>0.965</td>
<td>0.336</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HM</td>
<td>0.59</td>
<td>0.56</td>
<td>0.751</td>
<td>0.691</td>
<td>0.370</td>
<td>0.667</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PV</td>
<td>0.68</td>
<td>0.47</td>
<td>0.615</td>
<td>0.588</td>
<td>0.297</td>
<td>0.686</td>
<td>0.460</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HT</td>
<td>0.72</td>
<td>0.91</td>
<td>0.955</td>
<td>0.826</td>
<td>0.384</td>
<td>0.867</td>
<td>0.698</td>
<td>0.639</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BI</td>
<td>0.75</td>
<td>0.88</td>
<td>0.939</td>
<td>0.700</td>
<td>0.335</td>
<td>0.781</td>
<td>0.677</td>
<td>0.549</td>
<td>0.905</td>
<td></td>
</tr>
</tbody>
</table>

Note. The bold MSV values denote constructs in which the MSV is greater than the AVE, showing a lack of discriminant validity. The square root of the AVE is presented in bold on the diagonal at the right of the table, with an * marking values that are lower than the correlations shown between other variables for that construct.

Because CFA of the structural model showed issues with discriminant validity of PE, FC, and HT, subsequent modifications to the model in sequential iterations resulted in the removal of each of those constructs from the structural model. After those constructs were removed, discriminant validity was demonstrated as the MSV was lower than AVE for each construct, as shown in the left of Table 26. Additionally, in the right...
side of Table 26, the square root of AVE shown in bold on the diagonal is higher than the inter-construct correlations shown off-diagonal.

Table 26

*Discriminant Validity – After Deletion of PE, FC, and HT*

<table>
<thead>
<tr>
<th></th>
<th>AVE</th>
<th>MSV</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>EE</td>
<td>0.66</td>
<td>0.48</td>
<td>EE</td>
<td></td>
<td></td>
<td>0.810</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SI</td>
<td>0.72</td>
<td>0.14</td>
<td>SI</td>
<td>0.329</td>
<td>0.848</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HM</td>
<td>0.59</td>
<td>0.48</td>
<td>HM</td>
<td>0.692</td>
<td>0.373</td>
<td>0.771</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PV</td>
<td>0.68</td>
<td>0.34</td>
<td>PV</td>
<td>0.584</td>
<td>0.296</td>
<td>0.460</td>
<td>0.825</td>
<td></td>
</tr>
<tr>
<td>BI</td>
<td>0.74</td>
<td>0.48</td>
<td>BI</td>
<td>0.694</td>
<td>0.333</td>
<td>0.677</td>
<td>0.545</td>
<td>0.863</td>
</tr>
</tbody>
</table>

Note. MSV values must be less than the AVE value, and the square root of the AVE presented in bold on the diagonal at the right of the table must be lower than the inter-construct correlations shown off-diagonal to achieve discriminant validity.

After removal of PE, FC, and HT, the CFA model appeared as in Figure 19. This course of action was justified by the problems establishing reliability and validity of the model when all constructs were retained, as establishment of validity and reliability is of paramount importance. One researcher noted that “constructs are intangible by definition,” so “researchers are required to show evidence that all constructs in a model or research study are distinct and not just empirical reflections of each other” (Voorhees, Brady, Calantone, & Ramirez, 2016, p. 120).
After deletion of the PE, FC, and HT constructs due to challenges establishing validity and reliability, the UTAUT2 structural model was more parsimonious, at the expense of disabling the ability to address several of the hypotheses of interest.

**Full structural equation modeling (SEM).** At the conclusion of CFA of the main study measurement model, the full structural model was estimated in AMOS.

Figure 20 shows the original UTAUT2 model (a) and the reduced model (b) that
remained after removal of the PE, FC, and HT constructs. Note the removal of those constructs had a major effect on achievement of the objectives of the study and negated the ability to evaluate several hypotheses, which is detailed in the following section.

Figure 20. Full UTAUT2 model and reduced model. The full UTAUT2 model appears in (a) above. Removal of the PE, FC, and HT constructs due to discriminant validity concerns reduced the number of direct interactions with BI and UB, as well as the number of moderation relationships that could be tested.
To conduct the actual analysis of the full SEM model, the full model was entered into AMOS. The AMOS representation of the SEM model appears in Figure 21. AMOS supports clear graphical modeling that facilitates simple representations of the relationships posited in the UTAUT2 theory, enabling quick comprehension and analysis.

![Full structural model for SEM analysis. The PE, FC, and HT constructs have been removed, and the UB construct, comprised of the UB4 item, has been added.](image)

**Figure 21.** Full structural model for SEM analysis. The PE, FC, and HT constructs have been removed, and the UB construct, comprised of the UB4 item, has been added.

Note that the full SEM model uses the UB4 item to represent the UB construct.

As noted in Chapter 3, inadequate documentation of methodology in the primary literature reviewed, along with a general lack of consensus in the literature of how to best aggregate survey items to create a formative composite index with sufficient validity and reliability, suggested this course of action. UB4 was selected as it reflects pilot EFB use.
behavior during airborne operations, which is the flight phase of most interest for the present research project.

Once the SEM model was entered into AMOS, analysis of the full SEM model proceeded. Figure 22 shows two covariance terms added to the model to achieve acceptable model fit. Note the covariance between error terms E4-E7 and from E15-E17.

![Figure 22.](image)

*Figure 22.* Full SEM model after post-hoc analysis. Covariances between the unobserved exogenous constructs EE, SI, HM, and PV were added to the model to improve model fit.

Table 27 provides a comparison of the model fit indices for the final version of the CFA model after dropping PE, FC, and HT. The resulting fit indices were relatively unchanged from the final CFA model.
Table 27

Comparison of Model Fit for CFA and SEM Model

<table>
<thead>
<tr>
<th>Fit Indice</th>
<th>Final CFA Model</th>
<th>SEM Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi Square ($\chi^2$)</td>
<td>175.860</td>
<td>213.23</td>
</tr>
<tr>
<td>Degrees of Freedom ($df$)</td>
<td>92.000</td>
<td>107</td>
</tr>
<tr>
<td>Probability</td>
<td>$p = 0.00$</td>
<td>$p = 0.00$</td>
</tr>
<tr>
<td>CFI ($\geq 0.90$)</td>
<td>0.986</td>
<td>0.983</td>
</tr>
<tr>
<td>GFI ($\geq 0.90$)</td>
<td>0.963</td>
<td>0.958</td>
</tr>
<tr>
<td>AGFI ($\geq 0.90$)</td>
<td>0.946</td>
<td>0.941</td>
</tr>
<tr>
<td>NFI ($\geq 0.90$)</td>
<td>0.971</td>
<td>0.967</td>
</tr>
<tr>
<td>CMIN/DF ($\leq 3.00$)</td>
<td>1.912</td>
<td>1.993</td>
</tr>
<tr>
<td>RMSEA ($\leq 0.05$)</td>
<td>0.039</td>
<td>0.041</td>
</tr>
</tbody>
</table>

*Note.* CFI = GFI = Goodness of Fit Index, AGFI = Adjusted Goodness of Fit Index, NFI = Bentler-Bonett Normed Fit Index, CMIN/DF = Chi Square/Degrees of Freedom, RMSEA = Root Mean Square Error of Approximation.

**Hypothesis Testing**

Removal of the PE, FC, and HT constructs had the effect of eliminating several hypotheses. The moderating effects of AGE, GDR, and EXP were amended to eliminate evaluation of the effects of those moderators on the relationships of PE, FC, and HT.

Additionally, the following hypotheses were not evaluated as the full SEM model:

H1: Performance expectancy (PE) positively affects behavioral intention (BI).

H4: Facilitating conditions (FC) positively affects behavioral intention (BI).

H7: Habit (HT) positively affects behavioral intention (BI).

H8: Facilitating conditions (FC) positively affects use behavior (UB).

H9: Habit (HT) positively affects use behavior (UB).

H14: The demographic variable of age (AGE) moderates the effects of the exogenous variables facilitating conditions (FC) and habit (HT) on use behavior (UB).
H15: The demographic variable of gender (GDR) moderates the effects of the exogenous variable habit (HT) on use behavior (UB).

H16: The demographic variable of experience (EXP) moderates the effects of the exogenous variables facilitating conditions (FC) and habit (HT) on use behavior (UB).

The results are presented in two sections. The first section provides detailed results for Research Question 1 regarding the effect of exogenous factors on BI and UB, and includes Hypotheses 1 – 10. The second section covers results for Research Question 2 regarding the moderation effect of age, gender, or EFB experience, and includes Hypotheses 11 – 17.

Research question 1. Research Question 1 covered “What exogenous UTAUT2 factors affect pilot acceptance and adoption of EFB technology?” and was investigated in Hypotheses 1 – 10. Table 28 shows the results for hypotheses 1 – 10. Hypotheses were deemed supported if $p < .05$.

Overall, the results showed that effort expectancy, hedonic motivation, and price value had a positive effect on behavioral intention to use EFBs, and behavioral intention to use EFBs had a positive effect on use behavior. Social influence was rejected, having not shown a significant effect on behavioral intention. Figure 23 shows the path coefficients that resulted from the structural equation modeling of the reduced UTAUT model.
Table 28

_Hypothesis Testing H1 – H0_

<table>
<thead>
<tr>
<th>#</th>
<th>Summarized Hypothesis</th>
<th>Standardized Regression Weight</th>
<th>Critical Ratio (t-value)</th>
<th>Probability</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1</td>
<td>PE positively affects BI</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Construct Dropped</td>
</tr>
<tr>
<td>H2</td>
<td>EE positively affects BI</td>
<td>0.354</td>
<td>6.617</td>
<td>.001</td>
<td>Supported</td>
</tr>
<tr>
<td>H3</td>
<td>SI positively affects BI</td>
<td>0.038</td>
<td>1.056</td>
<td>.291</td>
<td>Not Supported</td>
</tr>
<tr>
<td>H4</td>
<td>FC positively affects BI</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Construct Dropped</td>
</tr>
<tr>
<td>H5</td>
<td>HM positively affects BI</td>
<td>0.342</td>
<td>6.24</td>
<td>.001</td>
<td>Supported</td>
</tr>
<tr>
<td>H6</td>
<td>PV positively affects BI</td>
<td>0.162</td>
<td>4.088</td>
<td>.001</td>
<td>Supported</td>
</tr>
<tr>
<td>H7</td>
<td>HT positively affects BI</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Construct Dropped</td>
</tr>
<tr>
<td>H8</td>
<td>FC positively affects UB</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Construct Dropped</td>
</tr>
<tr>
<td>H9</td>
<td>HT positively affects UB</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Construct Dropped</td>
</tr>
<tr>
<td>H10</td>
<td>BI positively affects UB</td>
<td>0.670</td>
<td>19.133</td>
<td>.001</td>
<td>Supported</td>
</tr>
</tbody>
</table>
Figure 23. Path estimates for Hypotheses 1 – 10. The path estimates (standardized regression weights) for Hypotheses 1 – 10 show support for Hypotheses 2, 5, 6, and 10. Hypotheses 3 was not supported by the data in the sample, and the remaining hypotheses were not evaluated due to the associated constructs being dropped from the model during CFA because of discriminant validity concerns.

Hypotheses 1, 4, 7, 8, and 9 were not evaluated and were dropped from the present research. This was a result of the exogenous factors PE, FC, and HT being dropped during factor analysis for lack of discriminant validity.

Hypothesis 2 (H2) showed that effort expectancy (EE) was supported as having a positive effect (P_{EE, BI} = .37) on behavioral intention (BI), and was significant (p < .001). This indicated that stronger values of effort expectancy related to stronger behavioral intention to use EFBs.

Hypothesis 3 (H3), the affect of social influence (SI) on BI, was not significant (p < .291). Consequently, the overall results of the UTAUT2 model in this study were that of the seven possible exogenous variables, three were shown to have a significant
positive effect on BI, three were untested as the factors were dropped during CFA, and one factor was found to not have a positive effect on BI.

Hypothesis 5 (H5), hedonic motivation (HM) showed a positive effect on BI at a stronger path estimate ($P_{HM,BI} = .54$) than for EE. The HM-BI relationship was significant ($p < .001$).

For Hypothesis 6 (H6), price value (PV) also had a positive effect on BI but with a lower path estimate ($P_{PV,BI} = .16$). This relationship was also significant ($p < .001$).

**Research question 2.** The second research question investigated in this study was “To what extent do the demographic variables of age, gender, or experience using EFBs moderate the relationships between the factors in the UTAUT2 model?” To test these relationships, moderation analysis was conducted using the PROCESS macro (Hayes, 2017) and linear regression.

Hypotheses 11, 12, 13, 14, and 16 relate to the moderating effects that age, gender, and experience using EFBs may have on the relationships between multiple constructs. To support analysis, calculation of the moderation effects for each of the relationships represented by dashed arrows in Figure 19 was conducted individually. This effectively formed sub-hypotheses for each of the variables, and were numbered in the form of the hypothesis number and a letter, as in $H11-a$ for the moderation effect of age on the relationship of PE and BI.

Table 29 shows the results for Hypothesis 11, moderation analysis of the effects of age on the relationships between the UTAUT exogenous constructs and BI. Moderation was not computed for constructs that were dropped, nor for the relationship SI to BI, as Hypothesis 3 showed that the relationship of SI and BI was not significant.
Table 29

_Hypothesis Testing for H11_

<table>
<thead>
<tr>
<th>Summarized Hypothesis</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>H11-a Age moderates the effect of PE on BI</td>
<td>Construct Dropped</td>
</tr>
<tr>
<td>H11-b Age moderates the effect of EE on BI</td>
<td>Not supported</td>
</tr>
<tr>
<td>H11-c Age moderates the effect of SI on BI</td>
<td>Not modeled as SI effect on BI was not supported</td>
</tr>
<tr>
<td>H11-d Age moderates the effect of FC on BI</td>
<td>Construct Dropped</td>
</tr>
<tr>
<td>H11-e Age moderates the effect of HM on BI</td>
<td>Not supported</td>
</tr>
<tr>
<td>H11-f Age moderates the effect of PV on BI</td>
<td>Supported</td>
</tr>
<tr>
<td>H11-g Age moderates the effect of HT on BI</td>
<td>Construct Dropped</td>
</tr>
</tbody>
</table>

The effects of age as a moderator on the relationship of EE and BI was assessed in Hypothesis 11-b. A linear regression analysis of the effects of AGE and EE as predictor variables, with BI as the dependent (outcome) variable showed that the interaction of the two variables had a significant effect on BI \((R^2 = .390, F(2,586) = 187.54, p < .001)\).

Using the PROCESS (Hayes, 2017) macro in SPSS, the interaction term for AGE and EE was added to the regression model, but did not result in a significant change in the variance of BI \((\Delta R^2 = .004, \Delta F(1,585) = 3.71, b = .003, t(585) = 1.927, p < .055)\). Figure 24 provides a plot of the interaction, showing that the relationship of EE and BI is minimally affected by AGE.
Hypothesis 11-e evaluated the moderating effects of AGE on the relationship of hedonic motivation (HM) on behavioral intention to use EFBs (BI). Linear regression showed that AGE and HM had a significant effect on BI ($R^2 = .324$, $F(2,586) = 140.697$, $p < .001$). When the interaction term for AGE and HM was added to the regression model, no significant change in the variance of BI resulted ($\Delta R^2 = .003$, $\Delta F(1,585) = 2.97$, $b = .003$, $t(585) = 1.723$, $p < .085$). Figure 25 provides a plot of the interaction, with the relationship of HM and BI minimally affected by AGE.
The moderating effects of AGE on the relationship of price value (PV) on behavioral intention to use EFBs (BI) was evaluated in Hypothesis 11-f. As expected based on the results of Hypothesis 6, linear regression showed that AGE and PV together had a significant effect on BI ($R^2 = .240$, $F(2,586) = 98.837$, $p < .001$), although that effect was not as strong as was the affect of EE and HM. Adding the interaction term for AGE and PV to the regression model resulted in a small but significant change in the variance of BI ($\Delta R^2 = .020$, $\Delta F(1,585) = 15.68$, $b = .008$, $t(585) = 3.960$, $p < .001$). The effect of AGE on the relationship of HM and BI is detectable in Figure 26, with older respondents having increased variance in their response to the price value construct.
Figure 26. Interaction plot for AGE on PV→BI. The increasing divergence of the lines in the interaction plot show that as age increases, there is a small but increasing effect for AGE on the relationship of PV and BI. Hypothesis 11-f is supported.

The results for Hypothesis H12 appears in Table 29 and shows that gender had mixed results for moderation of the relationships between the exogenous constructs and BI. H-12c was supported, while H12-e and H12f were not supported.

Table 30

*Hypothesis Testing for H12*

<table>
<thead>
<tr>
<th>Summarized Hypothesis</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>H12-a: Gender moderates the effect of PE on BI</td>
<td>Construct Dropped</td>
</tr>
<tr>
<td>H12-b: Gender moderates the effect of EE on BI</td>
<td>Supported</td>
</tr>
<tr>
<td>H12-c: Gender moderates the effect of SI on BI</td>
<td>Not modeled as the affect of SI on BI was not supported</td>
</tr>
<tr>
<td>H12-d: Gender moderates the effect of FC on BI</td>
<td>Construct Dropped</td>
</tr>
<tr>
<td>H12-e: Gender moderates the effect of HM on BI</td>
<td>Not Supported</td>
</tr>
<tr>
<td>H12-f: Gender moderates the effect of PV on BI</td>
<td>Not Supported</td>
</tr>
<tr>
<td>H12-g: Gender moderates the effect of HT on BI</td>
<td>Construct Dropped</td>
</tr>
</tbody>
</table>
The moderating effects of gender (GDR) on the relationship of EE to BI was evaluated in Hypothesis 12-b. Linear regression showed that GDR and PV together had a significant effect on BI ($R^2 = .376, F(2,586) = 176.176, p < .001$). When the interaction term for GDR and EE was added to the regression model, a small but significant change in the variance of BI resulted ($\Delta R^2 = .005$, $\Delta F(1,585) = 4.55$, $b = -0.171$, $t(585) = -2.133$, $p < .05$). Figure 27 shows the interaction plot for the effect of GDR on the relationship of EE and BI.

![Interaction plot for GDR on EE→BI](image)

*Figure 27.* Interaction plot for GDR on EE→BI. The plot shows that there is increased variance in the response of males for the effort expectancy construct, thus Hypothesis 12-b is supported.

Hypothesis 12-e examined the moderating effects of gender (GDR) on the relationship of HM to BI. Computed together, GDR and HM had a significant effect on BI ($R^2 = .321, F(2,586) = 138.735, p < .001$). No significant change was detected when the interaction term for GDR and HM was added to the regression model ($\Delta R^2 = .002$, $\Delta F(1,585) = 1.23, p > .05$).
ΔF(1,585) = 1.830, b = -0.123, t(585) = -2.353, p < .177). The interaction plot for the effect of GDR on the relationship of HM and BI is presented in Figure 28.

![Interaction plot for GDR on HM→BI](image)

*Figure 28.* Interaction plot for GDR on HM→BI. Although a small amount of divergence appears in the regression plots in the figure, the variance was not significant. Hypothesis 12-e is not supported.

Hypothesis 12-e examined the moderating effects of gender (GDR) on the relationship of PV to BI. When the effects of GDR and PV were modeled together in a linear regression, there was a significant affect on BI ($R^2 = .239$, $F(2,586) = 93.56$, $p < .001$). No significant change resulted when the interaction term for GDR and PV was added to the regression model ($ΔR^2 = .003$, $ΔF(1,585) = 2.329$, b = -0.126, t(585) = -1.526, $p < .128$). The interaction plot for the effect of GDR on the relationship of PV and BI is presented in Figure 29.
Figure 29. Interaction plot for GDR on PV→BI. Similar to Figure 25, although a small amount of divergence appears in the regression plots in the figure, the variance was not significant. Hypothesis 12-f is not supported.

Results showing the moderation effects of experience using EFBs on the relationships of the exogenous constructs and BI are presented in Table 31. Experience using EFBs was shown as a significant moderator of all three of the UTAUT2 constructs that were modeled.
Hypothesis Testing for H13

<table>
<thead>
<tr>
<th>Summarized Hypothesis</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>H13-a Experience moderates the effect of EE on BI</td>
<td>Supported</td>
</tr>
<tr>
<td>H13-b Experience moderates the effect of SI on BI</td>
<td>Not modeled as affect of SI on BI was not supported</td>
</tr>
<tr>
<td>H13-c Experience moderates the effect of FC on BI</td>
<td>Construct Dropped</td>
</tr>
<tr>
<td>H13-d Experience moderates the effect of HM on BI</td>
<td>Supported</td>
</tr>
<tr>
<td>H13-e Experience moderates the effect of PV on BI</td>
<td>Supported</td>
</tr>
<tr>
<td>H13-f Experience moderates the effect of HT on BI</td>
<td>Construct Dropped</td>
</tr>
</tbody>
</table>

Hypothesis 13-a tested the moderating effects of experience using EFBs (EXP) on the relationship of EE to BI. In a linear regression of the effects of EXP and EE together, there was a significant effect on BI ($R^2 = .423$, $F(2,586) = 214.477$, $p < .001$). A significant change resulted when the interaction term for EXP and EE was added to the regression model ($\Delta R^2 = .023$, $\Delta F(1,585) = 24.226$, $b = .117$, $t(585) = -4.922$, $p < .001$). The interaction plot for the effect of EXP on the relationship of EE and BI is presented in Figure 30.
Figure 30. Interaction plot for EXP on EE→BI. Lower experience using EFBs resulted in increased variation in the behavioral intentions of survey respondents to use EFBs. Respondents with low EFB experience and low effort expectancy had significantly lower behavioral intention to use EFBs. Hypothesis H13-a is supported.

The moderating effects of EXP on the relationship of HM to BI was tested in Hypothesis H13-d. The linear regression of the effects of EXP and HM together showed a significant effect on BI ($R^2 = .424$, $F(2,586) = 215.494, p < .001$). This result is nearly identical to the effect of EXP and EE in Hypothesis H13-a. Adding the interaction term for EXP and HM to the regression model had a significant effect ($\Delta R^2 = .027$, $\Delta F(1,585) = 28.628, b = .114, t(585) = -5.351, p < .001$). The interaction plot for the effect of EXP on the relationship of HM and BI is presented in Figure 31.
Figure 31. Interaction plot for EXP on HM→BI. The interaction plot for the relationship of EFB experience as a moderator for the HM to BI relationship is almost identical to the relationship modeled in Figure 27. Respondents with low EFB experience and low hedonic motivation had significantly lower behavioral intention to use EFBs than respondents with low EFB experience and high hedonic motivation. Hypothesis H13-d is supported.

Hypothesis H13-d related to the moderating effects of EXP on the relationship of PV to BI. Linear regression showed a significant effect for the combination of PV and EXP on BI ($R^2 = .316$, $F(2,586) = 135.472$, $p < .001$). Adding the interaction term for EXP and PV to the regression model had a significant effect ($\Delta R^2 = .011$, $\Delta F(1,585) = 9.511$, $b = .074$, $t(585) = -3.084$, $p < .01$). Figure 32 provides the interaction plot for the effect of EXP on the relationship of PV and BI.
Figure 32. Interaction Plot for EXP on PV→BI. Respondents with low EFB experience and lower response to the price value construct had significantly lower behavioral intention to use EFBs than respondents with low EFB experience and higher price value levels. Hypothesis H13-e is supported.

Table 32 presents the results of moderation testing relating to the UTAUT constructs on use behavior (UB). Because five of the six posited moderating effects on UB related to the variables dropped for insufficient discriminant validity, only Hypothesis 17 was analyzed for moderation effect.

Table 32

Hypothesis Testing for H14 – H17

<table>
<thead>
<tr>
<th>Summarized Hypothesis</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>H14-a Age moderates the effect of FC on UB</td>
<td>Construct Dropped</td>
</tr>
<tr>
<td>H14-b Age moderates the effect of HT on UB</td>
<td>Construct Dropped</td>
</tr>
<tr>
<td>H15 Gender moderates the effect of HT on UB</td>
<td>Construct Dropped</td>
</tr>
<tr>
<td>H16-a Experience moderates the effect of FC on UB</td>
<td>Construct Dropped</td>
</tr>
<tr>
<td>H16-b Experience moderates the effect of HT on UB</td>
<td>Construct Dropped</td>
</tr>
<tr>
<td>H17 Experience moderates the effect of BI on UB</td>
<td>Not Supported</td>
</tr>
</tbody>
</table>
Hypothesis H17 expected experience using EFBs (EXP) to moderate the effects of behavioral intention to use EFBs (BI) on actual use behavior (UB). Linear regression analysis of the combined effect of BI and EXP on UB showed a significant effect ($R^2 = .434$, $F(2,586) = 226.101, p < .001$). Adding the interaction term for EXP and BI to the regression model had no significant affect on UB ($\Delta R^2 = .001$, $\Delta F(1,585) = 1.134$, $b = -.0352$, $t(585) = -1.065, p < .288$). The interaction plot is provided in Figure 33.

![Interaction plot for EXP on BI→UB. The interaction plot shows almost no difference in the slope of the responses for behavioral intention whether EFB experience is low, average, or high. Hypothesis H17 is not supported.](image)

**Summary**

This chapter provided detailed information of the results of both the pilot study and main study applying a modified UTAUT2 model to the use of EFBs. Responses were obtained from a broad swath of the general aviation pilot population, with 589 responses remaining after factor analysis. The majority of the respondents held Private, Commercial, and ATP certificates, with less than 2% of the sample holding a Sport or
Recreational certificate. Although the sample had more men (81.6%) than women (18.4%), women were overrepresented in the sample, as only about 5.5% of the overall pilot population is female (FAA, 2017f).

The sample population’s age ranged from 18 to 83, and the mean age for respondents in each pilot certificate type corresponded well with the mean age reported by the FAA for each certificate level. The sample population had a broad range of experience levels, with the mean for private pilots in the hundreds (male $\bar{x} = 673.6$, female $\bar{x} = 287.3$), the low thousands for Commercial pilots (male $\bar{x} = 2,427.9$, female $\bar{x} = 1,111.7$), and high thousands for ATP respondents (male $\bar{x} = 12,225.6$, female $\bar{x} = 7,438.6$).

Over a third of the respondents reported having more than four years of experience using EFBs, and only 22.1% had less than one year of experience using the technology. The respondents reported using EFBs most for preflight planning and airborne operations, with relatively few of the respondents reporting they routinely used an EFB for preflight checks or post-flight operations. To simplify analysis, reported pilot usage of EFBs during airborne operations (takeoff, departure, climb, cruise, descent, approach, and landing) was used during SEM analysis of the full structural model.

During CFA of the measurement model, all factors displayed adequate convergent reliability after removal of item FC4, however a lack of discriminant validity resulted in removal of the constructs of performance expectancy (PE), facilitating conditions (FC), and habit (HT) from the full structural model. As a result, several of the hypotheses stated for the research were unable to be evaluated.
Support was shown for effort expectancy (EE), hedonic motivation (HM), and price value (PV) as latent exogenous factors that affected behavioral intention (BI) to use EFBs. Although experience (EXP) was shown to moderate the relationships of EE, HM, and PV on BI, results for the moderation of age (AGE) and gender (GDR) on BI was less consistent. AGE, GDR, nor EXP moderated the relationship of BI on use behavior (UB).
CHAPTER V

DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

The present research assessed what factors affect pilot acceptance and adoption of EFB technology using an adapted version of the extended Unified Theory of Acceptance and Use of Technology (UTAUT2). As a part of the evaluation, the role of age, gender, and experience using EFBs was also examined.

EFBs are increasingly utilized in all types of aviation, from general aviation pilots to air carrier operations to military flight operations. As many modern EFBs use COTS hardware, much of the focus for EFB development is on software design. New and innovative EFB capabilities continue to emerge, presenting an ever-increasing amount of information to pilots already engaged in managing the complexities of flight. Currently available EFBs provide key data to pilots in a format that is often easier to access than found in traditional paper resources and include extensive embedded capabilities to calculate critical information like time of arrival, expected time to destination, nearest airport, critical weather, and nearby aviation traffic.

Perhaps not surprising given the potential benefits offered by EFBs, 86% of the pilots that responded in the present research indicated they chose to use an EFB during their airborne flight operations. However, despite the rapid increase in the capability of EFBs, some pilots still choose to not use EFBs during their flight operations. Why would pilots choose not to use a technology that potentially provides such critical information of direct relevance to their flight operations? Understanding why some pilots choose to use EFBs while others choose not to use them, as well as learning what factors affect EFB
acceptance and adoption may be important for the aviation community as the use of EFBs continues to grow.

**Discussion**

The UTAUT2 model was selected for the present study because it was understood to be a validated, accepted benchmark in technology literature. The results obtained, however, indicated a lack of discriminant validity for the model when adapted to examine the use of EFBs in general aviation. Additionally, incomplete reporting on the formative composite index used to compile data related to use behavior (UB) hampered collection of data. Discussion in the following section addresses survey demographics, validity analysis, the UTAUT2 constructs as modified for research of EFBs, comments on the UTAUT2 constructs, and assesses the research questions in light of the results obtained.

The research in the present study was the first application of the UTAUT2 model into the context of aviation, filling a gap in the literature related to the exploration of what factors affect pilot decision-making as they choose to use or choose not to use EFBs in their flight planning and operations.

The results of the study are discussed below. Conclusions formed during the study are also presented, as well as recommendations for further research.

**Survey demographics.** Although 703 survey responses were collected for the large-scale survey, removal of responses during data preparation resulted in retention of 597 cases for analysis. This exceeded the minimum sample of 483 calculated using Westland’s (2010) algorithm for estimating appropriate SEM samples. 45.8% of the sample population was comprised of pilots holding a Private pilot certificate. This percentage is higher that the 27.8% of pilots with a Private pilot certificate documented in
the FAA’s 2017 estimate for the overall U.S. pilot population (FAA, 2017f). The sample population included 18.4% female pilots, which far exceeds the 5.5% figure for female pilots found in the general pilot population (FAA, 2017f). The FAA’s 2017 estimates are for the entire U.S. population of pilots, and there is insufficient data to determine whether those percentages reflect the true demographics of the pilot population of interest in the present research, which is GA pilots. It is possible that although the percentage of pilot certificates held and the number of female pilots in the sample population differs from the overall pilot population reported by the FAA, the sample may actually reflect the demographics of the overall GA pilot population. The differences from the statistics for the sample population from the overall population may be explained by the researcher’s selection of aviation events, mailing lists, and email contacts for the survey. For example, had the researcher solicited responses from a professional pilot union, the percentage of pilots holding Commercial and ATP may have increased. Such sampling choices for the present research were not selected as the researcher intended to target pilots with recent activity flying under GA operating rules.

Age demographics of the sample population for the large-scale survey were remarkably similar to FAA statistics of the overall U.S. pilot population. The mean age of the sample population was 46.5, while the mean age of the overall pilot population was 48.6 (FAA, 2017f). It should be noted that to control for the FAA’s inclusion of student pilots, flight instructors, and remote pilots in the FAA’s reported mean age, the researcher calculated a weighted average for the comparison that excluded those certificates.

Pilot experience reported by respondents to the main research study was extensive, with pilots holding a Private pilot certificate reporting $M = 612.7$ ($n = 273$),
Commercial $M = 2,114.9 \ (n = 185)$, and ATP $M = 11,406.6 \ (n = 131)$. Female pilots reported less pilot experience at all certificate levels.

Experience using EFBs was also extensive and increased for holding higher level pilot certificates. 69.9% of pilots holding a Private certificate reported having greater than 12 months experience using an EFB, while 80.6% of Commercial pilots and 90.9% of pilots holding an ATP certificate reported over 12 months EFB experience. These results may have a logical explanation, given that Commercial and ATP pilots may have increased exposure to EFBs during their flight operations as professional pilots. The use of EFBs may be mandated under company rules or by the operating certificates for which those professional operations are often conducted.

The survey instrument collected information regarding use behavior for EFBs during five phases of flight. Pilots reported the highest levels of EFB use for Preflight Planning and Airborne Operations, followed closely by Ground Operations, and reported much lower levels of EFB use for Preflight Checks and Post-Flight operations. There are several potential explanations for such reported differences. Pilots are trained to use checklists from the Pilot Operating handbook (POH) during ab initio training, and often have laminated paper checklists available for many GA aircraft. Carrying a paper checklist may be easier than carrying an EFB during pre- and post-flight checks and eliminates any concern for damaging EFB hardware. The perceived utility of EFBs during pre- and post-flight checks may also be lower than during other phases of flight, particularly given that many of the features of EFBs are related to flight planning and presentation of position, velocity, traffic, and similar information during ground and flight operations.
Reliability and validity analysis. The modified UTAUT2 constructs used in the present research demonstrated acceptable construct reliability early in the factor analysis process. All factor loadings were above the recommended value of .5 or higher, with the exception of item FC4. Similarly, Cronbach’s Alpha was above the recommended value of .7 or higher for all constructs except FC, and all construction showed CR values greater than .7 as well. Elimination of the FC construct resulted in the establishment of construct reliability for all six of the remaining exogenous UTAUT2 constructs.

Establishment of convergent validity was equally straightforward, as the AVE of six of the seven latent exogenous UTAUT2 constructs was acceptable upon initial calculation. Elimination of the FC construct for reliability resulted in six constructs with acceptable reliability and convergent validity.

Documentation of acceptable discriminant validity for the modified UTAUT2 model was problematic, as three (PE, FC, and HT) of the seven latent exogenous constructs had maximum shared variance values (MSV) above their associated AVE values. At the conclusion of CFA analysis, only four (EE, SI, HM, and PV) remained of the original seven constructs. As a direct consequence of removing the PE, FC, and HT constructs, several key aspects of the research questions were left unanswered.

Removal of three constructs due to concerns about discriminant validity was an unexpected result, given that many studies exist in the literature to validate the utility of the UTAUT2 theoretical model. The existence of a large body of studies validating the UTAUT2 model had led to the belief that UTAUT2 demonstrated nomological validity and had sufficient support in prior research (Hair et al., 2015). Albugami and Bellaaj (2014) studied internet banking in Saudi Arabia using UTAUT2 combined with four
factors from a service quality model, achieving discriminant validity for all constructs used \((n=133)\). In a study of internet banking, Arenas-Gaitán, Peral-Peral, and Ramón-Jerónimo (2015) also obtained sufficient discriminant validity using the UTAUT2 model \((n=474)\).

Morosan and DeFranco (2016) also achieved high discriminant validity in a study of NFC communication for mobile phone payments \((n=794)\), having made somewhat major modifications to the UTAUT2 survey items. PE was modified such that it had 14 items rather than the four found on the UTAUT2 model as published by Venkatesh, Thong, and Xu (2012), and the wording of other items was modified more extensively than was done in the present study. Morosan and DeFranco justified that such modifications were required to overcome a “major shortcoming” in the UTAUT2 documentation of PE, and to achieve a “more precise operationalization” of the concepts (2016, p. 22).

Other researchers demonstrated difficulty establishing discriminant validity for research using the UTAUT2 survey instrument. Francis (2016) studied physician acceptance of patient self-monitored devices (SMD), but chose to provide the survey to physician respondents without modifying the wording of the original UTAUT2 survey instrument, thus physicians were expected to mentally recognize that the use of the words “mobile internet” on a survey item was intended to represent that concept applied to the use of SMD. Despite not changing the survey instrument from the wording validated by Venkatesh et al. (2012), Francis found it necessary to remove FC, PV, and HT from her analysis due to poor discriminant validity.
**UTAUT2 construct modifications.** Given the mixed results regarding discriminant validity in both the literature and in the present research, it is prudent to more closely examine the efforts to modify the UTAUT2 survey instrument for use in the present study to evaluate acceptance and adoption of EFBs. The researcher initially believed that adaption of the survey items in the UTAUT2 theoretical model to the EFB context was relatively straightforward. For the majority of the constructs, the only change deemed required was to reword the survey item by replacing “mobile internet” with “electronic flight bag.” Such simple substitution may have been deceptive, however, as the challenges establishing discriminant validity described in the preceding paragraphs would seem to indicate that adequate adaption of the UTAUT2 survey items requires additional validation and testing than was conducted in the present research.

**Habit (HT).** Modifications made to the habit (HT) construct after the pilot study provide insight as to the type of changes required. During the pilot study, two of the HT items showed poor reliability and validity. Those items were revised based on review of the literature cited by Venkatesh, Thong, and Xu (2012) as they initially developed the HT construct. The revisions were partially successful, as the two revised survey items (HT2-A and HT3-A) had higher factor loadings than the items they replaced. However, despite having an improved and acceptable AVE, demonstrating convergent validity, the overall HT construct still had insufficient discriminant validity to be used in the final structural model.

**Use behavior (UB).** The most significant challenge in extending the UTAUT2 theoretical model to the EFBs and the aviation context was creating a supportable methodology to assess use behavior (UB). In an excellent treatise on the specification of
formative constructs, Petter, Straub, and Rai (2007, p. 636) argue that establishing content validity of formative constructs requires “full and complete definition” of all aspects that explain the constructs basis in theory, as well as the methodology by which it is constructed. Venkatesh, Thong, and Xu (2012) specifically defined UB as a formative composite index yet failed to report how they aggregated data for their UB construct, which made use of a similar formative composite index for the UB construct problematic in the present research. This is a critical oversight, as formative constructs require different analysis than the more common reflective measures used in the rest of the UTAUT2 model. Perhaps as a consequence, the UB construct is inconsistently utilized in many of the subsequent derivative applications of the UTAUT2 model that were reviewed during the present study. Interestingly, Petter et al. (2007) observe that one of the seminal theories in technology acceptance literature, the Technology Acceptance Model (Davis, 1986) utilizes a problematic construct, as the perceived usefulness construct used in that theory has both reflective and formative characteristics.

**Discussion of UTAUT2 construct results.** Three UTAUT2 constructs were supported as having a positive impact on pilot’s behavioral intention to use: EE, HM, and PV. SI was not supported, and the constructs PE, FC, and HT were dropped from the study for lack of discriminant validity as discussed previously. The following section discusses the results obtained for each UTAUT2 construct that was retained in the full SEM model tested.

**Effort expectancy (EE).** As defined in the UTAUT theoretical model and retained in the UTAUT2 model, EE refers to an individual’s belief that use of a system will help them in job performance. Related to perceived ease of use (PEOU) in the TAM
model (Davis, 1986), EE was shown to affect BI in multiple studies using the UTAUT2 theoretical model. In the present research, EE was adapted to assess a pilot’s belief that an EFB would help them in the performance of flight operations. EE explained a significant proportion of variance in BI, \( \beta = .354, t = 6.617, p < .001 \). This result makes sense given that EFBs with appropriate data inputs can provide dense displays of information significant to flight operations, enabling pilots to see where they are on a chart, the relative position nearby traffic or weather, and facilitate instant access to information like radio frequencies or runway lengths. This finding reinforces that pilots consider the utility of EFBs in providing timely and relevant information to be an important part of their decisions to use EFBs.

**Hedonic motivation (HM).** Hedonic motivation relates to the perception of enjoyment a user experiences from a technology, which Venkatesh et al. (2012, p. 161) referred to as “fun or pleasure”. This is an important concept added to the original UTAUT model in the creation of the UTAUT2 theoretical model, as such fun or enjoyment is considered a component of user motivation as they interact with voluntary-use technology and reflects part of the consumer behavior basis that Venkatesh et al. sought to model.

Like EE, HM was found to explain a significant portion of the variance in BI, \( \beta = .342, t = 6.24, p < .001 \). This may provide a useful insight as it shows that pilots derive pleasure from using EFBs and that such pleasure in using a technology increases the likelihood that pilots will intend to use it during their operations.

**Price value (PV).** Venkatesh et al. (2012) felt that the price value construct was important in modeling acceptance and adoption of technologies sensitive to consumer
behavior, as consumers responsible for acquisition and use costs related to a system would be likely to evaluate the tradeoffs between those costs and the perceived benefits of a system. Price value was shown to explain a significant portion of the variance in BI, $\beta = .162, t = 4.088, p < .001$, but the result was not as strong as the results found for EE and HM. This result may show that while pilots, as consumers, are sensitive to perceptions of price versus the perceived value of a system, but that PV is not the strongest consideration for pilots as they evaluate the use of EFBs. One potential interpretation of this result could be that pilots consider the utility (EE) and fun (HM) of using an EFB to be more important to their EFB acceptance and adoption behaviors than PV. If that viewpoint is considered an appropriate interpretation of the results, an EFB may choose to compete in the EFB marketplace by seeking to offer an EFB that has useful features that are fun to operate, and determine that competing with other EFBs on the basis of price is of slightly lesser importance.

**Social influence (SI).** For the present research, SI refers to the degree that a pilot feels that others important to them believe that the pilot should use an EFB. SI was not supported as an explanation of the variance of SI, $\beta = 0.038, t = 1.056, p < .291$. Potentially, this result may show that GA pilots that are free to use or not use an EFB make their own choices regarding EFB use, and are not significantly influenced by the opinions of other pilots or friends.

**Research question 1.** The first research question examined in the present study asked, “What exogenous UTAUT2 factors affect pilot acceptance and adoption of EFB technology?” Ten hypotheses were developed relating to the relationships between the exogenous and endogenous constructs in the UTAUT2 model. As PE, FC, and HT were
removed from the model due to discriminant validity concerns, only four of the seven exogenous factors in the UTAUT2 theoretical model were evaluated. The hypotheses that EE, FC, and HM have a positive effect on BI were supported, and the hypothesis that SI has a positive effect on BI was unsupported.

Venkatesh et al. (2012) believed that PE was the strongest predictor of BI in the UTAUT2 model. Intended to capture how strongly the respondent feels that using a system will help in job or task performance, it was expected that the present research would have obtained similar results. PE was previously supported in several research studies (Francis, 2016; Lewis et al., 2013; Nwosu, 2013), so it would be reasonable to believe that if the challenge establishing discriminant validity could be addressed, PE would be supported in the aviation context as a predictor of behavioral intention.

Effort expectancy, related to the ease of use of a technology system, was supported. This was expected, as the concept that a pilot’s intention to use EFBs would be related to the pilot’s perceptions regarding how easy or difficult the system might be to use has strong face value. Similarly, there is face value that if a pilot enjoys using a system, the pilot will have higher intentions to use the system, and so it was not surprising that hedonic motivation (HM) was supported.

Social influence (SI), which relates to the degree an individual feels other in their life feel that the individual should use a system, was not supported. This result was not expected, as popular aviation culture has seemingly thoroughly embraced the EFB concept, and the EFBs have become very popular and have experienced high sales for at least the past five years.
Research question 2. Research Question 2 investigated “To what extent do the demographic variables of age, gender, or experience using EFBs moderate the relationships between the factors in the UTAUT2 model?” Again, due to the removal of PE, FC, and HT from the full structural model due to concerns about discriminant validity, several of the relationships considered for Hypotheses 11 to 17 were unable to be evaluated.

H11 hypothesized that age (AGE) would moderate the effects of PE, EE, SI, FC, HM, PV, and HT on (BI). PE, FC, and HT were not evaluated, and age was found not to be a significant moderator of the effects of effort expectancy (EE) or hedonic motivation (HM) on behavioral influence (BI). The moderating effects of SI on BI were not evaluated, as it was shown in Hypothesis 3 that SI did not have a significant effect on BI. However, age was found to moderate the effects of price value (PV) on BI. Older pilots with lower scores for price value were found to have lower behavioral intention than older pilots with higher scores for price value. Thus Hypothesis 11 was only partially supported for one of the seven possible relationships.

H12 hypothesized that gender (GDR) would moderate the effects of PE, EE, SI, FC, HM, PV, and HT on (BI). PE, FC, and HT were not evaluated as they were dropped from the model, and the moderating effect of SI was not moderated as it did not have a significant effect on BI. Similar to the results for age, gender was found to have a moderating effect on only one of the remaining three constructs. Gender did not moderate the effects of HM or PV on BI but was found to moderate the effects of EE on BI. The moderating effect was weaker than for the age and was only significant at $p < .05$. Male and female respondents with low effort expectancy had approximately the
same level of behavioral intention, but males with higher levels of effort expectancy tended to have higher behavioral intention to use EFBs than did females with higher effort expectancy.

H13 hypothesized that experience using EFBs (EXP) would moderate the effects of PE, EE, SI, FC, HM, PV, and HT on (BI). As in H11 and H12, PE, FC, and HT were not evaluated, nor was SI. For the remaining three UTAUT2 constructs, EE, HM, and PV, experience using EFBs was found to have a significant and positive moderating effect on BI.

Because PE, FC, and HT were dropped from the model, Hypotheses H14, H15, and H16 were not evaluated. H17 hypothesized that experience using EFBs (EXP) would moderate the effects of BI on UB. Evaluation showed such was the case, and respondents with higher levels of experience using EFBs tended to report higher use behavior.

Conclusions

The present study was the first study that applied the UTAUT2 model in the aviation context. The intent of the study was to investigate the extent that the factors in the UTAUT2 model could contribute to an explanation of the pilot acceptance and adoption of EFBs in general aviation operations. The study provides a useful contribution by addressing the gap in the literature related to application of technology acceptance to the aviation domain. If the limitations in the UTAUT2 theoretical model identified in the present research are sufficiently addressed, an adapted version of the UTAUT2 model would be better able to pilot acceptance and adoption of voluntary-use aviation technology. Such a refined model could be a useful tool, as new technology
continues to be introduced into the aviation domain at a rapid pace, and understanding why pilots choose to adopt or fail to adopt a technology is important.

Both of the research questions were answered, but challenges with discriminant validity of the items in the survey instrument limited the utility of the results. The challenges experienced using the UTAUT2 survey instrument were troublesome. It is possible to interpret the results obtained as an indicator that the robustness of the UTAUT2 model for use in contexts other than the information technology context in which it was developed is less than ideal.

At the beginning of this research, it was assumed that the UTAUT2 survey instrument items adequately reflected their intended constructs. The researcher assumed that, having been validated in the original study by Venkatesh, Thong, and Xu (2012) and by subsequent researchers, simple modifications of a word or two of a survey item would result in achievement of results with high discriminant validity similar to the seminal UTAUT2 study. When that was not achieved, close examination of the survey items revealed that some of the items didn’t appear to be well-grounded in the literature that established the constructs they were aimed at capturing. Given that even with carefully considered modifications the survey items for habit still failed to achieve discriminant validity, refinement of the baseline UTAUT2 survey instrument may be necessary so future researchers can start from a common baseline. Having a robust baseline survey instrument that can be utilized with minimal adaptations is a fundamental concept and critical for comparison of the results of studies that utilize UTAUT2. If each researcher seeking to utilize UTAUT2 in varying contexts must extensively modify multiple survey
items to achieve acceptable validity, then the results obtained may have limited utility in terms of comparability and generalizability.

Despite the challenges with the UTAUT2 survey instrument, and although fewer of the constructs in the UTAUT2 model were evaluated than planned, the results are still generalizable to the general aviation population. For example, the results of this study showed that pilots with higher responses for price value had higher behavioral intentions to use EFBs. In common language, this result suggested that pilots who felt EFBs were reasonably priced and a good value for the money had greater intention to use EFBs during their flight operations. Similar results in effort expectancy suggest that pilots who feel EFBs are easy to use had higher behavioral intentions to use EFBs, and pilots that thought EFBs were pleasurable and fun (hedonic motivation) to use also had increased behavioral intention to use. Thus, if a regulator, EFB manufacturer, or other pilot influencer intends to increase pilot usage of EFBs, it would be expected that improvements in the perceived price value, ease of use, and enjoyment in using EFBs would help achieve that objective.

The results also suggested that while age and gender had limited effects on behavioral intention, experience using EFBs had a significant moderating effect in each of the evaluated constructs. Restated, as pilots gain experience using EFBs, they find EFBs easier and more fun to use and believe EFBs have higher value for the price of acquisition and use. This may suggest that increasing exposure to EFBs helps pilots lower their concerns about ease of use, increases the pleasure they experience while using an EFB, and helps them justify the costs associated with EFBs.
**Practical and theoretical implications.** The initial insights developed in the present research could help the aviation industry. The research could inform sales and marketing approaches for EFBs. For example, it might be considered that age could be a factor that affects consumer views of EFBs and other advanced technologies, especially in terms of how difficult older consumers perceive the devices are to use. If one searches on age and technology adoption in the literature, there is support in the body of research that could support generalizing such view to all types of technology, such as a 2006 study that found older adults could experience computer anxiety that reduces adoption rates (Czaja et al., 2005). But in the present research, age was found not to moderate pilot views of the perceived ease of use of technology. It may be imprudent to generalize the results of a single study to all aviation or all aviation technology, but the results obtained suggest that age may not be as significant a factor in the aviation context as it appears to be in other technology applications. Thus, the present study, if viewed as marketing research, could help guide allocation of precious sales and marketing resources.

If the approach used in the present research were further refined and validated in further studies, using an adapted version of the UTAUT2 model could provide theoretical support for the use of the UTAUT2 model for other voluntary-use aviation technologies. Two examples that may be good candidates for study using similar methodology are engine monitors and angle-of-attack (AOA) indicators. Comparison of the results of studies using a common model of technology acceptance adapted for the aviation context for EFBs, engine monitors, AOA indicators, and similar technologies would contribute to a richer understanding of how technology adoption theories fit the aviation population.
**Limitations of the study.** The present study had some limitations. First, the survey was conducted via the internet, which places limits on the population that can be surveyed as not all potential respondents in the population of reference are likely to have internet access. Similarly, the relatively few survey responses solicited at in-person events were conducted in a limited geographical area due to practical limitations in budget. In the present study, specific efforts were made to ensure a sample was obtained that was generalizable to GA flight operations. In-person solicitation of responses at aviation events, and future studies should also ensure similar efforts are undertaken, as it cannot be assumed that all GA pilots have internet access.

Second, the results achieved in the present research did not provide sufficient evidence to confirm discriminant validity for three of the exogenous factors in the UTAUT2 model. While UTAUT2 is not a holistic model that purports to cover all aspects of technology acceptance, it is widely accepted and has been replicated for multiple technologies in multiple contexts. The survey items were minimally adapted for use in the present research as the research believed that cautious and minimal modifications would best ensure the research embodied the core concepts of the UTAUT2 constructs. The unexpectedly poor discriminant validity achieved may indicate that more extensive modification and testing of the UTAUT2 model during a pilot study phase is necessary to successfully utilize the theory. Further study, as detailed in the Recommendations section of this chapter, is necessary.

Lastly, given that Venkatesh et al. (2012) did not fully report how they aggregated and operationalized their data for the UB construct, UB was represented as a single observed variable in the present research. The unclear documentation of the UB
construct in the literature reviewed compelled the use of only the UB4 survey item to represent use behavior, thus the research design used in this study may be less generalizable to other UTAUT2 studies than desired. This change was deemed necessary, as inclusion of an improperly specified formative composite index could have had a negative impact on the validity of the overall study.

**Recommendations for Future Research**

Three recommendations are suggested to guide future research of technology acceptance in the voluntary-use aviation context. First, further refinement of the survey instrument may improve the robustness, validity, and generalizability of an adapted UTAUT2 model for such purposes. Secondly, multiple pilot tests of the survey instrument may be required to ensure any modifications to the survey instrument are reliable and valid for application to the population of interest. Thirdly, modification of the theoretical model to include flight experience would capture one of the key indicators used in the aviation community to represent the relative experience levels of pilots in the aviation community. Lastly, inclusion of some aspects of research into resistance to change into the research model may extend and improve the explanatory power and utility of further research.

**Refinement of the survey items.** The survey instrument used was adapted from the UTAUT2 model published in 2012 but suffered from low factor loadings for one item and poor discriminant validity for three of the reflective exogenous constructs. Further research to refine the survey items is necessary so all of the constructs may be included as validated measures in future research. As noted in the Discussion section, Morosan and DeFranco (2016) made extensive modifications to address what they felt were
shortcomings in the UTAUT2 survey instrument. Future research should consider making similar modifications to the survey instruments to capture theoretical and empirical improvements made to the UTAUT2 model in the six years since its initial publication.

Other modifications to the survey instrument are likely required to better fit the survey items to the complexities of the highly-regulated environment of aviation. As noted in Chapter III, the survey instrument permitted pilots holding foreign pilot certificates to respond to the survey. Because the survey instrument in the present research did not require pilots to identify whether they held a foreign rating, there is no way to estimate how many pilots with foreign pilot certification responded. Future versions of the survey may benefit by having pilots report when they hold a foreign certificate, as that would assist in assessing the generalizability of the study results.

**More extensive pilot testing.** The present research included a pilot study of the survey instrument as modified for use to examine acceptance and adoption of EFBs, but the results obtain suggest that additional pilot testing to refine the survey instrument may have been useful. High values obtained in tests of discriminant validity “provides evidence that a construct is unique and captures some phenomena other measures do not” (Hair, Black, Babin, & Anderson, 2015, p. 619). Thus, as there was insufficient evidence to establish discriminant validity of the survey items as used in the present research, it is logical that extensive testing of iterative modifications of the survey instrument could have achieved better results.

**Integration of flight experience.** The aviation community routinely uses cumulative totals of flight hours logged by a pilot in official records as a means to
establish certifications, capture mandated experience, qualifications, and activities, and are a commonly used measure throughout aviation. Future research of technology adoption in the aviation domain would benefit from inclusion of flight experience as a construct in the adapted theoretical model of technology adoption that would be used in future studies. Flight experience could be modeled as an exogenous factor that directly affects behavioral intention or use behavior or included as an additional moderating variable. Inclusion of flight experience would permit development of additional hypotheses, as it might be expected that increased flight experience would increase pilot levels of PE and reduce levels for EE and PV.

**Integration of resistance to innovation.** Future research should consider inclusion of a construct related to resistance to innovation as outlined by Oreg and Goldenberg (2015). Oreg and Goldenberg suggest that while some individuals are *early adopters* of new technology, others have a dispositional resistance to change (RTC), and that resistance can manifest as resistance to new innovations. Oreg (2003) developed a 17-item scale to measure RTC, and the UTAUT2 theoretical model could be modified to include the RTC construct as a latent exogenous variable that would affect behavioral intentions to use a new technology. Future research could be conducted to incorporate some or part of the RTC scale into the UTAUT2 model, with the research aim of determining whether the UTAUT2 model could be improved and broadened to have better explanatory power regarding aviation technology acceptance.
REFERENCES


DC: AIR-100. Retrieved from


APPENDIX A

Permission to Conduct Research
APPENDIX A

Permission to Conduct Research

Dr. Viswanath Venkatesh, lead author of the research team that developed the UTAUT2 theoretical model and survey instrument, maintains an automated permissions website to grant researchers permission to use the UTAUT2 model and survey instrument. The website was available at http://www.vvenkatesh.com/permissions in December, 2016.

The following email was received in response to submission of a request to use the UTAUT2:

Begin forwarded message:

From: WordPress <techaut@my.erau.edu>
Subject: Papers-Permissions/Download
Date: December 7, 2016 at 11:23:14 AM EST
To: Troy Techau <techaut@my.erau.edu>

Thank you for your interest. Your permission to use content from the paper is granted. Please cite the work appropriately. Note that this permission does not exempt you from seeking the necessary permission from the copyright owner (typically, the publisher of the journal) for any reproduction of any materials contained in this paper.

Sincerely,

Viswanath Venkatesh
Distinguished Professor and George and Boyce Billingsley Chair in Information Systems
Email: vvenkatesh@vvenkatesh.us
Website: http://vvenkatesh.com
APPENDIX B

IRB Approval

Embry-Riddle Aeronautical University
Application for IRB Approval
Exempt Determination

Principal Investigator: Troy Techau
Other Investigators: Steven Hampton

Role: Student
Campus: Worldwide
College: Aviation/Aeronautics

Project Title: General Aviation Pilot Acceptance and Adoption of Electronic Flight Bag Technology

Submission Date: 11/02/2017

Review Board Use Only

Initial Reviewer: Teni Gabriel
Exempt: Yes
Date: 11/02/2017
Approval #: 18-046

Dr. Cheri Marcham
Pre-Reviewer Signature: Cheri Marcham, PhD, 2017.07.20 Reviewed Date: 11/02/2017

Dr. Michael Wiggins
IRB Chair Signature: Michael E. Wiggins, Ed.D.
Date: 11/13/2017

Expires: 11/12/18

Brief Description:
The purpose of this research is to examine the factors that affect pilot acceptance and adoption of Electronic Flight Bags technology (EFBs) in general aviation through the use of a survey.

This research falls under the exempt category as per 45 CFR 46.101(b) under:

☐ (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices, such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

☐ (2) Research involving only the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures (of adults), interview procedures (of adults) or observation of public behavior. Participant information obtained will remain anonymous or confidential.
APPENDIX B

IRB Approval

(3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) require(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.

(4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available or if the information is recorded by the investigator in such a manner that subjects cannot be identified, directly or through identifiers linked to the subjects.

(5) Research and demonstration projects which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) Public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.

(6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the Food and Drug Administration or approved by the Environmental Protection Agency or the Food Safety and Inspection Service of the U.S. Department of Agriculture.

An exempt research project does not require ongoing review by the IRB, unless the project is amended in such a way that it no longer meets the exemption criteria.
Human Subject Protocol Application

Campus: Worldwide
College: COA

Other Institution Name & Address:

Applicant: Troy Techau
Degree Level: PhD

ERAU ID: 2382570
ERAU Affiliation: Student

Project Title: General Aviation Pilot Acceptance and Adoption of Electronic Flight Bag Technology

Principal Investigator: Troy E. Techau

Other Investigators: Steven Hampton, Ed.D.

Submission Date: 10/31/2017
Beginning Date: 11/15/2017
Expected End Date: 11/14/2018

Type of Project: Survey
Type of Funding Support (if any): None

Questions:

1. Background and Purpose: Briefly describe the background and purpose of the research.

   Electronic Flight Bags (EFBs) have proliferated in their use throughout aviation such that some pilots in aircraft ranging from homebuilt aircraft to commercial airliners are replacing aviation charts, flight manuals, and cockpit references with EFBs. But to date, little research is available in the aviation context regarding which factors are most important to pilots as they evaluate, select, and implement EFB technology.

   The purpose of the present research is to address that gap by querying pilots using a previously validated survey instrument to gain insight into those factors affecting pilot decisions to adopt and use EFB technology. The project is based on an existing theoretical model of technology acceptance and adoption.
2. Design, Procedures, Materials and Methods: Describe the details of the procedure to be used and the type of data that will be collected.

This project uses a survey-based research design. Pilots will be asked to complete questions related to their use of EFBs, and to provide demographic information related to their age, gender, experience using electronic flight bags, and aviation flight experience. The survey invitation will be made available through a variety of media, including online via emails and advertisements, and in person on a computer tablet at selected aviation-related events. The survey will be administered using the SurveyMonkey website and application.

A pilot study will be conducted with approximately 50 individuals. The pilot study is aimed at evaluating the survey instructions and survey instrument to assess the documents clarity and suitability for the research. The researcher anticipates the possibility of making only very minor alterations to the survey instrument or survey instructions as a result of the pilot study.

An example of a survey invitation email and poster is attached.

3. Measures and Observations: What measures or observations will be taken in the study?

The study examines pilot responses to seven factors related to technology acceptance in a consumer context, including performance expectancy, effort expectancy, social influence, facilitating conditions, hedonic motivation, price value, and habit. Those responses are then evaluated to determine the extent they influence the individual's behavioral intentions to use EFBs and their actual use behavior of EFBs. The research is based on the Unified Theory of Technology Acceptance 2 (UTAUT2), developed by Venkatesh, Thong, and Xu (2012).

3b. If any questionnaires, tests, or other instruments are used, provide a brief description.

The survey instrument has three sections. In the first section, demographic data regarding pilot age, gender, and experience as pilots is sought. In the second section, 26 questions relate to the technology acceptance factors above using a 5-point Likert scale. The scale responses are: Strongly Disagree, Disagree, Neither Agree nor Disagree, Agree, and Strongly Agree. The third section of the survey seeks to gather information related to actual pilot use behavior of EFBs.

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 presented by subject participation in the study are minimal, with no risks to dignity, rights, health, or welfare of the human subjects that complete the survey. None of the questions should reasonably be considered invasive or otherwise likely to cause discomfort. This study has the potential benefit of increasing our collective understanding of what factors affect pilot decisions to adopt EFB technology, which could impact EFB product development, safety management considerations of EFB regulation, and development/delivery of EFB-related training. The risk-benefit ratio is that there is little to no risk with high potential benefits.

5. Informed Consent: Describe the procedures you will use to obtain informed consent of the subjects and the backdrop/feedback that will be provided to participants. See Informed Consent Guidelines for more information on Informed Consent requirements.

Informed consent will be obtained from all participants prior to allowing respondents to begin the survey. Whether the survey is presented online or in person on a tablet computer, the informed consent statement will be presented prior to the survey questions, and agreement with its contents will be necessary in order to proceed.

6. Anonymity: Will participant information be anonymous (not even the researcher can match data with names), confidential (Names or any other identifying demographics can be matched, but only members of the research team have access to that information. Publication of the data will not include any identifying information.), or public (Names and data will be matched and individuals outside of the research team will have either direct or indirect access. Publication of the data will allow either directly or indirectly, identification of the participants.)?

Anonymous
6b. Justify the classification and describe how privacy will be ensured/protected.

No personally identifiable data will be gathered during this research that would permit the research or anyone else to connect research observations to individual pilot names. Pilot names will not be collected, and demographic data such as pilot age, gender, flight experience, and EFB usage history will be collected, but will not be stored with any pilot identification.

Survey participants will have the option of entering a drawing for a $100 Amazon Gift Card ($50 for the pilot study), to be randomly selected from among those that choose to enter. Upon completion of the survey, participants will be provided a link where they may enter the drawing. For that optional drawing entry, a participant will be asked to provide their name, email address, and phone number in order to be entered into the drawing. The survey link and the link for a gift card drawing are distinct, and the researcher has no ability to use any data in the drawing survey to infer or attribute any responses in the main research survey to any individual. All data collected will be maintained online in the SurveyMonkey website using password protection, and data downloaded to the researcher's computer will be encrypted and password-protected.

7. Privacy: Describe the safeguards (including confidentiality safeguards) you will use to minimize the risks. Indicate what will happen to data collected from participants that choose to "opt out" during the research process. If video/audio recordings are part of the research, please describe how that data will be stored or destroyed.

Data downloaded to the researcher's computer will be encrypted and password-protected, and all data collected maintained online in the SurveyMonkey website will be protected using a password.

Participants will be free to stop participation in the research at any time. Incomplete surveys will be discarded and not utilized in the study. Entry into the drawing is optional; the link to enter the drawing will be presented at the end of the survey. Personally identifiable information collected for the drawing will be retained until publication of the dissertation and then deleted/destroyed. No personally identifiable information will be shared with any outside entity.

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 16 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 recruited that are pilots with Pilot certificates, and will be required to certify that they are over 18 years of age as a response on the survey instrument. Participants will be recruited using email invitations and a poster to be displayed at the Embry-Riddle campus and at several aviation-related events.

9. Economic Considerations: Are participants going to be paid for their participation?

No

9b. 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.

No, participants will not be paid. Research participants will have the option to enter into a drawing for an Amazon Gift Card as detailed in the Anonymity discussion (#6 above).

Participants who begin the main research survey but refuse informed consent or fail to complete the survey will be unable to enter the drawing, as the link to enter the drawing is presented at the end of the research survey.

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

The estimated time for completion of the survey is 15-20 minutes.
By submitting this application, you are signing that the Principal Investigator and 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

Electronic Signature:

Troy E. Teclau
APPENDIX C

Data Collection Device

INFORMED CONSENT

AGREEMENT TO PARTICIPATE IN SURVEY: General Aviation Pilot Acceptance and Adoption of Electronic Flight Bag Technology

STUDY LEADERSHIP. I am asking you to take part in a research project that is led by Troy Techau, a Ph.D. Candidate at Embry-Riddle Aeronautical University – Worldwide.

PURPOSE. The purpose of this study is to examine the factors that affect pilot acceptance and adoption of electronic flight bag technology in general aviation operations.

ELIGIBILITY. To be in this study, you must be 18 years or older, hold a pilot certificate issued under 14CFR 61.5, other than a student pilot certificate or remote pilot certificate, and have flown at least five hours as pilot-in-command under 14 CFR § 91 in the past 12 months (excluding flight of large or turbine-powered multiengine aircraft or fractional aircraft operated under 14 CFR § 91F or 14 CFR § 91K).

PARTICIPATION. During the study, you will be asked to complete a brief online survey regarding your flight experience, age, gender, and how certain factors affect your decisions related to the use of EFBs during general aviation (14 CFR § 91) flight operations. You are asked to answer each question if at all possible, as failing to provide a response to some questions on the survey could skew the results of the study. Completion of this survey will take approximately 15-20 minutes.

RISKS OF PARTICIPATION. The risks presented by subject participation in the study are minimal, with no risks to dignity, rights, health, or welfare for those that complete the survey.

BENEFITS OF PARTICIPATION. I don’t expect you to benefit personally from completion of this survey; however, your response will help me complete my Ph.D. research. I also hope that the data from this survey may help improve aviation safety as it relates to EFBs.

COMPENSATION. There is no direct compensation for participation in this research; however, at the end of the survey participants may choose to enter a drawing for an Amazon Gift Card. One person that completes the survey and enters the drawing will win, but it is not required that participants enter the drawing.
VOLUNTARY PARTICIPATION. Your participation in this study is completely voluntary. You may stop or withdraw from the study at any time. Your decision whether or not to participate will have no impact on your current or future connection with anyone at Embry-Riddle Aeronautical University - Worldwide.

RESPONDENT PRIVACY. Your responses to this survey will be anonymous, which means that no personally identifying information will be collected, such as your email address, pilot certificate number, or address. No personal information will be collected other than basic demographic descriptors. It would be very difficult for anyone to infer or discover the identity of any survey participant based on the specific data collected.

The survey link and the link for the gift card are distinct, and there is no ability to use any data in the drawing survey to infer or attribute any responses in the main research survey to any individual.

FURTHER INFORMATION. If you have any questions or would like additional information about this study, please contact myself, Troy Techau, at (813) 508-7698 or techaut@my.erau.edu. You may also contact my Dissertation Chair, Dr. Steven Hampton, at (386) 226-6725 or hamptons@erau.edu.

The ERAU Institutional Review Board (IRB) has approved this project. You may contact the ERAU IRB with any questions or issues at (386) 226-7179 or teri.gabriel@erau.edu. ERAU’s IRB is registered with the Department of Health & Human Services – Number – IORG0004370.

CONSENT. By clicking “Yes, I agree” below (online or tablet surveys) or signing below (written surveys), you certify that you are 18 years of age or older, and agree that you understand the information on this form, that any questions you have about this study have been answered, and you voluntarily agree to participate in the study.

A copy of this form can be requested from Troy Techau or Dr. Steve Hampton.

☐ Yes, I am over 18, am a pilot, and would like to participate

☐ No, I do not want to participate
Survey Items

Section A: Demographic Information

1. Are you:  ___ Male  ___ Female

2. How old are you?  ______
   (If you are under age 18, please discontinue the survey.)

3. What pilot certificate do you hold?
   ___ None*
   ___ Student Pilot*
   ___ Remote Pilot*
   ___ Sport Pilot
   ___ Recreational Pilot
   ___ Private Pilot or foreign equivalent
   ___ Commercial Pilot or foreign equivalent
   ___ Airline Transport Pilot or foreign equivalent

   (If you have no pilot certificate, are a student pilot, or hold a remote pilot certificate but not a higher pilot certificate, please discontinue the survey.)

4. Do you have an instrument rating?
   ___ Yes
   ___ No

5. Estimated total hours of logged flight experience  (in any category of aircraft except powered parachute or weight-shift control category aircraft operated under 14 CFR § 103. These flight hours may reflect flight in all types of flight operations).
   ___ Please fill in total hours of logged flight experience

6. Recent general aviation flight activity. Within the past 12 calendar months, have you flown at least 5 hours as Pilot in Command (PIC) in the general aviation category, 14 CFR § 91?  (Please exclude flight of large or turbine-powered multiengine aircraft or fractional aircraft operated under 14 CFR § 91F or 14 CFR § 91K.)
   ___ Yes
   ___ No

Pilot in command means the person who:
(1) Has final authority and responsibility for the operation and safety of the flight;
(2) Has been designated as pilot in command before or during the flight; and
(3) Holds the appropriate category, class, and type rating, if appropriate, for the conduct of the flight.

7. I estimate I have the following cumulative experience using electronic flight bag during preflight, in-flight operations, and post-flight operations:

   ____ I have less than 1 month experience using an electronic flight bag
   ____ I have 1 to 12 months experience using an electronic flight bag
   ____ I have 12 to 24 months experience using an electronic flight bag
   ____ I have 24 to 48 months experience using an electronic flight bag
   ____ I have more than 48 months experience using an electronic flight bag

Section B: Technology Beliefs

For the following 26 questions, you are asked to respond how much you agree or disagree with the statement provided. As you answer the questions, it is important that you answer with your personal beliefs about the use of electronic flight bags (EFBs), and only consider general aviation flight operations flown under 14 CFR § 91.

If you fly for the military, airlines, public use, or in another commercial setting, you are requested to not consider the use of EFBs in those contexts, but only in those situations in which you fly as a general aviation pilot with the freedom to make your own decisions regarding the use of EFBs.

Although some questions may seem to be similar, they are actually different, so please respond to each question with your best possible answer.

8. I find electronic flight bags useful in my flight operations.

   ____ Strongly Disagree
   ____ Disagree
   ____ Neither Agree nor Disagree
   ____ Agree
   ____ Strongly Agree

9. Using an electronic flight bag helps me accomplish things more quickly.

   ____ Strongly Disagree
   ____ Disagree
   ____ Neither Agree nor Disagree
   ____ Agree
   ____ Strongly Agree
10. Using electronic flight bags increases my productivity.

    ___ Strongly Disagree
    ___ Disagree
    ___ Neither Agree nor Disagree
    ___ Agree
    ___ Strongly Agree

11. Learning how to use electronic flight bags is easy for me.

    ___ Strongly Disagree
    ___ Disagree
    ___ Neither Agree nor Disagree
    ___ Agree
    ___ Strongly Agree

12. My interaction with electronic flight bags is clear and understandable.

    ___ Strongly Disagree
    ___ Disagree
    ___ Neither Agree nor Disagree
    ___ Agree
    ___ Strongly Agree

13. I find electronic flight bags easy to use.

    ___ Strongly Disagree
    ___ Disagree
    ___ Neither Agree nor Disagree
    ___ Agree
    ___ Strongly Agree

14. It is easy for me to become skillful at using electronic flight bags.

    ___ Strongly Disagree
    ___ Disagree
    ___ Neither Agree nor Disagree
    ___ Agree
    ___ Strongly Agree
15. People who are important to me think that I should use an electronic flight bag.
   ___ Strongly Disagree
   ___ Disagree
   ___ Neither Agree nor Disagree
   ___ Agree
   ___ Strongly Agree

16. People who influence my behavior think that I should use an electronic flight bag.
   ___ Strongly Disagree
   ___ Disagree
   ___ Neither Agree nor Disagree
   ___ Agree
   ___ Strongly Agree

17. People whose opinions that I value prefer that I use an electronic flight bag.
   ___ Strongly Disagree
   ___ Disagree
   ___ Neither Agree nor Disagree
   ___ Agree
   ___ Strongly Agree

18. I have the resources necessary to use an electronic flight bag.
   ___ Strongly Disagree
   ___ Disagree
   ___ Neither Agree nor Disagree
   ___ Agree
   ___ Strongly Agree

19. I have the knowledge necessary to use an electronic flight bag.
   ___ Strongly Disagree
   ___ Disagree
   ___ Neither Agree nor Disagree
   ___ Agree
   ___ Strongly Agree
20. Electronic flight bags are compatible with other technologies I use.

____ Strongly Disagree
____ Disagree
____ Neither Agree nor Disagree
____ Agree
____ Strongly Agree

21. I can get help from others when I have difficulties using an electronic flight bag.

____ Strongly Disagree
____ Disagree
____ Neither Agree nor Disagree
____ Agree
____ Strongly Agree

22. Using an electronic flight bag is fun.

____ Strongly Disagree
____ Disagree
____ Neither Agree nor Disagree
____ Agree
____ Strongly Agree

23. Using an electronic flight bag is enjoyable.

____ Strongly Disagree
____ Disagree
____ Neither Agree nor Disagree
____ Agree
____ Strongly Agree

24. Using electronic flight bags is very entertaining.

____ Strongly Disagree
____ Disagree
____ Neither Agree nor Disagree
____ Agree
____ Strongly Agree
25. Electronic flight bags are reasonably priced.

___ Strongly Disagree
___ Disagree
___ Neither Agree nor Disagree
___ Agree
___ Strongly Agree

26. Electronic flight bags are a good value for the money.

___ Strongly Disagree
___ Disagree
___ Neither Agree nor Disagree
___ Agree
___ Strongly Agree

27. At the current price, electronic flight bags provide a good value.

___ Strongly Disagree
___ Disagree
___ Neither Agree nor Disagree
___ Agree
___ Strongly Agree

28. The use of an electronic flight bag has become a habit for me.

___ Strongly Disagree
___ Disagree
___ Neither Agree nor Disagree
___ Agree
___ Strongly Agree

29. Using an electronic flight bag feels automatic to me.

___ Strongly Disagree
___ Disagree
___ Neither Agree nor Disagree
___ Agree
___ Strongly Agree
30. It is efficient and automatic for me to use an electronic flight bag.
   
   ___  Strongly Disagree
   ___  Disagree
   ___  Neither Agree nor Disagree
   ___  Agree
   ___  Strongly Agree

31. I intend to continue using an electronic flight bag in the future.
   
   ___  Strongly Disagree
   ___  Disagree
   ___  Neither Agree nor Disagree
   ___  Agree
   ___  Strongly Agree

32. I will always try to use an electronic flight bag in my flight operations.
   
   ___  Strongly Disagree
   ___  Disagree
   ___  Neither Agree nor Disagree
   ___  Agree
   ___  Strongly Agree

33. I plan to continue to use an electronic flight bag frequently.
   
   ___  Strongly Disagree
   ___  Disagree
   ___  Neither Agree nor Disagree
   ___  Agree
   ___  Strongly Agree

Section C: EFB Use Behavior

This section is intended to gather information about your actual usage of an electronic flight bag during several different time frames related to general aviation operations. As in the previous section, please disregard any experience using an EFB during military, commercial, or airline operations in which use of the EFB is influenced by an operating certificate or company rules.
Please choose your usage frequency for the following phases of flight:

34. Preflight planning (Weather, navigation, flight planning)
   ___ I do not use an electronic flight bag (0% of the time)
   ___ I sometimes use an electronic flight bag (1-24% of the time)
   ___ I often use an electronic flight bag (25-74% of the time)
   ___ I almost always use an electronic flight bag (75-99% of the time)
   ___ I always use an electronic flight bag (100% of the time)

35. Preflight checks (aircraft inspection, checklists, weight and balance)
   ___ I do not use an electronic flight bag (0% of the time)
   ___ I sometimes use an electronic flight bag (1-24% of the time)
   ___ I often use an electronic flight bag (25-74% of the time)
   ___ I almost always use an electronic flight bag (75-99% of the time)
   ___ I always use an electronic flight bag (100% of the time)

36. Ground operations (Taxi, both pre- and post-flight)
   ___ I do not use an electronic flight bag (0% of the time)
   ___ I sometimes use an electronic flight bag (1-24% of the time)
   ___ I often use an electronic flight bag (25-74% of the time)
   ___ I almost always use an electronic flight bag (75-99% of the time)
   ___ I always use an electronic flight bag (100% of the time)

37. Airborne operations (Takeoff, Departure, Climb, Cruise, Descent, Approach, Landing)
   ___ I do not use an electronic flight bag (0% of the time)
   ___ I sometimes use an electronic flight bag (1-24% of the time)
   ___ I often use an electronic flight bag (25-74% of the time)
   ___ I almost always use an electronic flight bag (75-99% of the time)
   ___ I always use an electronic flight bag (100% of the time)

38. Post-flight (aircraft checks, checklists, closing flight plans)
   ___ I do not use an electronic flight bag (0% of the time)
   ___ I sometimes use an electronic flight bag (1-24% of the time)
   ___ I often use an electronic flight bag (25-74% of the time)
   ___ I almost always use an electronic flight bag (75-99% of the time)
   ___ I always use an electronic flight bag (100% of the time)
APPENDIX D

Figures

D1 SurveyMonkey Example - Computer
D2 SurveyMonkey Example – iPad
D3 SurveyMonkey Example - iPhone
Figure D1. SurveyMonkey example - computer. This screenshot of the author’s computer shows the screen presented to a survey participant when viewed on a computer in a browser window. The example survey is a sample survey on instructor evaluation, displayed for illustrative purposes only.
Figure D2. SurveyMonkey example - iPad. This screenshot of the author’s iPad shows the screen presented to a survey participant when viewed on a computer in a browser window. The example survey is a sample survey on instructor evaluation, displayed for illustrative purposes only.
Figure D3. SurveyMonkey example - iPhone. This screenshot of the author’s iPhone shows the screen presented to a survey participant when viewed on a computer in a browser window. The example survey is a sample survey on instructor evaluation, displayed for illustrative purposes only.