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Pilot Perception of Electronic Flight Bags at Part 121 Air Carriers

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PILOT PERCEPTION OF ELECTRONIC FLIGHT BAGS AT PART 121 AIR CARRIERS

by

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This thesis, submitted by Donley Lytle in partial fulfillment of the requirements for the Degree of Master of Science from the University of North Dakota, has been read by the Faculty Advisory Committee under whom the work has been done and is hereby approved.

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This thesis meets the standards for appearance, conforms to the style and format requirements of the Graduate School of the University of North Dakota, and is hereby approved.

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Donley Lytle
December 1, 2015

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ABBREVIATIONS

AOM	Aircraft Operating Manual
APLC	Airport Performance Laptop Computer
ASRS	Aviation Safety Reporting System
ATSB	Australian Transport Safety Bureau
BEA	Bureau d'Enquêtes et d'Analyses (French Aviation Accident Authority)
CAA	Civil Aviation Authority (European Union)
COTS	Commercial Off-The-Shelf
FAA	Federal Aviation Administration
FSDO	Flight Standards District Office (FAA)
EFB	Electronic Flight Bag
EFK	Electronic Flight Kit
EGPWS	Enhance Ground Proximity Warning System
FOM	Flight Operations Manual
HF	Human Factors
HGS	Heads-Up Guidance System
IMC	Instrument Meteorological Conditions
Jepps	Navigation Charts provided by Jeppessen
NTSB	National Transportation Safety Board
OPC	Onboard Performance Computer
PED	Portable Electronic Device
QRH	Quick Reference Handbook
SPSS	Statistical Package for the Social Sciences
TCAS	Traffic Collision Avoidance System
TSB	Transport Safety Board of Canada
VMC	Visual Meteorological Conditions
Wi-Fi	Wireless Fidelity

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ABSTRACT

Electronic Flight Bags (EFBs) have been approved for use by pilots in flight operations at many Part 121 air carriers in the United States since 2010. As an automated device replacing paper in the cockpit, there are many human factor issues that relate to operation of the EFB. EFBs have been cited in accidents and incidents worldwide in large, transport category aircraft. While the EFB was not cited as the main cause of the accident/incident, it has been listed as a contributing factor. This study looks at pilot perception related to the safety aspect of the EFB in flight operations at Part 121 carriers in the United States. It surveys pilots that utilize the device in daily, routine flight operations to determine their perception of the EFB. The study is followed with a survey of a small group of pilots to help explain the results and any correlation between the variables.

CHAPTER I

INTRODUCTION

Statement of the Problem

An Electronic Flight Bag (EFB) is a defined by the Federal Aviation Administration in Advisory Circular 120-76, dated 9 July 2002, as an "electronic display system intended primarily for cockpit/flightdeck or cabin use. EFB devices can display a variety of aviation data or perform basic calculations (e.g., performance data, fuel calculations, etc.). In the past, some of these functions were traditionally accomplished using paper references or were based on data provided to the flightcrew by an airline's "flight dispatch" function" (FAA, 2002, p. 2).

Part 121 carriers, such as Southwest Airlines and FedEx, used an early version of an EFB during flight operations to calculate takeoff and landing performance data. (DOT, 2010). Jensen (2006) notes that FedEx is considered an EFB pioneer having used an EFB, called an Airport Performance Laptop Computer (APLC) since the early 1990s (p. 2). The Southwest EFB is called an Onboard Performance Computer (OPC) and was first used in 1997 (Majcher, 2013). Koebbe (2011) states that early EFBs, such as the APLC and OPC, were large, computing devices that relied on permanent mounting fixtures and had to be hard wired into the aircraft's electrical system. These issues prevented many airlines from using EFBs in airline operations.

The advent of Apple's iPad in 2010 solved many of the original issues with EFBs allowing more widespread use in airplanes. (Koebbe, 2011). Since that time, Part 121 air carriers in the United States have sought and gained certification for pilots to use EFBs in flight operations. The first approval was granted to American Airlines by the FAA in 2013 (Huguely, 2013). Along with American Airlines, many major and regional airlines in the United States have attained approval and allow usage of EFBs in flight operations, including Delta, Southwest, Frontier, United, Alaska, JetBlue, Virgin America, Federal Express, United Parcel Services, American Eagle, and Mesa (Huguely, 2013; Delta, 2013; Frontier, 2013; McKenna, 2013; JetBlue, 2013; Virgin, 2011; Carey, 2013).

EFBs have been cited in several accident reports in the United States and worldwide in airline operations (NTSB, 2006; ATSB, 2009; CAA, 2013; DOT, 2010) Analysis of ASRS (Aviation Safety Reporting System) reports also cited many human factor issues with EFBs during flight (DOT, 2014). One of the attributing factors is electronic display information elements which pertain to scrolling, zooming, information being off-screen, difficulty in reading, and incorrect or out-of-date information (DOT, 2014). Another contributing factor is self-reported human performance, which includes inexperience with the EFB, lack of expertise, distraction, and loss of situational awareness (DOT, 2014).

There are multiple human factors that relate to pilots utilizing automation. One such factor is referred to as misuse of automation that is defined as an "uncritical reliance on the proper function of an automated system without recognizing its limitations and the possibilities of automation failures" (Bahner, Huper & Manzey, 2007, p. 688). Another

human factor element that relates to the EFB is commission errors, which are the result of "not seeking out confirmatory or disconfirmatory information, or discounting other sources of information in the presence of computer-generated cues" (Bahner et al., 2007, p. 689). Psychologists have termed these two as automation complacency and automation bias (Carr, 2013).

In addition to human factor issues relating to EFBs, there are other factors to consider concerning the EFBs themselves, such as, fallibility. "Sooner or later, even the most advanced technology will break down, misfire, or in the case of a computerized system, encounter circumstances that its designers never anticipated" (Carr, 2013). Not only is there the possibility of EFB hardware failure, i.e., display cracks, the EFB software can also fail or work in ways that were not expected by its programmers.

Regardless of the potential human factor effects and reliability of EFB hardware and software, airline operators have forged ahead equipping airline pilots and airplanes with EFBs. Pilots at Part 121 air carriers have had to adapt to using a new, computerized device in the flight deck as opposed to traditional paper that many have used for years (FSF, 2005). It is paramount to flight safety that pilots be able to utilize the EFB in a competent manner. Cahill (2006) states:

> Electronic flight bag usability is critical to flight safety. Poor usability (inefficient task workflows and/or confusing information displays) can be costly in terms of pilot time/attention and overall workload. Pilots are continuously prioritizing and sequencing flight tasks, at different points in flight. For example, to access or make landing calculations, pilots must monitor a range of information displays (e.g. flight management system, situation displays, EFB and so forth) and

> resources (e.g. navigation charts). Evidently, problems in accessing/making landing calculations will distract pilots from the primary task of flying the aircraft safely, and could result in a loss of situation awareness at a critical point in flight. The accident literature details many accidents where loss of situation awareness and/or poor task management contributes to pilot error (p. 1).

To paraphrase Cahill, it is critical to the safety of flight to understand the nature of the EFBs in the flight deck and how pilots' interaction affects current tasks and workloads.

Purpose of the Study

This study will seek to better ascertain the effects of the EFB on pilot flows and workloads by querying pilots on their perception of the EFB since they are the ones operating and interacting with the devices. This study will seek to determine the perception of safety in relation to the EFB, as well as, its impact on flows and workload. The study will also attempt to determine if there is a correlation between demographics, such as, age, type of training, length of use, flight time, corrective lenses, etc., and the perception to the usability of the EFB. After obtaining the data, a small group of airline pilots will be interviewed to provide feedback on the results and possibly shed light on the nature of the results. Chandra (2013) agrees that:

> when crew workload is too high, or too low, performance suffers. Therefore, it is important to understand how a new system such as an EFB will affect workload patterns. Workload may be decreased in some ways and increased in other ways. Increased workload could result from inefficient design of the software or hardware, or even from limitations in the flexibility of using EFBs in relation to paper documents (p. 6).

There have also been concerns of training and implementation at airlines as many pilots are unfamiliar with an Electronic Flight Bag in addition to the basic operation of the iPad or Surface tablet. An ASRS report by a Part 121 pilot cites lack of training and familiarization as a large problem with the EFB:

> The company has assumed a level of proficiency with the iPad that doesn't exist. No standardized procedures as to the display and use of same in the cockpit. Many pilots will not even admit how lost they are as to the use of this new device. This was a very material and incomplete introduction of new technology into the cockpit and I feel very strongly that we didn't get proper training as a group. (ACN# 1022123) (Chase & Hiltunen, 2010).

Research Questions

What is pilot perception regarding the safety impact of EFBs in the flight deck?

Is the Electronic Flight Bag a distraction to pilots at Part 121 air carriers?

Does the EFB increase perceived workload as opposed to traditional paper?

Are there significant, demographic variations among pilot respondents?

What are pilot reported pros and cons of using an EFB?

Literature Review

Electronic Flight Bag

While the Electronic Flight Bag is new to airline operations in the United States, it is not new to the industry. There are numerous articles and studies that have been conducted concerning EFBs, including design, human factors, accidents and incidents, as well as the business case for the EFB as opposed to paper methods.

Regulatory guidance for EFBs is established under Advisory Circular (AC) 120-76. There have been three revisions to the original AC, dated in 2002, as the EFB hardware and software have evolved over the past eleven years. The current AC guidance is found in AC 120-76C dated May 9, 2014.

The Advisory Circular establishes classes of EFBs found in Table 1 in addition to software types found in Table 2. The Advisory Circular also provides guidelines for removal of paper products from the flight deck (FAA, 2014, p. 10). The AC also provides guidelines for hardware failures, safety concerns, in addition to, design recommendations. The Advisory Circular issues guidelines for Rapid Decompression Testing of Class 1 and 2 type EFBs to ensure that the device can sustain a rapid decompression and continue to operate (FAA, 2014, pp. 15-16).

AC 20-173, published in 2011, provides guidance on the installation of the EFB to components of the aircraft. This typically applies to Class 3 EFB Hardware installations and issues guidance for mounting the EFB, power provisioning, data connectivity (wired or wireless), in addition to failure conditions. Since Class 3 EFBs interface with the aircraft, there is more guidance provided by the additional AC (FAA, 2011).

Table 1
Hardware Classifications of Electronic Flight Bags

EFB Class	Description
Class 1 EFB Hardware	Commercial off-the-shelf (COTS) computers with no FAA design, production, or installation approval for the device or its internal components. Not mounted to the aircraft, connected to aircraft systems for data, or connected to a dedicated aircraft power supply. May be temporarily connected to an existing aircraft power supply for battery recharging. If the EFB contains Type B apps for aeronautical charts, approach charts, or checklist, it must be secured and viewable during critical phases of flight and not interfere with flight control movement.
Class 2 EFB Hardware	Commercial off-the-shelf (COTS) computers with no FAA design, production, or installation approval for the device or its internal components. Typically mounted in the aircraft and must be capable of being easily removed from mounts and can be temporarily connected to aircraft power supply for battery recharging. They may be connected to aircraft power, data ports, or installed antennas.
Class 3 EFB Hardware	Guidance provided by AC 20-173 in relation to mounting, power, and data connectivity with aircraft systems.

Table 2
EFB Software Types

Software Type	Description
Type A	Paper replacement for applications intended for use during flight planning, on the ground, or during non-critical phases of flight. Containing a failure condition classification of minor or less.
Type B	Paper replacement for aeronautical information required to be accessible for each flight at the pilot station and used during all phases of flight.
Type C	Non-EFB software applications found in avionics and include intended functions for communications, navigation, and surveillance that require FAA design, production, and installation approval. Considered with a failure condition classification of major hazard or higher.

The Case For the Electronic Flight Bag

One of the cases in favor of the EFB is the near-elimination of paper from the flight deck. Another reason for the drive to EFB implementation is the "enhanced safety, increased efficiency, and lower operating costs" (FSF, 2005). According to an April 2005 FAA study,

> The business case for deploying EFBs considers may types of benefits to airlines. Relative to traditional avionics, they come at a low initial cost, can be customized and are easily upgraded, making them an open-ended computing platform rather than a packaged system (FSF, 2005).

Apple Computer's release of the iPad in 2010 was a "game-changer" in EFB implementation at airlines as it solved many problems with previous EFBs, such as the

OPC or APLC. The following table shows the iPad benefit to airline operators (Koebbe, 2011).

Table 3
iPad Benefits to Airline Operators

Benefit	Description
Weight Savings	The iPad weighs 1.3 pounds (as opposed to 77 pounds of paper manuals (FSF, 2005).
Cost Savings	iPad is inexpensive at $499. Much cheaper subscription for charts (a typical aviation chart subscription on the iPad is under $100 per year.
Versatility	Many third-party applications to aid inflight
Updating	Easy updating with one touch, not manually removing and re-inserting charts
Organization	Easier to organize charts in-flight; they are always in order as opposed to paper that can be placed in the incorrect position
Geo-Referencing	Ability to show the aircraft position on a chart with GPS

While accidents and incidents have been attributed to the EFB, there have also been reports where the EFB has assisted pilots before making errors. One such case involves FedEx in 2004 from a flight between Memphis and Tokyo. Prior to takeoff, it was concluded that the aircraft was too heavy for takeoff. Under old operating rules prior to the EFB, cargo would have been offloaded to accommodate the takeoff; however, the EFB provided alternate solutions that allowed the pilots to retain all of the cargo and change the aircraft configuration for takeoff (FSF, 2005).

Another potential incident, mentioned by Scott Powell, Jeppesen manager of cockpit solutions, referenced a Continental plane that was trailing a truck on a snow-covered taxiway for taxi guidance. The truck drove past a turn where the aircraft should have gone, and the EFB's own-ship guidance allowed the pilots to stop the aircraft and query ground control before proceeding. This action prevented the aircraft from continuing into a dead-end and having to be towed back (Rosenburg, 2010).

The idea of the EFB from an operator's standpoint makes business sense: reduce paper, reduce subscriptions, reduce costs. However, there is a potential cost in doing so. "So the principle of the EFB is a sound idea that offers the operator gains in air safety and efficiency and operation costs reductions. But for every pro there is a con and whilst the pros are attractive the cons can quickly upset the equilibrium by turning foresight into failure or at worse, disaster" (Johnstone, 2013).

Human Factors Relating to Automation and the EFB

Captain Chesley Sullenberger, the infamous captain of US Airway Flight 1549 that ditched into the Hudson River in 2009, admits that, "the pilots and technology are failing together. If we look only at the pilots – the human factor – then we are ignoring other important factors. We have to look at how they work together" (Lowy, 2011). Richard Kemmler, a former flight psychologist for Lufthansa, believes that "visually speaking, they have reached the limits of what the human sensory perception system can handle" (Traufetter, 2009, p. 5).

The definition of a "normal" pilot has changed over the years with the introduction of automation into the flight deck. Whereas pilots at one time utilized piloting skills, such as stick-and-rudder, pilotage, and dead-reckoning, their function now

has become more of a manager of systems (Pasztor, 2013; Salas, 2010, p192). This shift to a manager yields a mental burden to pilots that Salas defines as "the relation between the function relating the mental resources demanded by a task and those resources supplied by the human operator (Salas, 2010).

The issues relating to human factors with the EFB and automation include automation bias and complacency, in addition to distraction, efficiency, and reliability and trust. "Designers tend to automate everything that leads to an economic benefit and leave the operator to manage the resulting system" (Parasuraman, 1997). However, by doing so, "their efforts to compensate for the unreliability of human performance, the designers of automated control systems have unwittingly created opportunities for new error types that can be even more serious than those they were seeking to avoid" (Reason, 2011, p.46). Leaving the pilot in such a situation can be detrimental as several aircraft manufacturers have expressed. "Concerned about the hazards of cockpit "information overload", a draft report told the FAA that, "today's technology allows for too much information to be presented to the pilot" (Pasztor, 2013). Salas (2010) also agrees stating that, "one of the challenges of the high technology cockpit is avoiding potential visual overload, as most data are acquired visually" (p. 165).

Flight Safety Foundation studies of aviation and psychology have revealed that automation does not necessarily make the pilot's job easier. First of all, pilots are familiar with using paper charts in the aircraft for navigation. Having used them for many years, pilots have "developed highly efficient and individualized strategies for retrieving chart information for reference and planning purposes" (FSF, 2005). Even if paper charts are removed from the flight deck with the introduction of the EFB, "most

pilots are so familiar with using paper charts that it will take some time for them to become as comfortable with electronic charts as they are with paper charts" (FSF, 2005; DOT, 2003). A study by the Flight Safety Foundation also finds that:

> using an EFB requires effort. There may be effort involved in locating and orienting the display for use and there is effort in looking at the display, processing the information and making any necessary entries. Data entry can produce particularly long head-down times and high workload. Visual scanning of the EFB (without data entry) does not require as much effort, but it is still an additional task for the pilot. The additional workload required to use an EFB may distract the pilot from higher-priority time-critical tasks during critical phases of flight (FSF, 2005, p. 35).

Pilots of automated aircraft have also been queried about their attitudes toward cockpit systems. "A notable finding was that only a minority of the pilots agreed with the statement, "automation reduces workload" (Parasuraman, 1997, p. 234). Most pilots agree that increases in automation also increase their workload. EFBs have also been attributed to negative side-effects noting that "they could increase workload and head-down time, and distract the flight crew from higher priority tasks" (DOT, 2003, p. v).

"Riley (1989) studied factors that might influence a person's decision to use automation that relate to how much workload the operator is experiencing in addition to the perceived risk involved" (p. 124). This research suggests that many pilots many not be inclined to using automation, such as the EFB, when workload is high.

A recent study of ASRS as well at other aviation accident and incident databases revealed numerous human factors in relation to the EFB. The results produced 335

unique reports in reference to the EFB or PED that were categorized into human factors (DOT, 2014). Table 4 shows the results of the report.

Table 4

Human Factor Concern from ASRS and CAA Report

Number of Reports	Human Factor
132	Electronic display information elements pertaining to the use of electronic charts, in particular scrolling and zooming
125	Inexperience/lack of experience and distraction, unfamiliar with limitations of EFB, lost position awareness, became preoccupied with the EFB and failed other duties
62	Hardware equipment error or failure or screen legibility concerns related to the displays brightness or readability
16	Placement, mounting, stowage; pilot had poor view of the EFB/PED; inadvertent activation of EFB controls; unsecured EFB on the flight deck

Aviation expert, David Learmount, has been asking pilots and labor leaders what role that the pilot should play in this system in the future.

> The pilots themselves are calling for a discussion of how their profession sees itself. "We have to turn men and computers into a jointly operating unit," says Nikolaus Braun of the pilots' union Cockpit. More technology, he says, should by no means mean less human presence in the cockpit. On the contrary, pilots become even more necessary as system complexity grows. "Their training has to be improved, not reduced," says Fran Hoyas of the European Cockpit Association (ECA)" (Traufetter, 2009, p. 5).

Automation Complacency and Bias

Psychologists have found in studies that when humans work with computers, they fall victim to two cognitive ailments: automation complacency and automation bias (Carr, 2013). These two factors weaken performance and lead to mistakes.

Automation complacency, by definition, occurs when a computer lulls a human into a false sense of security. Having confidence that the computer will work without error and handle any problem that arises, humans allow their attention to drift. This results in disengagement from work and awareness of what is occurring around (Carr, 2013).

Automation bias refers to a condition where humans place too much faith in automation or information coming from computers. The information becomes so strong that people begin to ignore other sources of information (Carr, 2013).

Salas and Maurino (2010) notes that "this flawed judgment has been identified as a factor in professional pilot judgment errors" (p. 165). He continues to further define two classes of technology-related errors that commonly are seen in hybrid decision-making environments. One is omission errors that are defined as failures to respond to system irregularities or events when automation devices fail to detect or indicate them. The second is commission errors which occur when decision makers incorrectly follow an automation-based directive or recommendation without verifying it against other available information. (Salas & Maurino, 2010).

Distraction

When the design of a new system enters the flight deck, "it is important that the pilot's expectations of how the aircraft operates are not violated by the EFB. If the EFB

is incompatible with the overall flight deck design, pilots will have trouble learning to use it, and they will be more likely to make errors" (DOT, 2003, p. 10). Without this consideration, the EFB can be a distraction to pilots. Other considerations in reference to distraction stem from legibility of text and screens, as well as the security of the device to prevent movement during takeoff and landing (Chandra, 2013; FSF, 2005). Another distraction to pilots could result from the EFB shifting during aircraft acceleration/deceleration (FSF, 2005). The Flight Safety Foundation also found distractions that pilots may experience using the EFB during high workload situations can prevent the pilots from scanning for traffic and also monitoring aircraft systems (FSF, 2005).

Reason (2011) states that, "here then is another irony of automation: flight management systems designed to ease the pilot's mental burden tend to be most enigmatic and attention-demanding during periods of maximum workload" (pp. 44-45).

A recent ASRS report from an anonymous Captain at a regional airline details a taxiway excursion due to the EFB being a distraction. The narrative reports:

> We had cleared Runway 16R after a normal landing. The EFBs were set up with the correct airport diagrams, arrival, and approach plates. After clearing the runway, we were given taxi instructions to the ramp. As a flight crew, we were familiar with the airport but needed the airport diagrams to reference for the taxi instructions. I attempted to switch pages from the approach plate to the airport diagram, but doing so with the right hand while using the left to operate the tiller and having to look away from the front window is a major distraction. A brief excursion from the taxiway centerline occurred but was quickly corrected. I had

> to stop the airplane and set the parking brake on the taxi in to properly adjust the EFB to scroll to the corresponding location of the airport and adjust the zoom level so that it was useful and readable. The EFBs have very small touch points that are really close together, which might actually be too small for some adult human fingers…even if the user taps the screen with the tip of a pen. The touch locations should be re-calibrated so that they actually match the picture of the touch button more closely ("Paperless", 2010, pp. 1-2).

This report is only one example of how the EFB can be a distraction to the crew and allow the aircraft to enter an undesired aircraft state (not on the centerline) that could potentially lead to a more dangerous, unrecoverable incident or accident.

Another ASRS report cites how the EFB can be a distraction during critical phases of flight: "Both EFB's locked up while in precipitation static while descending in clouds on [RNAV arrival], Copilot was flying. We were deviating for rain showers when both EFB's froze. Displays still worked, but no inputs on screens worked. Got out of seat to get paper backup charts stored in galley area. Bad time for major distraction. (ACN# 1084179)" (Chase, 2014, pp. 26-27).

Efficiency

Studies have been conducted in relation to pilot efficiency using the EFB. One quantitative study was conducted in 2004 where pilots were measured on their response to EFB inputs. It was discovered that pilot interaction with the EFB was significantly slower than paper by approximately seven seconds on the EFB (Hamblin, 2004). Another study was conducted in 2005 and found that an EFB was perceived by the

participants to be slower than paper, and data input was slower and more frustrating. The participants also felt that their workload was increased by using the EFB (Cahill, 2006).

FSF (2005) believes that "increased workload could result from inefficient design of the software or hardware, or even from limitations in the flexibility of using EFBs in relation to paper documents" (p. 33). While the inefficiency may increase workload in some areas, efficiency may decrease workload in other areas. The key to understanding efficiency is the overall net workload effect to the pilots. FSF (2005) confirms that, " Although workload might increase with electronic documents, this negative quality is offset by other factors, such as the improved electronic search capabilities and the fact that documents are typically referenced in low workload conditions. Overall, the net increase in workload may be judged acceptable" (p. 34). The report also states that, "the operator should understand in advance how workload patterns will change and should decide whether the changes will be acceptable. Any evaluation of the EFB-related workload should consider the time required to perform a specific task with an EFB, compared to the time required without an EFB. Related factors include the accessibility of the EFB controls and the EFB display, the amount of automation provided by the EFB and characteristics of the EFB software. Other considerations are whether errors would be more likely during periods of heavy workloads, how difficult error-recovery would be and whether efforts to resolve EFB problems would be likely to distract pilots from other tasks (FSF, 2005, p. 33).

EFB inefficiency is detailed in the following ASRS report that add to crew frustration, confusion and workload:

After stabilized, we attempted to locate the buffet speed chart in the manual on

> our iPads. It took me three attempts to login (error message about no wi-fi signal) and a total of more than 5 minutes to get to the performance section. No amount of searches could locate the appropriate document via the search function. I finally searched page by page in the performance chapter and found it. The use of the iPad is not intuitive and would be vastly improved had I received instruction when given the iPad. (ACN# 1068232) (Chase, 2014, p. 31).

A crew of three, type-rated Boeing 777 pilots detail the following report citing EFB inefficiency as a precursor to an accident or incident:

> I attempted to locate the taxi-in checklist on the ECL [Electronic Check List] under the un-annunciated checklists and several other areas of the ECL to no avail. The entire crew became frustrated and confused as to why three company 777 type rated pilots could not find the checklist for proper tow in procedures… We never found the checklist and were towed in using procedures we believed to be appropriate lacking any AFM or Checklist guidance. Our lack of training on new procedures, the location of checklists and use of the new AFM changes is overwhelming and dangerous. These procedures and the lack of quality training [are] going to cause damage to aircraft and injury to personnel. (ACN# 976947) (Chase, 2014, pp. 31-32).

Airline pilots that are using EFBs in line operations are not able to judge whether or not the changes from paper to EFB are acceptable. Operators have implemented EFB utilization and procedures, and pilots must adapt to interfacing with the EFB regardless of its efficiency or lack thereof.

Reliability and Trust

Reliability and trust in automation go hand in hand in that without reliability, there is no trust on the part of the user with the converse being true as well. "Automation is often problematic because people fail to rely upon it appropriately. Because people respond to technology socially, trust influences reliance on automation" (Lee & See, 2004, p. 50). Parasuraman (1997) notes that, "a factor in the development of trust is automation reliability. Several studies have shown that operators' use of automation reflects automation reliability" (p. 237). Therefore, "trust often determines automation usage. Operators may not use a reliable automated system if the believe it to be untrustworthy. Conversely, they may continue to rely on automation even when it malfunctions" (Parasuraman, 1997, p. 236).

A review of ASRS reports found the following narrative that describes the lack of reliability and trust that can be created by pilots using an EFB.

> I decided to intercept the **[last leg of route]** …to save time. When I made the turn, I realized on both the moving map on my panel GPS as well as the commercial chart software that I had running on a tablet PC as a back-up moving map, that the leg would cut across the southern edge of ZZZ's Class D airspace. In HDG mode on the autopilot, I proceeded to fly south of ZZZ's airspace, which on both moving maps was indicated to be a 5 nm radius from the ZZZ airport from the surface to 3,200 MSL. Even though I was at 3,500 MSL, I didn't want to get near ZZZ's airspace. I passed approximately 8 nm south of ZZZ airport according to both moving maps. As I got past ZZZ, for some odd reason I decided to look at my sectional to make sure I was clear of the Class D airspace, and to my horror, I

> found that what was depicted on both commercial databases was WRONG! The Class D airspace for ZZZ on the current database is depicted as a 5 nm radius from the ZZZ airport with a top of 3,200 feet MSL. When I look at the current sectional, it is depicted as a 5 nm radius from the surface to 8,000 feet MSL, and a 10 nm ring from 2,000 to 8,000 feet MSL **[actually the ZZZ TRSA]**. I had unintentionally incurred upon this outer ring by 2 nm and 1,300 feet above the floor. This was the third flight I made in the past week along this similar route! Each time, I relied on the data from three commercial sources along with the airspace depicted in the panel GPS from a commercial chart maker to help me avoid airspace along my route ("Paperless", 2010, p.2).

Incidents similar to this develop distrust among pilots since the EFB provided inaccurate information. As airline pilots are now required to carry and use EFBs on the flight decks, many without paper charts for a backup, there is no method to verify the accuracy of the EFB, which may create a distrust in the accuracy of the information provided by the EFB.

Accidents and Incidents

The following accidents and incidents have been attributed to usage of an EFB. While not the major cause of the accident or incident, the EFB has been cited as a contributing factor. "Cockpit automation has played a role in several accidents by confusing pilots, particularly when they become startled or the equipment acted in unusual ways, Rory Kay, the former air safety chairman of the Air Line Pilots Association, said in an interview" (Levin, 2013, p. 1).

A report released by the US National Aviation of Sciences (NAS) described several aircraft incidents in which pilots confused various computer settings. The

software performed as it was designed to perform, but not the way the pilot's expected it to. "Programs have become so complex that they can hardly be tested for all eventualities anymore" (Traufetter, 2009, p. 1).

On March 20, 2009, an Emirates Airbus A-340 taking off from Melbourne, Australia sustained a tail strike during the takeoff roll and subsequently overran the end of the runway. The investigation found that erroneous data was entered into the EFB during pre-flight which resulted in an incorrect takeoff weight being entered. Other factors contributed to the incorrect takeoff weight not being discovered on subsequent checks (ATBS, 2009).

On April 14, 2012, a Boeing 737 sustained damage to the rear fuselage skin during a tail strike on takeoff from Chambery Airport, France. The investigation revealed that the commander (pilot-in-command) failed to enter the takeoff weight into the EFB during preflight preparation. Unbeknownst to the crew, if the takeoff weight was not entered into the EFB, the EFB would enter the default takeoff weight from the previous flight. As a result, incorrect speed and thrust were calculated and used for the takeoff. The airspeed at rotation was too low and the pitch angle substantially high that impacted the tail onto the runway. The investigation revealed a wider problem with the general design and use of EFB computers in the flight deck (CAA, 2013).

A similar incident to the France crash involved a Boeing 747 taking off from Halifax in 2004. The investigation revealed that the takeoff parameters in Halifax were identical to the takeoff parameters from their previous departure at Bradley International Airport. TSB Canada cited that one of the causes to the EFB retaining "all the previous

takeoff performance calculations" from Bradley. The crash fatally injured the crew (CAA, 2013).

Table 5

Large Aircraft Accident/Incidents Involving EFBs

Year	Operator	Aircraft Type	Location
07/31/1997	FedEx 14	McDonnell-Douglass MD-11	Newark, New Jersey
10/14/2004	MK Airlines 1602	Boeing 747	Halifax, Nova Scotia
12/08/2005	Southwest Airlines 1248	Boeing 737	Chicago, Illinois
03/20/2009	Emirates 407	Airbus A-340	Melbourne, Australia
04/24/2012	Titan Airways	Boeing 737	Chambery, France

In the United States, Southwest Airlines overran runway 31C at Chicago Midway Airport on December 8, 2005 resulting in one fatality on the ground. The subsequent NTSB investigation revealed that a contributing factor to the crash was "the programming and design of the Onboard Performance Computer (OPC), which did not present inherent assumptions in the program critical to pilot decision-making" (NTSB, 2006, p. 67). The NTSB recommendation:

> Require all 14 Code of Federal Regulations Part 121 and 135 operators to ensure that all on board electronic computing devices they use automatically and clearly display critical performance calculation assumptions (NTSB, 2006, p. 49).

Another accident involved FedEx landing at Newark International Airport on July 31, 1997. FedEx, like Southwest, at the time, utilized an onboard computer to calculate airfield takeoff and landing performance calculations called the Airport Performance Laptop Computer (APLC). Based upon the data entered into the APLC, there was confusion as to the stopping distance of the aircraft, which prompted the Captain to touch down early and stop the aircraft abruptly. The aircraft was destroyed by impact and fire, and the five occupants received minor injuries. NTSB (2000) cited one of the causes of the accident to be, "the flight crew's calculation error in determining the runway length

required for landing influenced the captain's subsequent actions during final approach and landing by creating a sense of urgency to touch down early and initiate maximum braking immediately" (p. 60). NTSB (2000) also states, "the Safety Board is concerned that two pilots with significant APLC experience at FedEx failed to properly interpret the calculated landing distances and that other experienced flight crews may also be deficient in their operational knowledge of how APLC systems function" (p. 60).

NASA is also receiving more incident reports through the Aviation Safety Reporting System (ASRS) concerning EFBs. "The day of the paperless cockpit has dawned, and with that, ASRS is hearing more about incidents involving Electronic Flight Bags (EFBs), as these electronic displays are known" ("Paperless", 2010, p. 1).

A 2014 report by the Volpe National Transportation Systems Center looked at various reports from March 1994 to January 2014 for the keywords of EFB and PED. These reports included: ASRS reports, FAA runway incursion reports, FAA accident/incident reports, NTSB reports, CAA reports, ATSB reports, TSB reports, and French BEA reports. The investigation revealed over 5,000 such reports that matched EFB and PED (DOT, 2014).

Thomas Haueter, the former director of aviation safety at the NTSB, predicts, "Incidents of this nature are a harbinger of what is to come" (Traufetter, 2009, p. 4). He also states, "Lots of people are very concerned that previously unknown problems could arise from the overabundance of computers and software." He wants to makes sure that pilots never lose complete control over their aircraft. (Traufetter, 2009, p. 4). "The days are long gone when a pilot fully understood his aircraft. We have to make a huge effort so that we don't experience a decline in aviation safety" (Traufetter, 2009, p. 4).

In summary to the Electronic Flight Bag in the flight deck at airlines, Carr (2013) sums it up best:

> The experience of airlines should give us pause. It reveals that automation, for all its benefits, can take a toll on the performance and talents of those who rely on it. The implications go well beyond safety. Because automation alters how we act, how we learn, and what we know, it has an ethical dimension. The choices we make, or fail to make, about which tasks we hand off to machines shape our lives and the place we make for ourselves in the world. That has always been true, but in recent years, as the locus of labor-saving technology has shifted from machinery to software, automation has become ever more pervasive, even as its workings have become more hidden from us. Seeking convenience, speed, and efficiency, we rush to off-load work to computers without reflecting on what we might be sacrificing as a result (p. 3).

DEFINITIONS

- Advisory Circular - a publication offered by the Federal Aviation Administration to provide guidance for compliance with airworthiness regulations
- Automation Bias - the action of a human operator to favor guidance from an automated device and ignore guidance from a non-automated device, even if the latter is the correct action
- Automation Complacency - the action of a pilot relying exclusively on automation and failing to monitor the automation
- Brightness – EFB screen back-lighting intensity
- Dimness – low intensity of EFB back-lighting
- Glare – sunlight or artificial light reflecting on the EFB display
- Paging - the action of swiping one or more fingers across the screen of the EFB to advance to another page
- Pinching - the action of spreading two or more fingers apart or bringing them together on the screen of an EFB to either zoom in or out
- Scrolling - a touching action on the screen of the EFB that allows for moving the display data up, down, left, or right.
- Zooming - the action of pinching two or more fingers on the screen of the EFB to change the magnification of the display.

CHAPTER II

METHODOLOGY

Airline pilots face multiple human factors in modern, automated flight decks. The widespread implementation of Electronic Flight Bags (EFB) at airlines beginning in 2010 increased the potential for human error concerning automation complacency, bias, distraction, reliability and trust. There have been multiple studies concerning Electronic Flight Bags since their initial inception in the early 1990s. Review of literature did not discover a study to ascertain the effects on pilots and their perception of Electronic Flight Bags at airlines in a highly automated and regulated environment. The study focuses on the perception of airline pilots in regards to Electronic Flight Bag utilization on the flight deck at Part 121 air carriers in the United States. The study ascertains pilot views on the EFB as a distraction while being used during flight operations in addition to their perceived workload while interfacing with the devices. The study then looks at demographic variations between the respondent perception with respect to primary flight instruction, rank, total flight time, age, corrective lenses, and education level. In conclusion, the study will determine pros and cons that pilots experience while using an EFB.

Population

The population group in the study involves airline pilots certified by 14 CFR Part 121 (Part 121) that utilize Electronic Flight Bags on the flight deck during flight

operations. The study encompasses all types of airlines operating under Part 121 regardless of size or classification, for example, regional, national, major, cargo, legacy, etc. All pilots of aircraft under Part 121 were included in the study regardless or crew complement; therefore, the study includes single-pilot operations under Part 121. Single-pilot operations under Part 121 rely on only one pilot to aviate, navigate, monitor aircraft systems, as well as interface with an Electronic Flight Bag if one is in use. As such, the burden placed upon the pilot is greater than a multi-pilot flight deck.

Pilots operating under Part 121 are highly regulated for their training processes and operating procedures. Many of the flight deck environments are highly automated, and there is specific training and procedures for operating in such an environment. In addition to Electronic Flight Bags, pilots may utilize other automation in the flight deck such as autopilots, Flight Management Systems, navigation displays, enhanced ground proximity warning systems (EGPWS), head-up guidance systems (HGS), and traffic collision avoidance systems (TCAS). Part 121 carriers are trained and authorized to operate in a variety of weather conditions including visual meteorological conditions (VMC) and instrument meteorological conditions (IMC). Under IMC, carriers are further authorized to conduct Category I instrument approaches, and some are authorized for Category II and III instrument approach procedures. The latter two require additional training, regulation, and automation because of lower minimums on the approaches being conducted.

Pilots operating under 14 CFR Parts 91 and 135 were excluded from this study. While training and operations are more regulated under Part 135 as opposed to Part 91, there is no uniformity of training and procedures under these operations. These pilots

also fly a wider variety of aircraft and may not have the demands placed upon them as airline pilots under Part 121.

Data Sources and Collection

The study surveyed Part 121 airline pilots operating in the United States that are actively employed and utilizing an Electronic Flight Bag during flight operations. There was no compensation to participants for completing the survey. Any pilot participating in the survey did so voluntarily. To protect the anonymity of the participants, the survey was completed via the Internet and was available from any computer with Internet access. There was no time limit to complete the survey. The Internet survey also allowed respondents to complete the survey at their convenience.

The first two questions of the survey determined the status of the participant. If the participant answered that they were not employed as a pilot at a Part 121 airline or utilizing an Electronic Flight Bag in flight operations, the survey ended, and no further data was collected.

Participants were recruited by various methods. First, an email was sent to members of a professional pilot organization. (see Appendix A). Second, an email was sent from labor organizations at multiple airlines to its members asking for participation. (see Appendix B). The email contained a description of the study as well as the Internet link to complete the survey. The two aforementioned groups also posted a link to the survey on their social media website.

When navigating to the Internet survey, participants once again were presented with a description of the study and instructions on completing the survey. (see Appendix C). The survey was available for four weeks.

The survey contained both quantitative and qualitative questions. (see Appendix D). There were 27 questions that focused on several areas in relation to the Electronic Flight Bag: flight information, demographics, EFB training, EFB distraction, EFB trust, EFB personal activities, and narrative questions for both positive and negative aspects of the EFB.

Once a participant completed the Internet survey, it was saved online. After the survey closed, the results were imported into Microsoft Excel software for analysis. Quantitative data was imported into IBM Statistical Package for the Social Sciences (SPSS) for analysis. Significant values were set at 0.05 alpha level (two-tailed). Qualitative data was read through by the researcher to detect themes that emerged from the data. Once themes were identified, they were coded and classified into categories that were then reported.

Assumptions and Limitations

It is assumed that pilots responding to the survey are current pilots at Part 121 air carriers in the United States. AC 120-76C requires operators to train pilots on the EFB prior to use; therefore, it is also assumed that the pilots have been trained by their respective air carriers concerning normal and abnormal procedures relating to the Electronic Flight Bag, and that the EFB is being utilized in flight operations on the flight deck.

It will be difficult to measure events occurring in relation to the EFB since pilots are not counting each event as it occurs (quantitative). The questions will pose a range of percentages and rely on the pilot to recount an estimation of a certain event occurring in regard to the EFB since there is no quantifiable method for the purpose of this study. It

will also be difficult to ascertain whether pilots responding are being truthful in their responses based upon their perceptions. Some of the possible reasons for this could possibly be related to employment or government retaliation for actions while on the flight deck.

Protection of Human Subjects

The online survey that the participants completed received approval from the Institutional Review Board of the University of North Dakota. In order to protect the participant's identities, no personal information was gathered from the survey.

All participants voluntarily completed the online survey and follow-up study. This was conveyed at the beginning of the survey before beginning any questioning. The participants were notified that they should only answer questions that they felt comfortable with and could terminate the survey at any time.

If the participants felt uncomfortable with any questioning, they were directed to the researcher at efbstudy@gmail.com or the University of North Dakota Institutional Review Board at 701-777-4279.

CHAPTER III

RESULTS

Demographics

There were 565 total participants that completed the survey (N = 565). Results that were removed from the analysis are outlined in Table 6. After removal of participants that did not meet the criteria, there remained 470 valid responses that were included in the study (N = 470).

Table 6

Respondent Removal from Study

Number of Removals	Explanation
6	The entire record contained no data.
38	Respondents that indicated in Question 1 that they were not a pilot at a Part 121 air carrier.
5	The data contained no response in Question 2 pertaining to use of an EFB.
32	The respondents indicated in Question 2 that they did not use an EFB on the flight deck.
7	Questions 1 and 2 indicated that the respondent was a pilot for a Part 121 air carrier and used an EFB but did not provide any other data.
7	No demographic information was provided
95	TOTAL REMOVALS

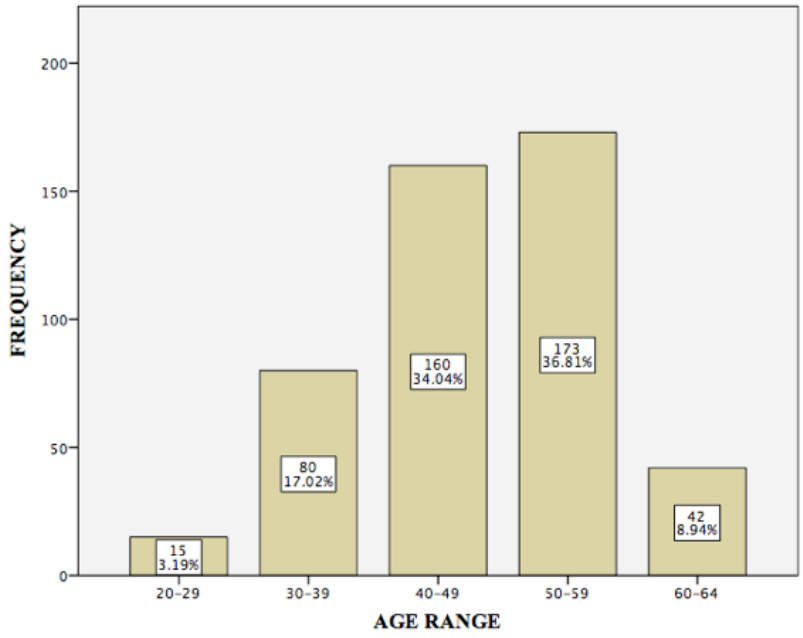
A series of demographics questions were asked of the participants that included age, current rank at the airline, flight time, initial type of training, corrective lens usage, highest level of education completed, and length of EFB use.

Age

The age demographic was broken down into ranges of: younger than 20, 20-29, 30-39, 40-49, 50-59, and 60-64. The Fair Treatment for Experienced Pilots Act of 2007 requires mandatory retirement for Part 121 pilots at age 65; therefore, the maximum age limit in the survey was 64. Figure 1 details a histogram of respondent ages (N = 470).

Figure 1

Histogram of Respondent Age Ranges

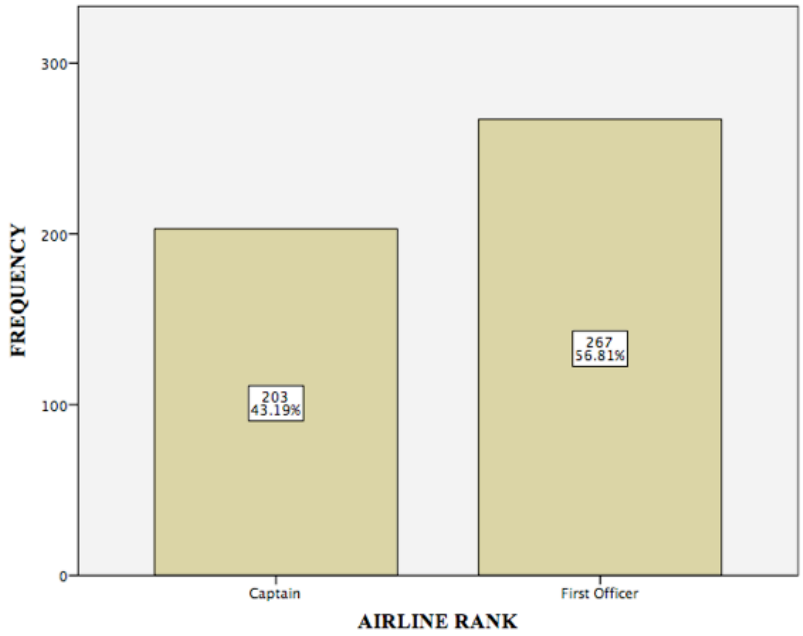


Airline Rank

Pilots were asked to provide their current rank at their carrier. The options presented were Captain, First Officer and Flight Engineer. Zero respondents indicated the rank of Flight Engineer. Figure 2 details the respondents rank as Captain and First Officer (n = 470).

Figure 2

Histogram of Airline Rank

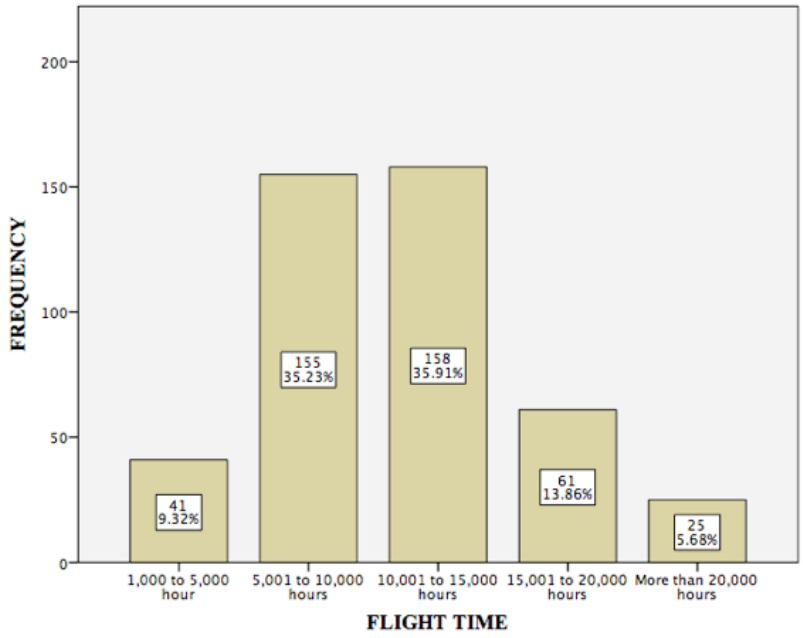


Flight Time Experience

Respondents were asked to provide their approximate flight time and was then coded into the following ranges: 1,001 to 5,000, 5,001 to 10,000; 10,001 to 15,000; 15,001 to 20,000; and greater than 20,000. The minimum answer provided was 1,150 hours, and the maximum was 34,000 hours. Figure 3 details the flight time categories of the pilot respondents (N = 440).

Figure 3

Histogram of Flight Time



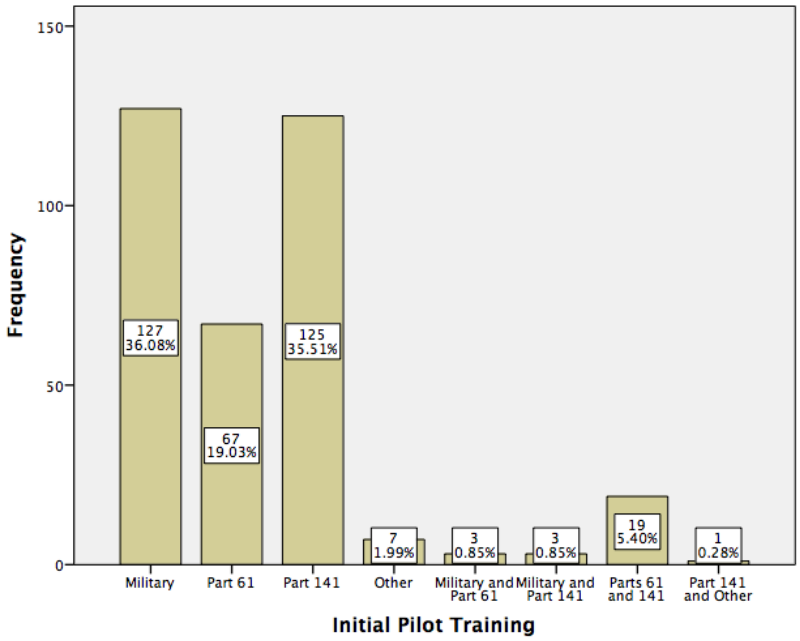
Initial Flight Training

Pilots were asked to provide the type of initial training they received. The options presented in the survey were: Military, Part 61 flight school, Part 141 flight school, Other, and Other Explanation. Three of the Other answers were coded to Part 61 flight school with the Other Explanation listed as: "Independent flight instructors", "local FBO", and "private lessons with CFI". Two of the Other responses were "UND" and

"Embry Riddle" and were coded as Part 141 flight school. One Other response was detailed as "121 airline" and was omitted from analysis since pilots do not receive initial flight training from Part 121 airlines. All additional responses of Other that are detailed contained no additional information from the respondent. A majority of pilots indicated only one type of initial training; however, some indicated more than one type of initial training. The reason for multiple answers are attributed to pilots completing one rating in one category and complete other ratings in another category. For example, a pilot could receive Private Pilot training at a Part 61 school and then continue further ratings in the Military. The responses are detailed in Figure 4 (N = 415).

Figure 4

Histogram of Initial Pilot Training

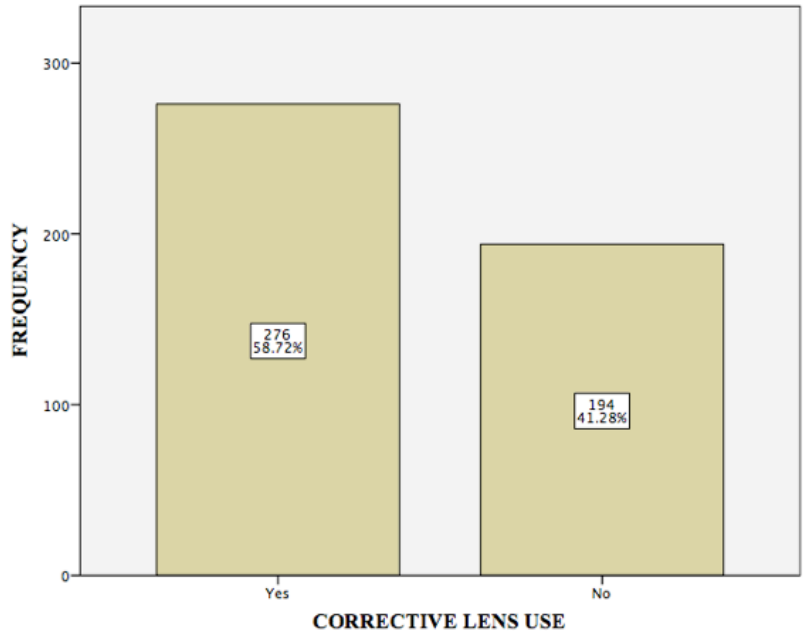


Corrective Lenses

A question was presented to respondents to determine their corrective lens use while working on the flight deck. The purpose was to determine if there was a correlation between corrective lens use and pilot perceptions. Figure 5 shows the breakdown of corrective lens utilization on the flight deck (N = 470).

Figure 5

Histogram of Corrective Lenses

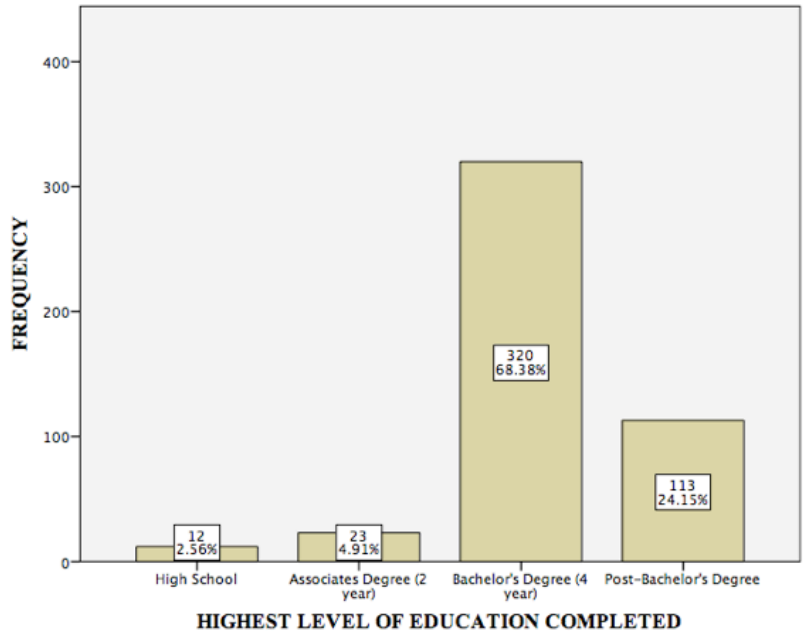


Highest Education Level Completed

Pilots were asked to provide their highest education level completed. The options presented were high school, associate's degree (2 year), bachelor's degree (4 year), and post-bachelor's degree. 2 respondents did not provide a response and are not included in the analysis (N = 468). Figure 6 shows the histogram of pilot answers (N = 468).

Figure 6

Histogram of Highest Level of Education Completed

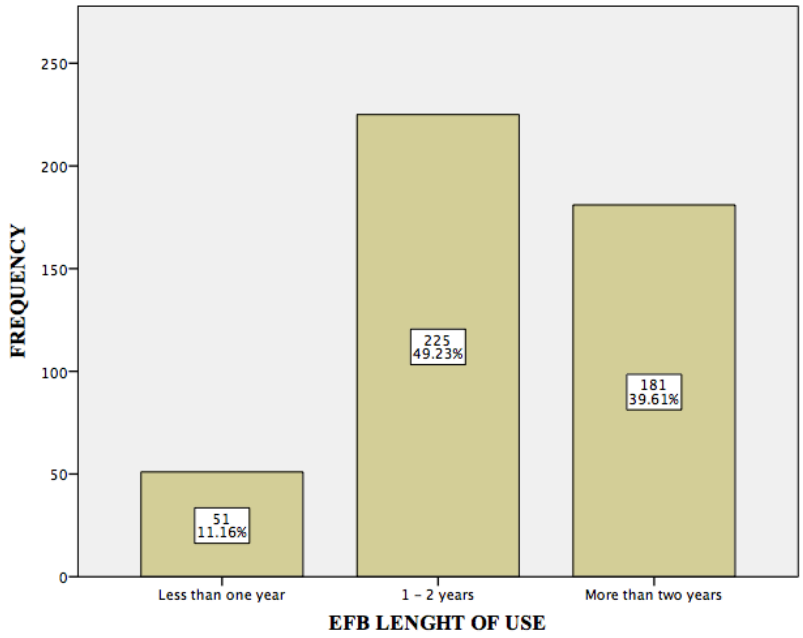


Length of EFB Use

Respondents were also asked to provide the length of time that they have been using an EFB on the flight deck. Upon analysis, responses were coded into three categories: less than one year, one to two years, and more than two years. The following histogram details the responses:

Figure 7

Histogram of Length of EFB Usage



Frequencies

Types of EFB

Participants were also asked which type(s) of EFB that are utilized on the flight deck. The options presented to the participants were: Apple iPad, Microsoft Surface Tablet, Onboard Performance Computer (OPC), Airport Performance Laptop Computer (APLC), and Other with a detailed explanation of Other. Table 7 details the responses from the pilots (N = 470).

Table 7

Type of EFB Used

EFB TYPE	Utilization	%
Apple iPad	419	89.15
Microsoft Surface	39	8.30
APLC	30	6.38
OPC	91	19.36
Other	34	7.23

There were 34 responses of Other of which 17 presented detailed answers. 2 of the 17 were omitted yielding 15 valid responses because of the provided answers of "Tablet ?????" and "Jeppesen Flight Deck Pro" which is a charting software program utilized on an EFB, not the hardware device. The valid Other details are displayed in Table 8.

Table 8

Type of EFB Used - Other Responses

RESPONSE	FREQUENCY
Android	1
EFB installed by Boeing	1
Integrated APLC and EFB	1
NavAero	1
NavPro	1
Nexis	3
Panasonic Tough Tablet	1
Panasonic Windows EFB	1
Samsung Galaxy Android	1
Samsung Tablet	1
Installed in the aircraft	2
Windows Tablet (not Surface)	1
Total	15

Type of EFB Utilization

Participants provided the types of tasks that are performed using an EFB on the flight deck. The options available for selection were: Charts (SID, STAR, Approach, Enroute, etc.), Company Related Manuals (FOM, AOM, Training, etc.), Performance, Weight and Balance, and Other with an Explanation. There were 330 valid responses provided and 24 Other responses. Two Other responses of "De-ice chart" and "MEL" were categorized under Company Manuals. One Other response of "Specific foreign airport familiarization" was coded under "Charts." Table 9 details the responses (N = 470). Other responses are detailed in Table 10.

Table 9

EFB Utilization Applications

EFB Utilization	Utilization	%
Charts	468	99.57
Company Manuals	459	97.66
Performance	135	28.72
Weight and Balance	46	9.79
Other	33	7.02

Table 10

EFB Application Utilization - Other Responses

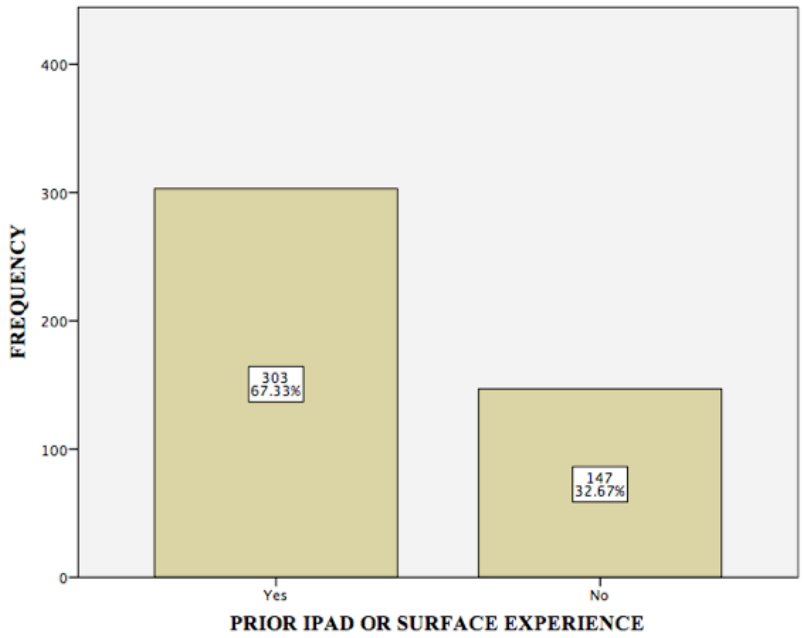
RESPONSE	FREQUENCY
AIM	1
Company email	1
Recurrent training	1
Training supplements	1
Weather	10
TOTAL	14

Prior Experience

If a respondent indicated that an Apple iPad or Microsoft Surface Tablet was used on the flight deck, the participant was further asked if there was prior experience with an iPad or Surface Table prior to using one as an EFB. 450 responses were given (N = 450) with 19 non-responses. Figure 8 presents the responses.

Figure 8

Prior iPad or Surface Experience



Workload

Pilots were asked if they believed that the use of an EFB on the flight deck adds to their workload. The answer options to the question were Yes and No. 470 pilots provided valid responses (N = 470). Figure 9 details the workload perception responses. Table 11 details the demographics with pilot perception.

Figure 9

Workload Perception

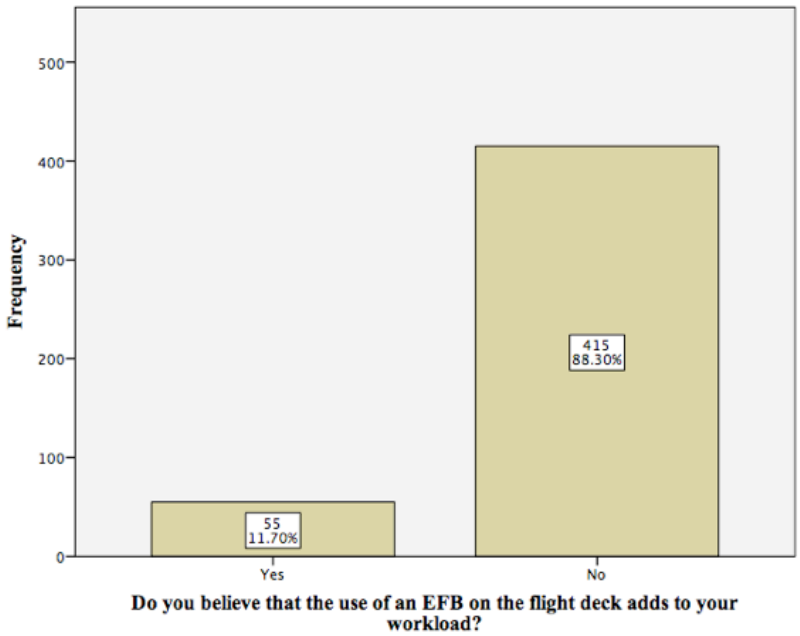


Table 11

EFB Workload Perception by Demographic Category

Do you believe that the use of an EFB on the flight deck adds to your workload?

Primary Flight Instruction*	Yes	%	No	%	Total
Military	17	9.83%	156	90.17%	173
Part 61	8	9.88%	73	90.12%	81
Part 141	19	12.10%	138	87.90%	157
Rank	Yes	%	No	%	Total
Captain	29	14.29%	174	85.71%	203
First Officer	26	9.74%	241	90.26%	267
Flight Time	Yes	%	No	%	Total
1,000 to 5,000 hours	4	9.76%	37	90.24%	41
5,001 to 10,000 hours	18	11.61%	137	88.39%	155
10,001 to 15,000 hours	19	12.03%	139	87.97%	158
15,001 to 20,000 hours	5	8.20%	56	91.80%	61
More than 20,000 hours	5	20.00%	20	80.00%	25

Table 11. EFB Workload Perception by Demographic Category (continued)

Age	Yes	%	No	%	Total
20-29	2	13.33%	13	86.67%	15
30-39	7	8.75%	73	91.25%	80
40-49	14	8.75%	146	91.25%	160
50-59	27	15.61%	146	84.39%	173
60-64	5	11.90%	37	88.10%	42
Corrective Lenses	Yes	%	No	%	Total
Yes	37	13.41%	239	86.59%	276
No	18	9.28%	176	90.72%	194
Education	Yes	%	No	%	Total
High School	1	8.33%	11	91.67%	12
Associate's Degree (2 year)	5	21.74%	18	78.26%	23
Bachelor's Degree (4 year)	34	10.63%	286	89.38%	320
Post-Bachelor's Degree	14	12.39%	99	87.61%	113
EFB Type**	Yes	%	No	%	Total
iPad	33	11.38%	257	88.62%	290
Surface	5	15.15%	28	84.85%	33
APLC	0	0.00%	3	100.00%	3
OPC	0	0.00%	1	100.00%	1
iPad and APLC	5	23.81%	16	76.19%	21
iPad and OPC	10	11.90%	74	88.10%	84
Prior iPad or Surface Experience	Yes	%	No	%	Total
Yes	32	10.56%	271	89.44%	303
No	23	15.65%	124	84.35%	147
EFB Length of Use	Yes	%	No	%	Total
Less Than One Year	5	9.80%	46	90.20%	51
1 - 2 Years	28	12.44%	197	87.56%	225
More Than Two Years	22	12.15%	159	87.85%	181

* Only military, Part 61, and Part 141 are listed. Multiple training selections and "Other" were outliers that were not reported.

** Combinations of other EFB Types that are not listed were not reported due to them being outliers in the data.

Distraction

The survey asked participants if they believe that the EFB is a distraction to their normal flight deck duties. 470 pilots responded (N = 470). The answer option were Yes and No. Figure 10 details pilot perception toward the EFB as a distraction. Table 12 shows distraction perception crossed with the demographics.

Figure 10

Distraction Perception

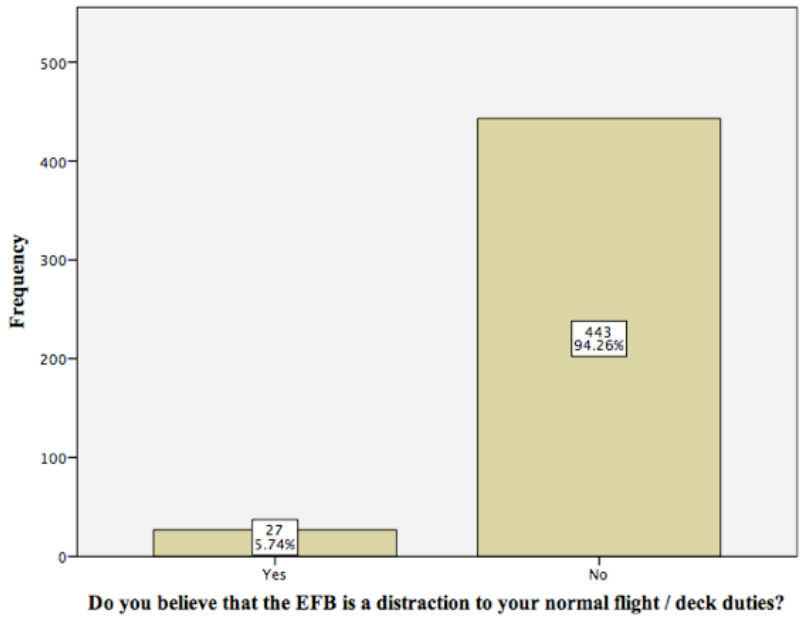


Table 12

EFB Distraction Perception by Demographic Category

Do you believe that the EFB is a distraction to your normal flight deck duties?

Primary Flight Instruction*	Yes	%	No	%	Total
Military	7	4.05%	166	95.95%	173
Part 61	5	6.17%	76	93.83%	81
Part 141	12	7.64%	145	92.36%	157

Table 12. EFB Distraction by Demographic Category (continued)

Rank	Yes	%	No	%	Total
Captain	14	6.90%	189	93.10%	203
First Officer	13	4.87%	254	95.13%	267
Flight Time	Yes	%	No	%	Total
1,000 to 5,000 hours	0	0.00%	41	100.00%	41
5,001 to 10,000 hours	7	4.52%	148	95.48%	155
10,001 to 15,000 hours	11	6.96%	147	93.04%	158
15,001 to 20,000 hours	4	6.56%	57	93.44%	61
More than 20,000 hours	3	12.00%	22	88.00%	25
Age	Yes	%	No	%	Total
20-29	0	0.00%	15	100.00%	15
30-39	3	3.75%	77	96.25%	80
40-49	9	5.63%	151	94.38%	160
50-59	11	6.36%	162	93.64%	173
60-64	4	9.52%	38	90.48%	42
Corrective Lenses	Yes	%	No	%	Total
Yes	17	6.16%	259	93.84%	276
No	10	5.15%	184	94.85%	194
Education	Yes	%	No	%	Total
High School	1	8.33%	11	91.67%	12
Associate's Degree (2 year)	2	8.70%	21	91.30%	23
Bachelor's Degree (4 year)	21	6.56%	299	93.44%	320
Post-Bachelor's Degree	3	2.65%	110	97.35%	113
EFB Type**	Yes	%	No	%	Total
iPad	16	5.52%	274	94.48%	290
Surface	2	6.06%	31	93.94%	33
APLC	0	0.00%	3	100.00%	3
OPC	0	0.00%	1	100.00%	1
iPad and APLC	2	9.52%	19	90.48%	21
iPad and OPC	5	5.95%	79	94.05%	84
Prior iPad or Surface Experience	Yes	%	No	%	Total
Yes	12	3.96%	291	96.04%	303
No	14	9.52%	133	90.48%	147

Table 12. EFB Distraction by Demographic Category (continued)

EFB Length of Use	Yes	%	No	%	Total
Less Than One Year	2	3.92%	49	96.08%	51
1 - 2 Years	14	6.22%	211	93.78%	225
More Than Two Years	11	6.08%	170	93.92%	181

* Only military, Part 61, and Part 141 are listed. Multiple training selections and "Other" were outliers that were not reported.
** Combinations of other EFB Types that are not listed were not reported due to them being outliers in the data.

Information Overload

Pilots were asked if the EFB gives them a sensation of information overload. The answer options were Yes and No. 470 pilots responded to the question with 5 pilots opting not to answer (N = 470). Figure 11 details the responses in relation to information overload. Table 13 details information overload perception in relation to demographics.

Figure 11

Information Overload Perception

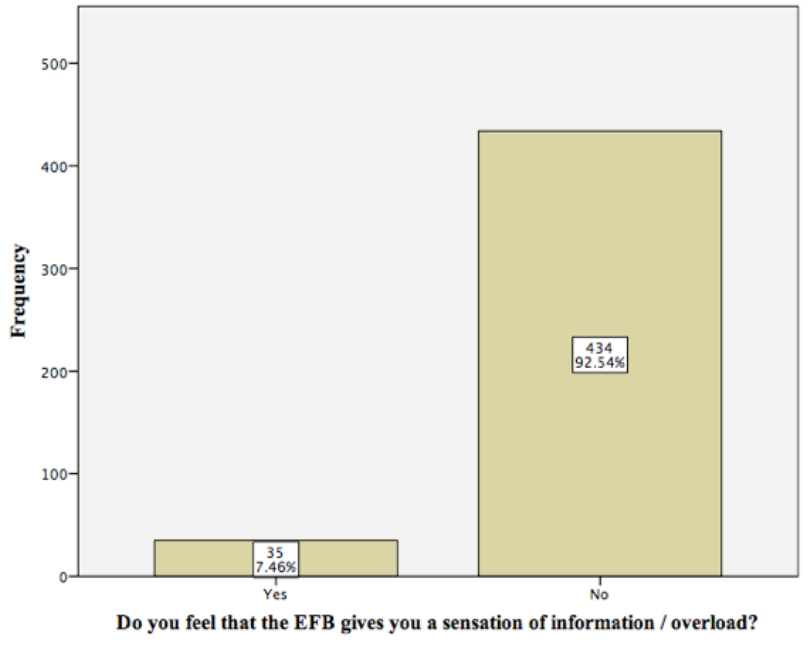


Table 13

EFB Information Overload Perception by Demographic Category

Do you feel that the EFB gives you a sensation of information overload?

Primary Flight Instruction*	Yes	%	No	%	Total
Military	16	9.30%	156	90.70%	172
Part 61	4	4.94%	77	95.06%	81
Part 141	11	7.01%	146	92.99%	157
Rank	Yes	%	No	%	Total
Captain	18	8.91%	184	91.09%	202
First Officer	17	6.37%	250	93.63%	267
Flight Time	Yes	%	No	%	Total
1,000 to 5,000 hours	1	2.44%	40	97.56%	41
5,001 to 10,000 hours	7	4.52%	148	95.48%	155
10,001 to 15,000 hours	16	10.19%	141	89.81%	157
15,001 to 20,000 hours	7	11.48%	54	88.52%	61
More than 20,000 hours	3	12.00%	22	88.00%	25
Age	Yes	%	No	%	Total
20-29	0	0.00%	15	100.00%	15
30-39	4	5.00%	76	95.00%	80
40-49	8	5.00%	152	95.00%	160
50-59	23	13.37%	149	86.63%	172
60-64	0	0.00%	42	100.00%	42
Corrective Lenses	Yes	%	No	%	Total
Yes	25	9.06%	251	90.94%	276
No	10	5.18%	183	94.82%	193
Education	Yes	%	No	%	Total
High School	2	16.67%	10	83.33%	12
Associate's Degree (2 year)	4	17.39%	19	82.61%	23
Bachelor's Degree (4 year)	18	5.63%	302	94.38%	320
Post-Bachelor's Degree	11	9.82%	101	90.18%	112

Table 13. EFB Information Overload Perception by Demographic Category (continued)

EFB Type**	Yes	%	No	%	Total
iPad	25	8.65%	264	91.35%	289
Surface	1	3.03%	32	96.97%	33
APLC	0	0.00%	3	100.00%	3
OPC	0	0.00%	1	100.00%	1
iPad and APLC	1	4.76%	20	95.24%	21
iPad and OPC	7	8.33%	77	91.67%	84
Prior iPad or Surface Experience	Yes	%	No	%	Total
Yes	20	6.62%	282	93.38%	302
No	15	10.20%	132	89.80%	147
EFB Length of Use	Yes	%	No	%	Total
Less Than One Year	6	11.76%	45	88.24%	51
1 - 2 Years	18	8.04%	206	91.96%	224
More Than Two Years	11	6.08%	170	93.92%	181

* Only military, Part 61, and Part 141 are listed. Multiple training selections and "Other" were outliers that were not reported.
** Combinations of other EFB Types that are not listed were not reported due to them being outliers in the data.

Difficulty In Navigating The EFB

Pilots were asked if the believe that they have difficulty navigating the EFB, for example, switching between applications or finding information that is needed. Again, the question has possible answer choices of Yes and No. 470 pilots responded with 4 opting not to answer the question (N = 470). Figure 12 details the responses in relation to pilot perception of difficulty navigating the EFB. Table 14 details perception of difficulty in navigating the EFB crossed with the demographics.

Figure 12

Perception of EFB Navigation Difficulty

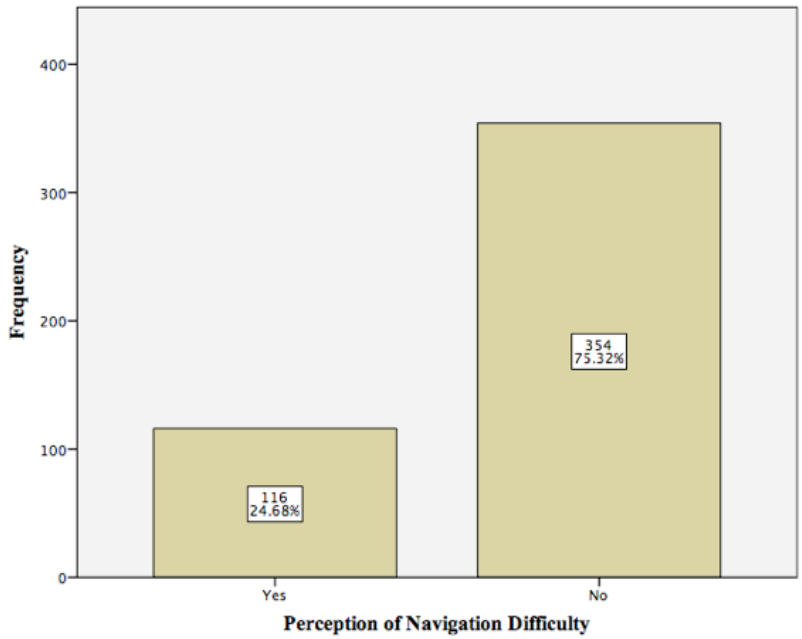


Table 14

EFB Navigation Difficulty by Demographic Category

Do you have difficulty navigating the EFB, for example, switching between applications or finding information that you need?

Primary Flight Instruction*	Yes	%	No	%	Total
Military	40	23.12%	133	76.88%	173
Part 61	24	29.63%	57	70.37%	81
Part 141	35	22.29%	122	77.71%	157
Rank	Yes	%	No	%	Total
Captain	63	31.03%	140	68.97%	203
First Officer	53	19.85%	214	80.15%	267
Flight Time	Yes	%	No	%	Total
1,000 to 5,000 hours	3	7.32%	38	92.68%	41
5,001 to 10,000 hours	26	16.77%	129	83.23%	155
10,001 to 15,000 hours	39	24.68%	119	75.32%	158
15,001 to 20,000 hours	20	32.79%	41	67.21%	61
More than 20,000 hours	13	52.00%	12	48.00%	25

Table 14. EFB Navigation Difficulty by Demographic Category (continued)

Age	Yes	%	No	%	Total
20-29	2	13.33%	13	86.67%	15
30-39	8	10.00%	72	90.00%	80
40-49	38	23.75%	122	76.25%	160
50-59	54	31.21%	119	68.79%	173
60-64	14	33.33%	28	66.67%	42
Corrective Lenses	Yes	%	No	%	Total
Yes	78	28.26%	198	71.74%	276
No	38	19.59%	156	80.41%	194
Education	Yes	%	No	%	Total
High School	6	50.00%	6	50.00%	12
Associate's Degree (2 year)	8	34.78%	15	65.22%	23
Bachelor's Degree (4 year)	79	24.69%	241	75.31%	320
Post-Bachelor's Degree	23	20.35%	90	79.65%	113
EFB Type**	Yes	%	No	%	Total
iPad	72	24.83%	218	75.17%	290
Surface	9	27.27%	24	72.73%	33
APLC	0	0.00%	3	100.00%	3
OPC	0	0.00%	1	100.00%	1
iPad and APLC	7	33.33%	14	66.67%	21
iPad and OPC	21	25.00%	63	75.00%	84
Prior iPad or Surface Experience	Yes	%	No	%	Total
Yes	67	22.11%	236	77.89%	303
No	46	31.29%	101	68.71%	147
EFB Length of Use	Yes	%	No	%	Total
Less Than One Year	17	33.33%	34	66.67%	51
1 - 2 Years	59	26.22%	166	73.78%	225
More Than Two Years	39	21.55%	142	78.45%	181

* Only military, Part 61, and Part 141 are listed. Multiple training selections and "Other" were outliers that were not reported.

** Combinations of other EFB Types that are not listed were not reported due to them being outliers in the data.

Initial EFB Training

Participants were asked their perception of their initial EFB training to be proficient in normal flight operations (N = 469). A Likert scale was used to ascertain pilot perception of initial EFB training with responses ranging from "Strongly Disagree" to "Strongly Agree." Figure 13 details pilot responses. Table 15 breaks down these results based on demographics.

Figure 13

Initial Training Proficiency - Normal Operations

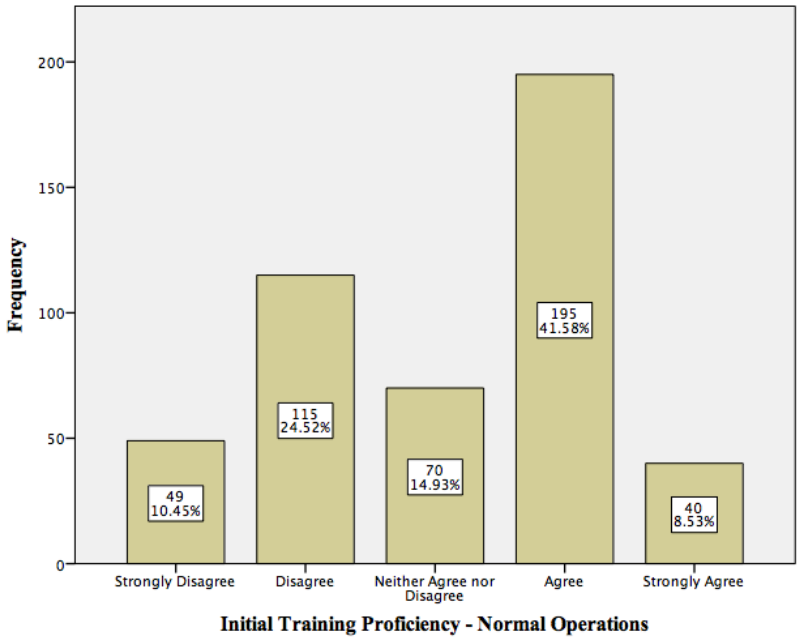


Table 15

EFB Initial Training (Normal) Perception by Demographic Category

Do you feel that your initial Electronic Flight Bag training was adequate to be proficient in normal flight operations?

Primary Flight Instruction*	SD	D	Neither	A	SA
Military	16	44	27	75	11
Part 61	10	24	14	23	10
Part 141	15	34	20	71	17

Table 15. EFB Initial Training (Normal) Perception by Demographic Category (continued)

Rank	SD	D	Neither	A	SA
Captain	27	52	33	75	15
First Officer	22	63	37	120	25
Flight Time	SD	D	Neither	A	SA
1,000 to 5,000 hours	1	6	8	20	6
5,001 to 10,000 hours	10	47	20	65	13
10,001 to 15,000 hours	20	37	24	65	12
15,001 to 20,000 hours	10	10	9	23	8
More than 20,000 hours	3	6	5	10	1
Age	SD	D	Neither	A	SA
20-29	0	2	2	10	1
30-39	5	12	14	35	14
40-49	15	45	15	74	11
50-59	21	45	30	67	9
60-64	8	11	9	9	5
Corrective Lenses	SD	D	Neither	A	SA
Yes	38	66	40	111	20
No	11	49	30	84	20
Education	SD	D	Neither	A	SA
High School	2	5	1	4	0
Associate's Degree (2 year)	2	8	7	5	1
Bachelor's Degree (4 year)	34	77	49	131	28
Post-Bachelor's Degree	11	24	12	55	11
EFB Type**	SD	D	Neither	A	SA
iPad	24	69	48	122	26
Surface	2	7	6	15	3
APLC	0	1	0	2	0
OPC	0	0	0	1	0
iPad and APLC	6	4	4	7	0
iPad and OPC	13	20	11	34	6
Prior iPad or Surface Experience	SD	D	Neither	A	SA
Yes	29	64	47	133	30
No	17	44	21	55	9

Table 15. EFB Initial Training (Normal) Perception by Demographic Category (continued)

EFB Length of Use	SD	D	Neither	A	SA
Less Than One Year	6	11	14	18	2
1 - 2 Years	19	55	25	105	20
More Than Two Years	23	46	27	68	17

* Only military, Part 61, and Part 141 are listed. Multiple training selections and "Other" were outliers that were not reported.
** Combinations of other EFB Types that are not listed were not reported due to them being outliers in the data.

Continuing on the subject of initial training, pilots were asked their perception of initial EFB training in regards to failure or malfunction of the EFB (N = 468). Figure 14 highlights the responses. A Likert scale was also used to determine pilot perception concerning their initial training ranging from “Strongly Disagree” to “Strongly Agree”. Figure 14 details the responses. Table 16 highlights the responses with the demographics.

Figure 14

Initial Training Proficiency - Failure or Malfunction

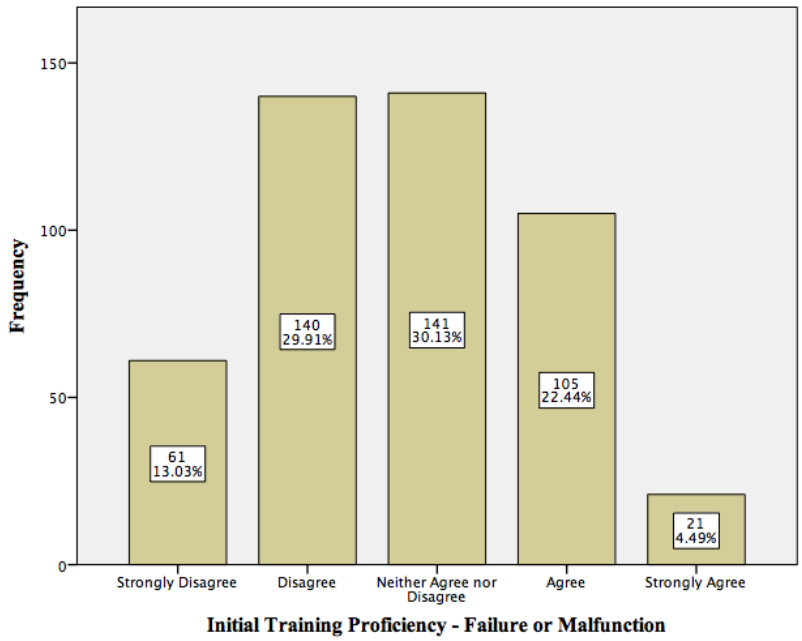


Table 16

EFB Initial Training (Malfunction) Perception by Demographic Category

Do you feel that your initial Electronic Flight Bag training was adequate to prepare you for malfunctions or failures?

Primary Flight Instruction*	SD	D	Neither	A	SA
Military	22	61	46	38	6
Part 61	11	28	19	16	6
Part 141	20	37	54	37	8
Rank	SD	D	Neither	A	SA
Captain	33	66	61	35	7
First Officer	28	74	80	70	14
Flight Time	SD	D	Neither	A	SA
1,000 to 5,000 hours	1	11	15	10	4
5,001 to 10,000 hours	19	49	42	37	7
10,001 to 15,000 hours	21	43	52	37	5
15,001 to 20,000 hours	10	24	11	11	4
More than 20,000 hours	3	5	10	6	1

Table 16. EFB Initial Training (Malfunction) Perception by Demographic Category (continued)

Age	SD	D	Neither	A	SA
20-29	0	4	5	6	0
30-39	5	20	27	19	9
40-49	21	51	48	34	6
50-59	26	53	48	40	4
60-64	9	12	13	6	2
Corrective Lenses	SD	D	Neither	A	SA
Yes	41	75	84	65	9
No	20	65	57	40	12
Education	SD	D	Neither	A	SA
High School	3	3	5	1	0
Associate's Degree (2 year)	3	8	8	3	1
Bachelor's Degree (4 year)	41	89	98	74	16
Post-Bachelor's Degree	14	39	29	27	4
EFB Type**	SD	D	Neither	A	SA
iPad	30	95	91	60	12
Surface	4	7	13	7	2
APLC	0	2	0	1	0
OPC	0	0	0	1	0
iPad and APLC	7	2	4	8	0
iPad and OPC	12	26	22	19	5
Prior iPad or Surface Experience	SD	D	Neither	A	SA
Yes	39	83	92	69	18
No	19	52	42	31	3
EFB Length of Use	SD	D	Neither	A	SA
Less Than One Year	6	19	15	11	0
1 - 2 Years	24	72	73	46	8
More Than Two Years	30	44	49	45	13

* Only military, Part 61, and Part 141 are listed. Multiple training selections and "Other" were outliers that were not reported.

** Combinations of other EFB Types that are not listed were not reported due to them being outliers in the data.

Failure Or Malfunction

Respondents were also asked about their experience with EFB failures and malfunctions. Since this is not a total count of events, it is drawing upon pilots' memories of the approximate percentages of such experiences (N = 469). Table 17 details pilot responses in relation to failure or malfunction of the EFB. Table 18 displays the perception crossed with demographics.

Table 17

EFB Failure or Malfunction Experience

N	Never	1% - 24%	25% - 49%	50% - 74%	Greater than 75%
469	268	191	8	2	0

Table 18

EFB Malfunction/Failure Experience by Demographic Category

In your experience, at what frequency has the Electronic Flight Bag failed or malfunctioned?

Primary Flight Instruction*	Never	1-24%	25-49%	50-74%	<75%
Military	102	71	0	0	0
Part 61	47	34	0	0	0
Part 141	86	65	5	1	0
Rank	Never	1-24%	25-49%	50-74%	<75%
Captain	123	75	2	2	0
First Officer	145	116	6	0	0
Flight Time	Never	1-24%	25-49%	50-74%	<75%
1,000 to 5,000 hours	25	16	0	0	0
5,001 to 10,000 hours	81	71	3	0	0
10,001 to 15,000 hours	97	54	5	2	0
15,001 to 20,000 hours	35	25	0	0	0
More than 20,000 hours	13	12	0	0	0

Table 18. EFB Malfunction/Failure Experience by Demographic Category (continued)

Age	Never	1-24%	25-49%	50-74%	<75%
20-29	12	3	0	0	0
30-39	47	32	1	0	0
40-49	79	74	6	1	0
50-59	107	63	1	1	0
60-64	23	19	0	0	0
Corrective Lenses	Never	1-24%	25-49%	50-74%	<75%
Yes	158	112	4	1	0
No	110	79	4	1	0
Education	Never	1-24%	25-49%	50-74%	<75%
High School	7	5	0	0	0
Associate's Degree (2 year)	15	8	0	0	0
Bachelor's Degree (4 year)	179	132	7	1	0
Post-Bachelor's Degree	67	44	1	1	0
EFB Type**	Never	1-24%	25-49%	50-74%	<75%
iPad	191	94	2	2	0
Surface	7	22	4	0	0
APLC	0	3	0	0	0
OPC	0	1	0	0	0
iPad and APLC	2	18	1	0	0
iPad and OPC	60	23	1	0	0
Prior iPad or Surface Experience	Never	1-24%	25-49%	50-74%	<75%
Yes	178	117	5	2	0
No	86	58	3	0	0
EFB Length of Use	Never	1-24%	25-49%	50-74%	<75%
Less Than One Year	30	20	1	0	0
1 - 2 Years	153	69	2	1	0
More Than Two Years	80	94	5	1	0

* Only military, Part 61, and Part 141 are listed. Multiple training selections and "Other" were outliers that were not reported.

** Combinations of other EFB Types that are not listed were not reported due to them being outliers in the data.

Not Functioning As Expected

Pilots were asked if, in their experience, that the EFB did not function as the pilot expected. This question also drew upon the pilot's memory of approximate percentage or such events occurring, not an actual count. Table 19 details the pilot responses, and Table 20 shows the perception grouped by demographic category.

Table 19

EFB Not Functioning as Expected Experience

N	Never	1% - 9%	10%-24%	25%-49%	50%-74%	Greater than 75%
469	159	261	30	5	2	12

Table 20

EFB Not Operating as Expected by Demographic Category

What percentage of the time has the EFB operated in a manner that you were not expecting?

Primary Flight Instruction*	Always	1-9%	10-24%	25-49%	50-74%	<75%
Military	48	110	10	0	0	0
Part 61	31	42	7	0	0	0
Part 141	63	78	10	2	1	0
Rank	Always	1-9%	10-24%	25-49%	50-74%	<75%
Captain	70	107	15	1	2	7
First Officer	89	154	15	4	0	5
Flight Time	Always	1-9%	10-24%	25-49%	50-74%	<75%
1,000 to 5,000 hours	15	25	1	0	0	0
5,001 to 10,000 hours	44	95	11	2	0	0
10,001 to 15,000 hours	60	81	8	2	2	0
15,001 to 20,000 hours	21	28	8	1	0	0
More than 20,000 hours	10	14	0	0	0	0

Table 20. EFB Not Operating as Expected by Demographic Category (continued)

Age	Always	1-9%	10-24%	25-49%	50-74%	<75%
20-29	9	6	0	0	0	0
30-39	29	41	8	1	0	1
40-49	54	92	8	2	1	3
50-59	58	94	11	2	1	6
60-64	9	28	3	0	0	2
Corrective Lenses	Always	1-9%	10-24%	25-49%	50-74%	<75%
Yes	90	157	18	3	2	5
No	69	104	12	2	0	7
Education	Always	1-9%	10-24%	25-49%	50-74%	<75%
High School	6	5	1	0	0	0
Associate's Degree (2 year)	11	9	0	2	0	0
Bachelor's Degree (4 year)	115	171	22	3	2	0
Post-Bachelor's Degree	27	76	6	0	0	0
EFB Type**	Always	1-9%	10-24%	25-49%	50-74%	<75%
iPad	109	150	16	3	1	0
Surface	5	21	6	0	1	0
APLC	0	2	1	0	0	0
OPC	0	1	0	0	0	0
iPad and APLC	2	16	1	1	0	0
iPad and OPC	37	41	4	1	0	0
Prior iPad or Surface Experience	Always	1-9%	10-24%	25-49%	50-74%	<75%
Yes	109	163	19	4	1	7
No	46	83	10	1	1	5
EFB Length of Use	Always	1-9%	10-24%	25-49%	50-74%	<75%
Less Than One Year	16	30	3	2	0	0
1 - 2 Years	96	108	10	2	1	0
More Than Two Years	42	116	16	1	1	0

* Only military, Part 61, and Part 141 are listed. Multiple training selections and "Other" were outliers that were not reported.

** Combinations of other EFB Types that are not listed were not reported due to them being outliers in the data.

Loss Of Situational Awareness

Pilots were asked if the EFB had been a cause for them to lose situational awareness while pilot the aircraft. The answer responses were to draw upon the pilot's approximate percentage of the situation occurring. Table 21 details the pilot responses, and Table 22 yields the results crossed with the demographics.

Table 21

Loss of Situational Awareness Experience

N	Never	1% - 9%	10%-24%	25%-49%	50%-74%	Greater than 75%
470	375	88	4	3	0	0

Table 22

EFB Situational Awareness Experience by Demographic Category

What percentage of time have you lost situation awareness in the flight deck due to the Electronic Flight Bag?

Primary Flight Instruction*	Never	1-9%	10-24%	25-49%	50-74%	<75%
Military	137	34	1	1	0	0
Part 61	65	15	1	0	0	0
Part 141	126	29	0	2	0	0
Rank	Never	1-9%	10-24%	25-49%	50-74%	<75%
Captain	161	40	1	1	0	0
First Officer	214	48	3	2	0	0
Flight Time	Never	1-9%	10-24%	25-49%	50-74%	<75%
1,000 to 5,000 hours	35	6	0	0	0	0
5,001 to 10,000 hours	124	29	2	0	0	0
10,001 to 15,000 hours	125	30	2	1	0	0
15,001 to 20,000 hours	50	10	0	1	0	0
More than 20,000 hours	17	7	0	1	0	0

Table 22. EFB Situational Awareness Experience by Demographic Category (continued)

Age	Never	1-9%	10-24%	25-49%	50-74%	<75%
20-29	14	1	0	0	0	0
30-39	65	14	1	0	0	0
40-49	123	33	3	1	0	0
50-59	144	28	0	1	0	0
60-64	29	12	0	1	0	0
Corrective Lenses	Never	1-9%	10-24%	25-49%	50-74%	<75%
Yes	215	56	2	3	0	0
No	160	32	2	0	0	0
Education	Never	1-9%	10-24%	25-49%	50-74%	<75%
High School	11	1	0	0	0	0
Associate's Degree (2 year)	18	4	0	1	0	0
Bachelor's Degree (4 year)	251	64	3	2	0	0
Post-Bachelor's Degree	93	19	1	0	0	0
EFB Type**	Never	1-9%	10-24%	25-49%	50-74%	<75%
iPad	237	49	3	1	0	0
Surface	28	5	0	0	0	0
APLC	2	1	0	0	0	0
OPC	1	0	0	0	0	0
iPad and APLC	12	8	0	1	0	0
iPad and OPC	70	13	0	1	0	0
Prior iPad or Surface Experience	Never	1-9%	10-24%	25-49%	50-74%	<75%
Yes	244	54	3	2	0	0
No	114	31	1	1	0	0
EFB Length of Use	Never	1-9%	10-24%	25-49%	50-74%	<75%
Less Than One Year	42	8	0	1	0	0
1 - 2 Years	182	40	2	1	0	0
More Than Two Years	140	38	2	1	0	0

* Only military, Part 61, and Part 141 are listed. Multiple training selections and "Other" were outliers that were not reported.

** Combinations of other EFB Types that are not listed were not reported due to them being outliers in the data.

Safety Perception

Pilots were asked if they believe that utilization of the EFB on the flight deck is safe. The answer responses used a Likert scale ranging from "Strongly Disagree" to "Strongly Agree" Table 23 details the safety perception of pilots and Table 24 shows the results by demographic category.

Table 23

EFB Safety Perception

N	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
470	10	5	19	137	299

Table 24

EFB Safety Perception by Demographic Category

Do you feel that utilization of the Electronic Flight Bag on the flight deck is safe?

Primary Flight Instruction*	SD	D	Neither	A	SA
Military	3	3	4	47	116
Part 61	2	0	4	23	52
Part 141	3	2	5	49	98
Rank	SD	D	Neither	A	SA
Captain	6	4	9	64	120
First Officer	4	1	10	73	179
Flight Time	SD	D	Neither	A	SA
1,000 to 5,000 hours	0	0	1	7	33
5,001 to 10,000 hours	6	1	7	45	96
10,001 to 15,000 hours	1	1	5	43	108
15,001 to 20,000 hours	2	1	3	17	38
More than 20,000 hours	1	2	0	11	11

Table 24. EFB Safety Perception by Demographic Category (continued)

	SD	D	Neither	A	SA
Age					
20-29	0	0	0	2	13
30-39	1	2	4	17	56
40-49	6	0	5	45	104
50-59	3	1	7	60	102
60-64	0	2	3	13	24
Corrective Lenses	SD	D	Neither	A	SA
Yes	7	3	10	93	163
No	3	2	9	44	136
Education	SD	D	Neither	A	SA
High School	0	0	1	4	7
Associate's Degree (2 year)	0	0	2	13	8
Bachelor's Degree (4 year)	8	5	12	94	201
Post-Bachelor's Degree	2	0	4	25	82
EFB Type**	SD	D	Neither	A	SA
iPad	7	3	11	88	181
Surface	1	2	0	13	17
APLC	0	0	0	1	2
OPC	0	0	0	0	1
iPad and APLC	0	0	1	9	11
iPad and OPC	1	0	4	18	61
Prior iPad or Surface Experience	SD	D	Neither	A	SA
Yes	9	5	9	81	199
No	1	0	9	50	87
EFB Length of Use	SD	D	Neither	A	SA
Less Than One Year	0	1	2	20	28
1 - 2 Years	6	4	6	70	139
More Than Two Years	4	0	10	43	124

* Only military, Part 61, and Part 141 are listed. Multiple training selections and "Other" were outliers that were not reported.

** Combinations of other EFB Types that are not listed were not reported due to them being outliers in the data.

EFB vs. Paper

Pilot respondents were questioned on their preference of EFB, paper, or a combination of both while performing their duties in the flight deck. Total respondents equaled 470 (N = 470). Figure 15 details the responses, and Table 25 shows the responses by demographic category.

Figure 15

Preference of EFB, Paper or Combination

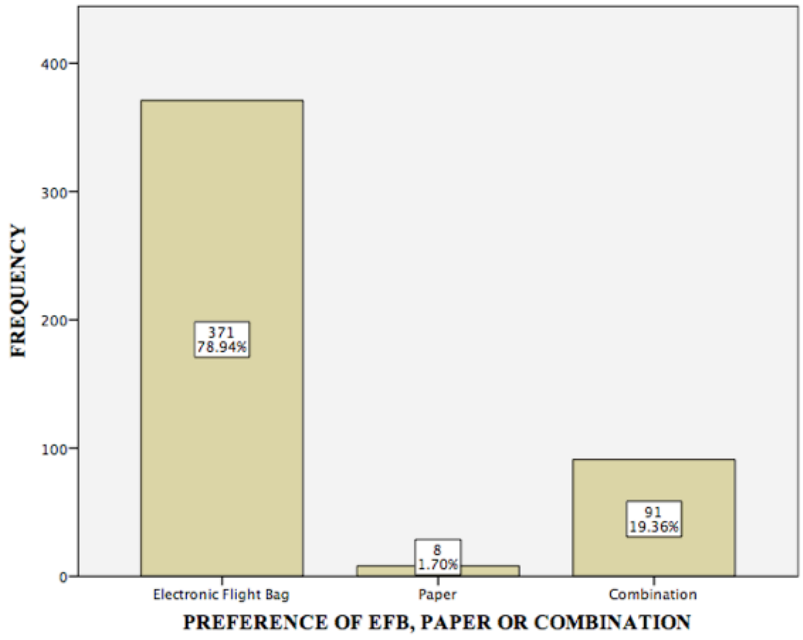


Table 25

EFB vs. Paper Preference by Demographic Category

If you had your choice in the flight deck, would you prefer to use an Electronic Flight Bag, paper or a combination of the two?

Primary Flight Instruction*	EFB	Paper	Combo
Military	141	3	29
Part 61	61	2	18
Part 141	123	2	32
Rank	EFB	Paper	Combo
Captain	156	2	45
First Officer	215	6	46
Flight Time	EFB	Paper	Combo
1,000 to 5,000 hours	37	0	4
5,001 to 10,000 hours	126	2	27
10,001 to 15,000 hours	122	4	32
15,001 to 20,000 hours	48	0	13
More than 20,000 hours	17	2	6
Age	EFB	Paper	Combo
20-29	12	0	3
30-39	64	2	14
40-49	125	2	33
50-59	138	3	32
60-64	32	1	9
Corrective Lenses	EFB	Paper	Combo
Yes	210	6	60
No	161	2	31
Education	EFB	Paper	Combo
High School	7	0	5
Associate's Degree (2 year)	18	1	4
Bachelor's Degree (4 year)	252	6	62
Post-Bachelor's Degree	92	1	20

Table 25. EFB vs. Paper Preference by Demographic Category (continued)

EFB Type**	EFB	Paper	Combo
iPad	229	5	56
Surface	22	1	10
APLC	2	0	1
OPC	1	0	0
iPad and APLC	17	0	4
iPad and OPC	69	2	13

Prior iPad or Surface Experience	EFB	Paper	Combo
Yes	246	5	52
No	109	3	35

EFB Length of Use	EFB	Paper	Combo
Less Than One Year	36	1	14
1 - 2 Years	176	7	42
More Than Two Years	148	0	33

*Only military, Part 61, and Part 141 are listed. Multiple training selections and "Other" were outliers that were not reported.
** Combinations of other EFB Types that are not listed were not reported due to them being outliers in the data.

Pilots that indicated a combination of both were further asked to detail their response. Of the 91 pilots that answered a combination of EFB and paper, 71 provided a detailed response (N = 71). The themes that emerged from the pilot responses preferring paper over the EFB included: paper as a backup, checklists, company manuals, ease of use for paper, enroute charts, and speed considerations. Some pilots indicated that their respective airlines have removed paper sources of charts and company manuals, and they would like to have the EFB as a tool; however, they would like to have paper backups in the flight deck in case of EFB failure.

Other pilots indicated a preference for checklists and emergency procedures, such as the Quick Reference Handbook (QRH), being in paper format. One pilot responded

that, “Checklists are more usable in paper format.” Another pilot stated that, “Emergency procedures should remain paper. Something to grab quickly and work your problem. Everything else can be electronic.”

Other pilots prefer the EFB for charts; however, want company manuals to be in paper format. One pilot reinforced this by stating, “EFB for charts and performance. Paper manuals and airplane manuals to read and solve problems.” Other pilots preferred company manuals in paper due to highlighting and note taking. One pilots notes, “I prefer paper for company manuals. It is easier (for me) to quickly find information, and I miss highlighting and being able to write pertinent notes in the margins.” Another pilot would also light the permanence of highlighting company manuals by responding, “I like paper for things like FOM. Can permanently high light them.”

Paper charts were a preference for their ease of use with some pilots indicating that, “There is only one interface with the efb. Not easy at times to navigate. The need to access more than one doc at a time. My company is cheap.” Another respondent indicated that, “With Paper I can have multiple charts available....taxi + SID + Engine out all at once.”

Almost half of the respondents indicated that they prefer to have Enroute Charts available in paper format for their ease of finding pertinent information. It was also indicated that the EFB software for enroute charts is very slow and crashes frequently. Responses included, “Enroute charts are still easier to read and contain more information than its electronic equivalent”, “I like using paper copies of Enroute charts. The EFB is too slow and crashes too much to use them due to their large size,” and another pilot

agreeing by stating, “It is helpful for international flights to have paper hi/low charts. Easier to find ball notes, etc...”

Paper preference was noted as much faster than the EFB for certain flight tasks. One response said that it is, “currently quicker to find certain things with paper,” and another response echoed that by stating, “sometimes it’s faster to find the information needed with a paper product.” Another pilot detailed further, “unable to keep notes or quick reference items with an EFB so looking up info that would be the flip of a page or two becomes a major slow down in accomplishing tasks,” and another stating, “when there are numerous details to reference during a short period of time, the EFB isn't always the best at allowing you to select exactly what you want to see and in what order to present it. For example, displaying the DP on the EFB during the takeoff roll might be considered SOP by some operators. But what about the after takeoff engine out procedure at a terrain critical airport? The EFB can't display both at the same time. But with the paper combination, I can clip the engine out chart to the yoke, the side window, or lay it on the shelf outboard of my seat. When the engine quits, I don't even have to touch the EFB, I can keep my hands on the thrust levers and the flight controls, and simply adjust my focus to the paper chart to establish the necessary flight path.”

Relationships Between Demographics and Perception

To analyze the relationship between demographics and pilot perception of the EFB, a Pearson’s *r* was used. Some of the data was collected using a Likert scale as was previously noted and also noted in the Notes section of each table; therefore, a positive *r* value indicates a decrease in frequency, and a negative *r* value indicates an increase in frequency.

Table 26

Relationship Between Demographics and Workload Perception

Do you believe that the use of an EFB on the flight deck adds to your workload?	
Airline Rank	.070
Initial Training Type	-.065
Flight Time	-.025
Age	-.061
Corrective Lenses	.063
Education	.007
EFB Usage Time	-.014
Note: n varies with each demographic question with a range from 440 to 470. *p < .05, **p < .01	

Table 27

Relationship Between Demographics and EFB Distraction

Do you believe that the EFB is a distraction to your normal flight deck duties?	
Airline Rank	.043
Initial Training Type	.009
Flight Time	-.099*
Age	-.072
Corrective Lenses	.021
Education	.072
EFB Usage Time	-.019
Note: n varies with each demographic question with a range from 440 to 470. *P < .05, **p < .01	

Table 28

Relationship Between Demographics and Information Overload

Do you feel that the EFB give you a sense of information overload?	
Airline Rank	.048
Initial Training Type	.017
Flight Time	-.117*
Age	-.068
Corrective Lenses	.073
Education	.025
EFB Usage Time	.063
Note: n varies with each demographic question with a range from 439 to 469. *P < .05, **p < .01	

Table 29

Relationship Between Demographics and Navigation Difficulty

Do you have difficulty navigating the EFB, for example, switching between applications or finding information that you need?	
Airline Rank	.128**
Initial Training Type	.002
Flight Time	-.231**
Age	-.173**
Corrective Lenses	.099*
Education	.108*
EFB Usage Time	.083
Note: n varies with each demographic question with a range from 440 to 470. *P < .05, **p < .01	

Table 30

Relationship Between Demographics and Initial Training - Normal Ops

Do you feel that your initial EFB training was adequate to be proficient in normal operations?	
Airline Rank	.101*
Initial Training Type	.027
Flight Time	-.083
Age	-.184**
Corrective Lenses	.100*
Education	.110*
EFB Usage Time	-.018
Note: n varies with each demographic question with a range from 439 to 469. *p < .05, **p < .01; Likert scale	

Table 31

Relationship Between Demographics and Initial Training - Abnormal Ops

Do you feel that your initial EFB training was adequate to prepare you for malfunctions or failures?	
Airline Rank	.133**
Initial Training Type	-.003
Flight Time	-.069
Age	-.149**
Corrective Lenses	.027
Education	.030
EFB Usage Time	.058
Note: n varies with each demographic question with a range from 438 to 468. *p < .05, **p < .01; Likert scale	

Table 32

Relationship Between Demographics and EFB Failure/Malfunction

In your experience, at what frequency has the EFB failed or malfunctioned?	
Airline Rank	.052
Initial Training Type	.045
Flight Time	-.009
Age	-.001
Corrective Lenses	.015
Education	.007
EFB Usage Time	-.163**
Note: n varies with each demographic question with a range from 439 to 469. *p < .05, **p < .01	

Table 33

Relationship Between Demographics and EFB Not Operating As Expected

What percentage of the time has the EFB operated in a manner you were not expecting?	
Airline Rank	-.041
Initial Training Type	.055
Flight Time	.029
Age	.098*
Corrective Lenses	.009
Education	.068
EFB Usage Time	.090
Note: n varies with each demographic question with a range from 439 to 469. *p < .05, **p < .01	

Table 34

Relationship Between Demographics and Loss of Situational Awareness

What percentage of the time have you lost situational awareness in the flight deck due to the EFB?	
Airline Rank	.003
Initial Training Type	-.003
Flight Time	.077
Age	.047
Corrective Lenses	-.066
Education	-.020
EFB Usage Time	.033
Note: n varies with each demographic question with a range from 440 to 470. *p < .05, **p < .01	

Table 35

Relationship Between Demographics and EFB Safety Perception

Do you feel that utilization of the EFB on the flight deck is safe?	
Airline Rank	.099*
Initial Training Type	-.024
Flight Time	-.089
Age	-.077
Corrective Lenses	.080
Education	.088
EFB Usage Time	.048
Note: n varies with each demographic question with a range from 440 to 470. *p < .05, **p < .01; Likert scale	

Table 36

Relationship Between Demographics and Paper Choice

If you had your choice in the flight deck, would you prefer an EFB or paper?	
Airline Rank	-.054
Initial Training Type	-.033
Flight Time	.090
Age	.010
Corrective Lenses	-.079
Education	-.065
EFB Usage Time	-.067

Note: n varies with each demographic question with a range from 440 to 470. *p < .05, **p < .01

Pilot Likes of the EFB

When asked about what was liked about the EFB, 318 provided detailed information (N = 318). Some pilots listed only one aspect that they liked while others detailed multiple. The common themes that emerged from the responses indicated the following likes: functionality aspects (highlighting, zooming, note taking), consolidation of resources, revision updating, convenience, efficiency, and lightweight.

In regards to the functionality aspect, one pilot notes that, "Can zoom in and highlight. Can change pages quickly. I also really like not having to turn on a map light to read the plates at night." Another pilots agree that, “I like the ease of navigating my charts quickly, along with being able to make notes on the page easily, with only my finger. Also, not being forced to carry a heavy, separate bag from my Jepps and

company publications is fantastic." Numerous pilots like the, "ability to zoom" and the "ability to enlarge charts."

Another pilot summed up most of the prevalent themes about the EFB by stating, "All information needed for a flight is available in one location. The EFB permits me to set up the flight in stages and create personalized pages with highlighting and notes where needed. Extracting information for unplanned flight events (diversions, re-routes, etc.) is very easy and makes the transition smooth. It permits me to focus more on piloting or monitoring without worrying about paper charts. An added benefit is the elimination of carrying an additional (and heavy) chart case and the requirement to update chart sets." Numerous other pilots indicated that, "all information is in one place", "all information is at my fingertips", and "all information is readily accessible." One pilot responded, "all information up to speed (revision), quick easy access. Functions I would not have on paper (e.g. Search of fixes, airports, frequencies, fir boundary notes searchable, all company pubs searchable and on and on and on.....)"

Pilots also indicated that they like the ease of updating, or in some cases auto-updating, or revisions. One pilot notes that, "Always having the most current revisions automatically downloaded." Numerous pilots responded that the EFB is, "much easier to keep up to date."

Respondents also like the convenience aspect of the EFB since most of them will be carrying a PED with them at work anyway. One pilot notes, "Convenience of everything I need at my fingertips in a small, light-weight package (that I'm going to carry anyway)." This convenience also allows pilots to carry multiple publications by noting, "Convenience. Ease of packing for trip and not having to lug around paper

books." One respondent believes that this convenience aspect is much safer by stating, "all manuals and charts in one handy location that I never have to go heads down in critical situations."

Efficiency of the EFB was also a recurring theme of characteristics that pilots like about the EFB. Various responses indicate, "ease, quick efficient availability of pubs and charts", "much easier and less time consuming than paper charts. You can switch between the charts u [sic] need very quickly and efficiently", "quick access to charts, not having to replace used charts" , "efficient in terms of cockpit time management", and "the efficiency of accessing information is better than I ever imagined. It is a completely new paradigm in accessing information."

Respondents also indicated that they like the weight reduction from carrying manuals to a lightweight Electronic Flight Bag. Various pilots noted that the EFB is, "very light to carry." One pilot indicated, "it does not take up as much room and much lighter" with other pilots agreeing by stating, "weight and space saving."

Pilot Dislikes of the EFB

Pilots were asked what they disliked about using the EFB on the flight deck. There were 408 respondents that provided feedback (N = 408). Common themes that emerged concerning dislikes include: FAA restrictions on usage, battery life, manual highlights and bookmarks are lost with revision updates, slow processing speed, limited search capabilities, mounting location, difficulty locating items, poor training, glare, freezing, and the ability to only view one page at a time.

Some pilots view the Federal Aviation Administration for holding back progress of the EFB with one pilot stating, "how the potential of the EFB is currently being limited

by the FAA. Part 121 operations in general are being held back due to the lack of vision and ability for the FAA to adapt to the modern age." Another pilots states that the "problem is the FAA is slow in adopting the new platform."

The lack of battery life for the EFB was another complaint from many pilots. "iPad battery could last longer", "must have power source installed to maintain adequate battery life", and "The battery life is lacking. You cannot spend a lot of time enroute reviewing manuals, and have enough battery life for the entire day" were some of the sentiments echoed from some pilots.

Pilots report that as updates occur on the EFB, the highlights and bookmarks are frequently lost. Pilot responses to this dislike include, "losing bookmarks and highlighting in the manuals portion. FOM, AOM, etc.", "having to re-bookmark a publication after it is updated", and "bookmarks and hi-lites [sic] tend to get lost or disappear."

Pilots also note slow processing speed of the EFB. Pilots commented, "slow operating system, our carrier purchased the cheapest", "sometimes gets slow, maybe a little overwhelmed because I demand things faster than it can process them. This is a software/hardware issue, not a philosophical issue", "sometimes runs a bit slow sometimes slow to switch modes or between charts", and "having to use it to look up information in company pubs! Takes too long."

Search capabilities on the EFB are another dislike that emerged as a theme from pilot responses. "Interface to navigate sources of directive information (FOM, AOM, etc.) is poor. It is hard to search for information." Another pilot notes that, "manual are

surprisingly difficult to search through, I prefer the electronic approach charts. However I strongly prefer printed AOM FOM etc." One pilots states that, "you must use exact verbiage to find stuff. Search function is useless." While searching for information can be challenging, other pilots commented that it can be difficult navigating the EFB for information. "Sometimes difficult to locate a particular manual or document", "trying to find company reference material can be problematic based on how the company structures the file system and how often they change locations of a document within the file system", and "you must study ahead of time to know what location your info you are seeking is in what area on the iPad."

A source of distraction to pilots is the mounting feature of the Electronic Flight Bag. "Mounting location on the side cockpit window. Out of my normal scan and too close to my face." One other response indicated that, "mounting solution on window can fail", and another indicated, "Mounting. Aircraft manufacturers should integrate them into flight deck design, ie. build a charging mount on the side window."

Sunlight reflection, or glare, on the EFB was another common theme that pilots reported as a dislike. "During day flights the screen can be hard to see due to glare" and "glare from the white shirt in some bright conditions and trying to use enroute charts." Glare can also cause other problems with the EFB as one pilot commented, "glare on the screen and auto shutdown when it overheats."

Pilots also reported that they did not like the EFB freezing during operations. Three pilots noted, "IPad sometimes freezes during critical phases of flight", "JEPPESEN FD Pro app has become a little slower with a few bugs causing it to freeze up during a full city pair route change", and "occasionally freezes or locks up." In addition to

locking up, other pilots note that applications sometimes crash. "Sometimes the apps will crash, but they always come right back up. So no real consequence except annoyance", and another pilot states, "system crashes happen at the worst time. Login is laborious and required too often."

Another complaint from respondents is the ability to only view one page at a time. This was echoed from numerous pilots with some responses indicating, "only 1 page at a time can be viewed", "only one page available at a time", and "can't cross reference more than one page at a time."

One of the biggest complaints from pilots was the training that was received for operation of the Electronic Flight Bag. One pilot bluntly stated, "Difficult to find information. Poor training." Another response indicated that, "I wish I had more training how to search out info from company manuels [sic]." Pilots also note that much of their software training is "trial and error" where one pilot stated, "every couple of months new software version come out, with no training or instruction on the changes, making it hard to become high proficient on the device. Most training on new software versions is the trial and error method." Yet another pilot commented that, "All the updates that are not user friendly, inability to get the big picture using international maps, the company updates which delete all saved notes and highlights, the complete lack of any type of training other than here it is and all the info is on the ipad to the point that you almost need 2 iPads, one to read through its operation and one to do it on while reading."

Pilot Comments Concerning EFBs

As the final question of the survey, pilots were asked for additional comments concerning the EFB. There were 179 responses (N = 179). Various themes in this

question also applied to the likes and dislikes of the EFB, so those answers were not considered applicable to this question. Upon analysis of the valid responses, prevalent themes that emerged include: distraction, the Federal Aviation Administration, the EFB as an improvement over previous applications, inefficiency, nuisances, safety, training, updates, and Wi-Fi.

Pilots indicated that the EFB is a distraction for various reasons. One pilots notes that, "Cockpit placement is an issue. Company wants it midway back on the window. This causes a large amount of head movement to acquire and see the iPad. Moving it forward causes interference with outside references. All places bring it SIGNIFICANTLY closer to my eyes, creating a 4th visual range to acquire. (iPad, yoke, instruments, outside) My aircraft was not designed to integrate it's use (MD-11) Newer aircraft may do a better job at this." Another response also concerned the positioning of the EFB by stating, "Having it off to the side is turning you away from looking ahead where your going on an approach or departure. If it's a complicated single engine take off too, it's not good to be looking away." One response stated that, "a good EFB is only as good as its mount." Another pilot attributes unfamiliarity with the EFB as a distraction by responding, "there are certain times in high work load environment where I can see or have seen unfamiliarity with device or software that can hamper and distract if you are not fully comfortable or proficient in navigating the device." One respondent agrees that the EFB can be a distraction but also adds, "EFBs aren't unsafe or a distraction unless the pilot mismanages it." Another respondent indicates that the EFB can be a distraction to "unprofessional crews" by stating, "If texting and driving is bad, EFBs on flight decks are equally susceptible to be a distraction to unprofessional crews." These distractions can

pose safety threats as one pilot notes, "People will tend to utilize off and online apps and materials on the EFB during flight as electronic gadgets are part of everyday life now. That might help with boredom, but for many, it is a distraction with potential safety issues."

Another theme that emerged from respondent comments was the issue of the Federal Aviation Administration regulations concerning the EFB. One pilot notes that the functionality of the EFB is severely restricted by the FAA by saying, "Prohibition against using personal electronic devices on the flight deck is poorly thought out, counter-productive to flight management and can actually decrease safety. There are a number of flight related applications that are available, updated and introduced that vastly improve the pilots ability to do his/her job on the flight deck. By not allowing PED use on the flight deck the FAA is restricting pilots to an unnecessarily small 'toolkit' in the performance of their duties." Other pilots agreed: "FAA needs to allow aircraft position displayed on charts -- arrival and departure, approaches and airfield diagrams. I use it in my GA plane and it increases SA. FAA needs to allow Internet access for real time weather, NOTAMS, ...", Not being able to utilize all functionality of programs. Thank you FAA", and "once 'own ship' function of use is authorized it will enhance the ability and function of the EFB / (my personal aircraft has a Garmin 500 panel and 430W GPS that has safe taxi and moving map that I use)." Still more pilots want more EFB functionality but are restricted by the FAA citing, "The FAA needs to approve inflight use of Wi-Fi for up-to-date weather information while enroute. I also wish that we could go completely paperless and have dispatch releases pushed to the EFB." This theme was also echoed by another response, "The FAA needs to face the fact that the EFB is the way

of the future and be less resistant to modernizing it. For instance, the use of the Internet on the flight deck to monitor rapidly changing weather conditions is an obvious improvement to safety but prohibited. " The FAA is also unstandardized, according to another pilot, by stating, "FAA adoption is slow. Each FSDO has their own idea. If you have a FSDO without forward thinkers you are out of luck. We need national regulation a new FAA chapter to govern the EFB.. right now it is a bunch of papers and FAA guidance but no unified set of regulations. Open to too many opinions."

While safety issues have been cited by some pilots, other view the EFB as a vast improvement from the previous methods that the EFB replaced. "All in all the EFB is a great tool and makes managing the flight deck easier. Like all technology there're times when it doesn't always work as advertised, but paper documents were cumbersome, time consuming to maintain, and the weight caused a lot of physics injuries." One response stated, "...there is no going back to paper. The efficiency and accuracy of access to information is light years beyond what we used to have. It is a tremendous increase in safety, I believe." One pilot stated that, "Any airline that doesn't do this [the EFB] is foolish." There were other similar responses echoing the same response: "EFBs are great, but I think they have a long way to go. They'll just get better with time", "I am getting used to it now and overall a very positive experience", "I think in time improvements will be made. It's an evolving technology", "I think it is a good product and will continue to improve and be a benefit to pilot situational awareness", "I think it is a great addition to the cockpit. Obviously there will be growing pains especially with the older pilots but anyone remotely familiar with an IPAD or windows based tablet will fine an EFB seamless and far more useful", "I think safety is improved because it is much

easier to determine the valid dates of the charts, especially charts with future effective dates", and "I think the EFB is a win. Much of it's success or failure can be tied to organizational implementation, as I've keyed in on. I believe that much more information- helpful information- is possible with the EFB. Information not currently taken advantage of at my company. This would include real-time weather display, moving- map location information, performance data calculations, and interactive aircraft systems diagrams and information. Essentially anything that would promote problem-solving and information for safer decisions." One respondent was initially skeptical of the EFB but relented by saying, "I was not initially a big fan of the idea. I was wrong. EFB is a vast improvement over paper charts." A veteran pilot notes, "It's so easy to use and so natural, I can barely remember using paper charts even though I did so for 25+ years. Amazing." Various pilots had the same response that "the positives outweigh the negatives", "Love it!", and "very pleased with the technology." Other safety aspect included glare and overheating of the EFB. " One response offered a solution to glare and overheating of the EFB stating, "include in the EFB program equipment a glare and heat relief sun shade system to reduce chances of iPad overheating and auto shutdown during a critical phase of operation. There is a product available right now on the market which provides this protection to the sensitive electronic equipment, and UV plus Thermal protection for the crew members."

Various reports of EFB inefficiency were cited. One pilots notes, "With two I-Pads on the flight deck you cannot send or exchange information between the two units. With our hard wired EFB's a sharp F/O will send me the taxi chart on roll out or send me

the SID as I take the runway if it's my leg. I like that." This is a limitation of the iPad EFB that some pilots view as inefficient in their operations.

Safety issues, both positive and negative, were listed from pilots. For the positive, some pilots believe that the EFB reinforces safety in their airline operations while others view the EFB as a detriment to safety. Without much elaboration on the positive, many pilots indicated, "adds to cockpit safety", "Enhances safety and situational awareness in task loaded instances like runway change, arrival change, etc.
", and "makes flying much more safe." As a negative for safety, one pilots notes, "Applications closing and restarting on their own during approaches or critical phases of flight is dangerous. Very little training on how to solve iPad problems. Company provided help line phone number useless in a plane. Rely on individual knowledge of how to use iPads only works if you have had one before." Many pilots reported applications closing and restarting and believed that this could have a negative safety impact on the flight.

Pilots cite training on the EFB, or lack thereof, as a problem. One pilots notes, "totally unprepared to use the EFB when it was sprung on us. It took me to COS enroute to Honolulu to get the route loaded." Another response indicated, "it is more convenient in some ways and less in others. I think that individual companies have better or worse implementation and update procedures. My company is terrible." Lack of training was also cited, "our company went through two iterations of EFB. The first was based on the Lufthansa LIDO system. The training provided was lacking from the start. Only through experience did a pilot really become comfortable with using the EFB. This caused a significant amount of resistance from the pilot force. Once the crew force became

comfortable and proficient with the LIDO system the company switched to Jeppesen and the process started over again. This has led to wide variations in pilot proficiency and comfort with the current system. Additionally, over a year ago the company introduced FAA authorized iPads containing the Jeppesen product. Now it is not uncommon for one pilot to use the iPad version and the other to use the installed EFB. This can lead to confusion and prevents the pilots from syncing or sharing data between terminals." One respondent compares EFB training to aircraft training, "Training, training, training is everything. After all, they don't thrown me on a self study and then have me fly an airplane, there is more to it than that." One surveyor agreed that the initial training was deficient but then stated, "Once I master how to find what information I need, this EFB will be excellent for me."

The issue of updating the EFB was a recurring theme in the responses. Some airlines are updating frequently which has an overwhelming effect on many of the pilots. One participant noted, "Some items of importance can be overlooked, especially when flying to new destinations. When receiving important bulletins, we are asked to authenticate several times instead of once which makes me feel like a child. Information overload because some writers of manuals and books are not telling us what is the objective or point of their message." This information overload was also conveyed by noting that, "company manuals and bulletins have flowed into the EFB like Niagara Falls- too easy for the company to pump out information in haste. Difficult to find information with multiple manuals. I actually found it easier to reference a book in the past." Along the same sentiments, another response read, " Bottom line is way to much information (not really an iPad issue, more of a company issue)." Airlines are blamed for

this overwhelming amount of information updated on the EFB in the responses, "The easier it is for tech writers to write the more likely they will make changes to the materials and the result of increased changes will mostly likely go unnoticed," and "while the revision time is now approaching zero the amount of information / revisions has soared to the point of being unable to keep up . Company uses it to distribute propaganda that is useless in flight operations. I don't want the chief pilots hotline." Updates also proved to create confusion among some pilots. "Updating of my365 is confusing at times. Changes to procedures just update and you have a much harder time to identify and compare new with old. I think all procedural changes should be highlighted through paper backup and paper comparisons. It's way too easy to just update a computer and not see what changed."

Some pilots would like to see more functionality of the EFB for safety, namely allowing Wi-Fi access for real-time weather updates in-flight. Notes one pilot, "using the Wi-Fi, which is currently prohibited in the flight deck would add so much more situational awareness relating to weather along route." Another pilot echoed the same with, "in-flight data access (weather, etc.) would complete the promise of the device." One pilot believed that the Wi-Fi access would be beneficial in remote areas noting, "the company I work for doesn't utilize all aspects of the EFK. Wireless access in the cockpit (on the ground) would increase weather/NOTAM situational awareness and allow a better route study just prior to departure, as we travel internationally and have very poor information at some remote locations."

Some responses stated merely that, "it sucks" but did not provide any elaboration on this sentiment.

Responses to Research Questions

1. What is pilot perception regarding the safety impact of EFBs in the flight deck?

   Of 470 valid responses, 92.77% either agreed or strongly agreed that they believe that EFB usage on the flight deck is safe. Pilot responses to EFB safety on the flight deck indicated that there was a significant statistical positive correlation between airline rank and safety perception (r=.099 , p=.05).

2. Is the Electronic Flight Bag a distraction to pilots at Part 121 air carriers?

   94.26% of 470 valid pilot responses indicate that they do not believe that the EFB is a distraction to normal flight deck duties. Responses to the survey revealed that distraction perception has a significant statistical positive correlation with the amount of total flight time (r=.099, p=.05).

3. Does the EFB increase perceived workload as opposed to traditional paper?

   88.3% of 470 valid pilot respondents perceive that their workload does not increase while using the EFB. There were not significant statistical correlations between demographics and perceived workload.

4. Are there significant, demographic variations among pilot respondents?

   Pilot responses indicated various significant statistical correlations between demographics and pilot perception indicated in Table 26.

Table 37

Significant Statistical Correlations

Experience	Demographic	Pearson's r	p
Initial Training (Malfunction/Failures)	Age	-.149	.01
Initial Training (Normal)	Age	-.184	.01
Navigation Difficulty	Age	-.173	.01
EFB Not Operating As Expected	Age	.098	.05
Initial Training (Malfunction/Failures)	Airline Rank	.133	.01
Navigation Difficulty	Airline Rank	.128	.01
Initial Training (Normal)	Airline Rank	.101	.05
Safety	Airline Rank	.099	.05
Initial Training (Normal)	Corrective Lenses	.100	.05
Navigation Difficulty	Corrective Lenses	.099	.05
Initial Training (Normal)	Education	.110	.05
Navigation Difficulty	Education	.108	.05
Failure/Malfunction	EFB Usage	-.163	.01
Navigation Difficulty	Flight Time	-.231	.01
Distraction	Flight Time	.099	.05
Information Overload	Flight Time	-.117	.05

5. What are pilot reported pros and cons of using an EFB?

The common themes that emerged from the data indicated that pilots like the functionality aspects of the EFB, consolidation of resources, revision updating, convenience, efficiency, and the reduction in weight of the device. Aspects that pilots do not like concerning the EFB are FAA restrictions on usage, battery life, manual highlights and bookmarks being lost with updating, slow processing speed, limited search capabilities, mounting location, difficulty locating items, poor training, glare, freezing, and the limited viewing capabilities.

CHAPTER IV

DISCUSSION

Issues that arise with pilots interfacing with an EFB in the flight deck need to be viewed from the human factor aspects in addition to the automation and how the two work in unison. With several years of utilization available, pilots are now able to detail their experiences with EFB interaction. Significant statistical correlations and pilot comments in the study allow researchers, manufactures, airlines and regulators a focal point to address these issues and evolve the EFB and pilots into more harmonious operations.

Statistical Correlations

Age

When the demographic of age is considered, as pilot age increases, there is a negative correlation between initial training, both for normal and malfunction/failure, and navigation difficulty. This would conclude that as pilot age increases the perception of training and navigation difficulty are less favorable. In addition, as pilot age increases, there is a positive correlation with the EFB not operating as expected. This indicates that as pilot age increases, there is an increase in the pilot experience of the EFB not operating as is to be expected.

Airline Rank

The demographic of airline rank, Captain and First Officer, there is a positive correlation between initial training (both normal and malfunction/failures), navigation difficulty, and safety perception. This indicates that Captains have a less favorable perception of the EFB in these areas.

Corrective Lenses

Pilots that wear corrective lenses have a significant positive correlation with initial training (normal operations) and navigation difficulty indicating that pilots that wear corrective lenses have a less favorable perception of initial training (normal operations) and increased navigation difficulty.

Education

Interpretation of the data indicates that as education level increases, pilots have a positive correlation with initial training (normal operations) and navigation difficulty. Based upon the answer selections, pilots that have higher level of education have better perception of initial training (normal operations) and less issues with navigation difficulty.

EFB Usage

A negative correlation exists between prior iPad or Surface usage and the failure or malfunction experience. Pilots that have used an iPad or Surface prior to using one as an EFB have less perception of failures and malfunctions than pilots that have not.

Flight Time

When pilot flight time is considered, there is a significant positive correlation between flight time and distraction and a significant negative correlation between flight time and navigation difficulty and information overload. Interpretation would indicate that as flight time increases, pilots believe that the EFB provides a sense of information overload and pilots have more difficulty navigating the EFB. However, as flight time increases, pilots do not believe that the EFB is a distraction.

Human Factors and the EFB

Perceived Workload

Referencing Cahill (2006), "Electronic flight bag usability is critical to flight safety. Poor usability (inefficient task workflows and/or confusing information displays) can be costly in terms of pilot time/attention and overall workload. Pilots are continuously prioritizing and sequencing flight tasks, at different points in flight… Evidently, problems in accessing/making landing calculations will distract pilots from the primary task of flying the aircraft safely, and could result in a loss of situation awareness at a critical point in flight." Based upon the research data, 88.30% of pilots do not perceive an increase in workload. Perceived workload would also include the pilot's difficulty in navigating the EFB, and 77.32% of respondents indicated that there is no perception of navigation difficulty. As workload increases, pilots focusing attention to the EFB could lose situational awareness. Data indicates that pilots experience of losing situational awareness related to the EFB are low with 79.79% having never experienced and another 18.7% losing situational awareness 1 percent – 9 percent of the time.

Distraction

Various reports and research previously mentioned detail the EFB as a distraction to pilots. This can be detrimental to pilots during periods of high workload, thereby, threatening safety. Since pilots have been using EFBs for up to five years on the flight deck and in many cases have become accustomed to their use, the data indicates that pilots do not perceive the EFB as a distraction with 94.26% pilots responding in the negative.

While a majority of pilots do not believe that the EFB is a distraction, details were presented in the comments that highlight potential issues. The EFB, "provides distractions in cockpit when not used as flight equipment," and "distracting at critical moments on ground and in air switching between screens." Other pilots note that, " the position on the side window sometimes is distracting", "distracting to have to swipe (sometimes through multiple pages) to get to diagram", "EFBs aren't unsafe or a distraction unless the pilot mismanages it", " if texting and driving is bad, EFBs on flight decks are equally susceptible to be a distraction to unprofessional crews", "EFBs…might help with boredom, but for many, it is a distraction with potential safety issues", and "there are certain times in high work load environment where I can see or have seen unfamiliarity with device or software that can hamper and distract if you are not fully comfortable or proficient in navigating the device."

Training

Training for EFB usage on the flight deck was gauged from pilots on two fronts: normal operations and malfunction / failure. Generally, pilots indicated that initial training on both fronts for EFB operations was lacking. Concerning normal operations,

barely more than half of respondents indicated that initial training for normal operations was adequate at 50.11%. When analyzing data for failures or malfunctions, 26.93% of pilots felt that their training was adequate.

Future Studies

This study focused on a general overview of Electronic Flight Bag utilization since its widespread inception at Part 121 air carriers. There was no limitation on the type of EFB, the software utilized, the particular airline, the type of aircraft flown, or the crew compliment. These are areas that could be the focus of future studies to determine if there are significant differences between the various groups. This would narrow the results for modifications to hardware or software changes, in addition to, training at the particular airline.

Other studies could include pilot observations in simulated conditions and measure their responses to workload, distraction, and efficiency with the EFB.

Conclusions

While Electronic Flight Bags have been in use at airlines since 2010, the hardware and software aspects of them are very dynamic and require continuous training and adaption with the interface as they change. Results from the survey indicate that pilot perception of the EFB generally is positive. Pilots indicate there are areas of EFBs that need to be addressed with regulatory, airline, and manufacturer entities. As EFBs continue to evolve, pilot input and perception can assist in shaping them to be user friendly and mitigate the human factors that are associated with them.

APPENDICES

APPENDIX A

Email Sent From a Professional Pilot Organization to its Members or Posted on Social Media Site

Fellow pilots,

My name is Donley Lytle, and I am completing my master's degree in aviation at the University of North Dakota. As a research study topic, I am conducting a survey of airline pilots at Part 121 airlines concerning their perception of Electronic Flight Bag safety in the flight deck. I would like to ask for your help and let me know how you feel about using an EFB in your daily operations at work on the flight deck.

The survey is completely anonymous and voluntary. No data will be collected about you that could identify you, so your open and honest answers are appreciated.

If you decide to do so, the survey will take about 10 minutes to complete.

Please go to the following website to complete the survey: http://und.qualtrics.com

Thank you for your participation,

Donley Lytle

APPENDIX B

Email Sent From Labor Organizations to its Pilots

Fellow pilots,

My name is Donley Lytle, and I am completing my master's degree in aviation at the University of North Dakota. As a research study topic, I am conducting a survey of airline pilots at Part 121 airlines concerning their perception of Electronic Flight Bag safety in the flight deck. I would like to ask for your help and let me know how you feel about using an EFB in your daily operations at work on the flight deck.

The survey is completely anonymous and voluntary. No data will be collected about you that could identify you, so your open and honest answers are appreciated.

If you decide to do so, the survey will take about 10 minutes to complete.

Please go to the following website to complete the survey: http://und.qualtrics.com.

Thank you for your participation,

Donley Lytle

APPENDIX C

Survey Introduction

Thank you for you participation in the survey.

I am completing my master's degree in aviation from the University of North Dakota and am researching pilot perception towards Electronic Flight Bags (EFB) safety in the flight decks at Part 121 airlines. The research is designed to focus on human factor issues that you face while interfacing with the EFB at work. The results of the research will help to better understand pilot interaction with EFBs in a highly automated, attention-demanding environment.

This survey is completely anonymous, and no data will be gathered from you that could identify you. No identifying Internet information will be gathered, either, such as an IP address. Your open and honest responses would be greatly appreciated. At any point during the survey you may discontinue. Completion or non-completion will not jeopardize you, your airline, or organization.

If you have any questions or concerns regarding the survey, please contact Donley Lytle at efbstudy@gmail.com or the University of North Dakota Institutional Review Board at 701-777-4279.

Thank you!

APPENDIX D

Survey Questions

1. Are you presently employed as a pilot for a Part 121 air carrier in the United States?
   - Yes
   - No

2. Do you use an Electronic Flight Bag as a pilot in the flight deck?
   - Yes
   - No

3. In what capacity do you utilize your Electronic Flight Bag on the flight deck? (Check all that apply)
   - Charts (SID, STAR, Approach, Enroute, etc.)
   - Company Related Manuals (FOM, AOM, Training, etc.)
   - Performance
   - Weight and Balance

4. Where did you receive your primary flight instruction?
   - Military
   - Part 61 Flight School
   - Part 141 Flight School
   - Other

5. What is your current rank with your airline?
   - Captain
   - First Officer
   - Flight Engineer

6. What is your approximate total flight time?

7. What is your age?
   - younger that 20
   - 20-29
   - 30-39
   - 40-49
   - 50-59
   - 60-64

8. Do you wear corrective lenses while working on the flight deck?
   - Yes
   - No

9. What is your highest level of education completed?
   - High School
   - Associate's Degree (2 year)
   - Bachelor's Degree (4 year)
   - Post-Bachelor's Degree (Master's, Ph.D., JD, etc.)

10. Which version of Electronic Flight Bag do you use? (Check all that apply)
   - Apple iPad
   - Microsoft Surface Tablet
   - Airport Performance Laptop Computer (APLC)
   - Onboard Performance Computer (OPC)
   - Other

11. Did you have prior experience with an iPad or Surface tablet prior to using it in your current position as a pilot?
   - Yes
   - No

12. How long have you used an Electronic Flight Bag in the flight deck? (in years)

13. Do you believe that the use of an EFB on the flight deck adds to your workload?
   - Yes
   - No

14. Do you believe that the EFB is a distraction to your normal flight deck duties?
   - Yes
   - No

15. Do you feel that the EFB gives you a sensation of information overload?
   - Yes
   - No

16. Do you have difficulty navigating the EFB, for example, switching between applications?
   - Yes
   - No

17. Do you feel that your initial Electronic Flight Bag training was adequate to be proficient in normal flight operations?
   - Strongly Disagree
   - Disagree
   - Neither Agree nor Disagree
   - Agree
   - Strongly Agree

18. Do you feel that your initial Electronic Flight Bag training was adequate to prepare you for malfunctions or failures?

Strongly Disagree
Disagree
Neither Agree nor Disagree
Agree
Strongly Agree

19. In your experience, at what frequency has the Electronic Flight Bag failed or malfunctioned?

I have never experienced an Electronic Flight Bag failure or malfunction
1-24%
25-49%
50-74%
more than 75%

20. What percentage of time has the EFB operated in a manner that you were not expecting?

It always performs as I expect it to
1% - 9%
10% - 24%
25% - 49%
50% - 74%
more than 75%

21. What percentage of time have you lost situation awareness in the flight deck due to the Electronic Flight Bag?

I have never lost situational awareness as a result of the Electronic Flight Bag
1% - 9%
10% - 24%
25% - 49%
50% - 74%
more than 75%

22. Do you feel that utilization of the Electronic Flight Bag on the flight deck is safe?

Strongly Disagree
Disagree
Neither Agree nor Disagree
Agree
Strongly Agree

23. If you had your choice in the flight deck, would you prefer to use an Electronic Flight Bag, paper or a combination of the two?

    Electronic Flight Bag
    Paper
    Combination of Electronic Flight Bag and Paper

24. Please elaborate on your selection of a combination of both an Electronic Flight Bag and paper.

25. What are positive aspects of using an Electronic Flight Bag?

26. What are negative aspects of using an Electronic Flight Bag?

27. Additional comments concerning the Electronic Flight Bag.

28. If you would like to participate in a follow-up interview via email to help the researcher ascertain some of the results, please enter your email address. (This information is confidential and will only be revealed to the researcher.)

29. After the survey is complete and the results are reviewed, would you like to be included in a follow-up study to help the researcher interpret those results? (You identity will remain anonymous and personal information will be kept confidential.)

    Yes
    No

30. Please provide your email address for follow-up contact by the researcher. (This information will be kept confidential and the researcher will only contact you by email.)

    Email Address

31. After the survey is complete, would you like to receive a copy of the study?

    Yes
    No

29. Please enter your email address to receive a copy of the study once it is published. (This information will be kept confidential.)

    Email Address

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