An Examination of Safety Reports Involving Electronic Flight Bags and Portable Electronic Devices

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13. ABSTRACT (Maximum 200 words)
The purpose of this research was to develop a better understanding of safety considerations with the use of Electronic Flight Bags (EFBs) and Portable Electronic Devices (PEDs) by examining safety reports from Aviation Safety Reporting System (ASRS), FAA Runway Safety Office (RSO) and Accident/Incident Data System (AIDS), National Transportation Safety Board (NTSB), Civil Aviation Authority (CAA), Australian Transportation Safety Bureau (ATSB), Transportation Safety Board of Canada (TSB), and French Bureau of Enquiry and Analysis for Civil Aviation Safety (BEA). A total of 335 human factors concerns were identified from the ASRS and CAA reports; most human factors concerns pertained to the use of electronic charts, and in particular scrolling and zooming. Pilots also noted the presentation of incorrect or out-of-date information, and information presented differently on electronic charts than on paper charts. Additional human factors concerns were related to inexperience/lack of expertise and distraction with the PED/EFB. Four FAA runway incursion and accident/incident reports cited EFB/PED distraction, head-down time and erroneous aircraft performance parameters (e.g., incorrect temperature). The two NTSB accident reports that involved an EFB as a contributory factor both involved pilot misinterpretation of performance calculation data during landing, one due to inadequate training and the other the result of hidden assumptions underlying performance calculations. The reports from ATSB, BEA, and TSB primarily cited take-off performance data errors as a primary factor which led to increased workload (e.g., last-minute change which could lead to errors in calculating take-off speeds).

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
oz	ounces	28.35	grams	g
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	$candela/m^2$	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
mL	milliliters	0.034	fluid ounces	fl oz
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
g	grams	0.035	ounces	oz
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	$candela/m^2$	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	Kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003)

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The views expressed herein are those of the authors and do not necessarily reflect the views of the Volpe National Transportation Systems Center or the United States Department of Transportation.

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Contents

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List of Figures

List of Tables

List of Abbreviations

Abbreviation	Term
AC	Advisory Circular
ACARS	Aircraft Communications Addressing and Reporting System
ACN	Accession Number
AIDS	Accident/Incident Data System
ALPC	Airport Performance Laptop Computer
AMC	Aircraft Maintenance Company Airlines
ARP	Aerospace Recommended Practices
ASIAS	Aviation Safety Information Analysis and Sharing
ASRS	Aviation Safety Reporting System
ATC	Air Traffic Control
ATIS	Automatic Terminal Information Service
ATSB	Australian Transportation Safety Bureau
BEA	French Bureau of Enquiry and Analysis for Civil Aviation Safety
BLT	Boeing Laptop Tool
CAA	Civil Aviation Authority
CFR	Code of Federal Regulations
COTS	Commercial Off-the-Shelf
CTOP	Computerized Take-Off Performance
DME	Distance Measuring Equipment
ECL	Electronic Checklist
EFB	Electronic Flight Bag
FAA	Federal Aviation Administration
FCP	Flight Control Panel
FedEx	Federal Express, Inc.
FL	Flight Level
FLT	Flight
FMC	Flight Management Computer
FMGC	Flight Management Guidance Computer
FMGS	Flight Management and Guidance System
FMS	Flight Management System
FOVE	Flight Operations Versatile Environment
GA	General Aviation
GPS	Global Positioning System
LPC	Less Paper Cockpit
MEL	Minimum Equipment List
MFD	Multi-Function Display
MTOW	Maximum Take-Off Weight
NASA	National Aeronautics and Space Administration
NOTAM	Notice To Airmen
NTSB	National Transportation Safety Board
OPC	Onboard Performance Computer
OPT	Onboard Performance Tool

Abbreviation	Term
PED	Portable Electronic Device
PF	Pilot Flying
RSO	Runway Safety Office
RVSM	Reduced Vertical Separation Minimum
SOP	Standard Operating Procedures
STARS	Standard Terminal Automation Replacement System
SWA	Southwest Airlines
TFR	Temporary Flight Restriction
TSB	Transportation Safety Board of Canada
TSO	Technical Standard Order
UK	United Kingdom
US	United States
VHF	Very High Frequency
VOR	VHF Omnidirectional Radio Range

Executive Summary

The purpose of this research was to develop a better understanding of human factors safety considerations with the use of Electronic Flight Bags (EFBs) and Portable Electronic Devices (PEDs) by examining anecdotal data provided in safety reports. Federal Aviation Administration (FAA) Advisory Circular (AC) 120-76C defines three classes of EFBs. Class 1 and 2 EFBs are portable, commercial off-the-shelf (COTS) devices, authorized for use as EFBs, and Class 3 EFBs are installed hardware on the aircraft that require design and airworthiness approval. All three classes of EFB were included in this assessment; however, the specific EFB class was not provided in many of the safety reports. The results of this research are intended to identify human factors concerns associated with EFBs and PEDs to inform the development of FAA regulatory and guidance material. This document updates a previous EFB safety report analysis, *Review of Safety Reports Involving Electronic Flight Bags*, (Chandra & Kendra, 2010), and extends that analysis by considering a broader scope of devices used as EFBs.

Over 5,000 safety reports that mentioned an EFB or PED were identified from one aviation safety reporting system and six different aviation/transportation agencies. The reports spanned the timeframe of March 1994 to January 2014. Of these, only 276 reports of unique events were identified to be relevant to this effort. These reports are comprised of 239 National Aeronautics and Space Administration (NASA) Aviation Safety Reporting System (ASRS) reports, two FAA runway incursion reports, two FAA accident/incident reports, two National Transportation Safety Board (NTSB) reports, 27 Civil Aviation Authority (CAA) reports, three Australian Transportation Safety Bureau (ATSB) reports, two Transportation Safety Board of Canada (TSB) reports, and one French Bureau of Enquiry and Analysis for Civil Aviation Safety (BEA) report.

A total of 335 human factors concerns were identified from the 266 ASRS and CAA safety reports, and were organized into four human factors categories, as listed below. It is important to recognize that due to the nature of the information in ASRS reports, the issues noted in the reports could not be linked directly to a specific root cause because the narrative did not give us direct evidence.

- *Electronic display information elements* (132 reports) largely pertained to the use of electronic charts, and in particular scrolling and zooming. For example, critical information was off-screen or was difficult to read due to its small size. Pilots also noted the presentation of incorrect or out-of-date information presented on electronic charts.
- *Self-reported human performance* (125 reports) mostly included inexperience/ lack of expertise and distraction, e.g., pilots were not familiar with features or limitations of a new application, missed important information, lost position awareness, or became preoccupied with the EFB and failed to complete other duties.
- *Hardware* (62 reports) primarily involved an equipment error or failure (e.g., an unexpected shutdown or inoperable/partially operable device) or screen legibility concerns related to the display's brightness and readability of the device in different lighting conditions.
- *Placement/mounting/stowage* (16 reports) included concerns of the pilot having a poor view of

the EFB/PED, inadvertent activation of controls due to EFB/PED placement, unsecured EFB/PEDs on the flight deck, and mounting solutions that took up space on the flight deck that was previously used for paper charts.

In addition to the human factors and user interaction issues noted, the FAA was interested in examining the 112 ASRS reports related to EFB/PED software to develop an understanding of whether the issues reported were due to an error in the specification of the system requirements or an error in the software processing. In general, information needed to diagnose a software error requires specific knowledge about how the software was programmed, and the requirements used to develop the software. Again, the issues noted in the reports could not be linked directly to a specific root cause related to software engineering because the narrative did not give us direct evidence. While no potential *software processing errors* were identified, 52 reports were classified as potential *system requirement errors,* 19 were attributed to *lack of training,* and 41 were categorized as *unsure*.

In applying the findings from the ASRS and CAA reports, it is important to note that not all safety concerns are reported. Due to the voluntary nature of ASRS and CAA reports, these results should not be considered representative of the actual number of potential EFB related safety concerns that occur.

Four FAA runway incursion and accident/incident reports identified an EFB/PED as a factor. Three of these reports involved head-down time/distraction*,* and one involved the use of incorrect performance parameters. Two NTSB accident reports identified an EFB as a contributory factor; both involved pilot misinterpretation of performance calculation data during landing -- one due to data misinterpretation, and the other the result of hidden assumptions underlying performance calculations. One ATSB report cited EFB failure as a contributing factor, while the remaining ATSB, BEA, and TSB reports all cited take-off performance data errors due to lack of training, use of values or calculations from the previous flight, and incorrect data entry, as a primary factor which led to unsafe departures and collisions.

1. Introduction

An Electronic Flight Bag (EFB) or Portable Electronic Device (PED) used as an EFB can potentially increase the safety and efficiency of operations if integrated into the flight deck appropriately (Chandra, Yeh, Riley & Mangold, 2003). Federal Aviation Administration (FAA) Advisory Circular 120-76C, *Guidelines for the Certification, Airworthiness, and Operational Use of Portable Electronic Flight Bags*, defines an EFB as "an electronic display system intended primarily for flight deck use that includes the hardware and software necessary to support an intended function." These functions may include aircraft performance calculations, electronic charts, documents, handbooks and checklists. AC 120-76C further states that "EFB displays may use various technologies, formats, and forms of communication." A PED may also be used as an EFB for operational purposes. There are three classes of EFB as defined in FAA Order 8900.1 Volume 4, Chapter 15, Section 1, *Electronic Flight Bag Operational Authorization Process*:

Class 1 - *These EFBs are portable, commercial off-the-shelf (COTS) devices that are part of a pilot/crewmembers flight kit. Class 1 EFBs are not mounted to the aircraft, connected to the aircraft systems for data, or connected to a dedicated aircraft power supply* (FAA Order 8900.1, 4-1643A).

Class 2 - *These EFBs are portable, COTS devices that are part of a pilot's/crewmember's flight kit. Class 2 EFBs are typically mounted to a permanently installed mounting device and may be connected to a data source (wired or wireless), hardwired power source, or an installed antenna* (FAA Order 8900.1, 4-1643B).

Class 3 - *These hardware devices are installed with design approval [in accordance with applicable airworthiness regulations]* (FAA Order 8900.1, 4-1643C).

All three classes of EFB were included in this assessment; however, the specific EFB class could not always be identified, as this information was not provided in many of the safety reports. Appendix C provides information on the device types identified in the safety reports, but does not distinguish the EFB class.

The purpose of this research was to develop a better understanding of human factors safety considerations with the use of Electronic Flight Bags (EFBs) and Portable Electronic Devices (PEDs) by examining anecdotal data provided in safety reports. The results of this research are intended to identify human factors concerns associated with EFBs and PEDs to inform the development of FAA regulatory and guidance material This document updates a previous EFB safety reports analysis titled, *Review of Safety Reports Involving Electronic Flight Bags* (Chandra & Kendra, 2010), and extends the previous analysis by considering a broader scope of devices used as EFBs by including portable electronic devices. This report also examined both national and international safety reports from 2010 – 2014.

Safety considerations should be understood both in terms of those already documented through the

occurrence of reported events, and by looking at safety risk prospectively. Anecdotal information in the safety reports can assist in the assessment of technology, including whether or not it is an improvement over the current technology/procedure it is replacing. A number of government agencies, both national and international, record safety events for all modes of transportation. Safety reports are unique in that they do not follow the same format or collect the same types of information about an event; each agency has its own reporting structure, which may vary based on the purpose of reporting the incident (e.g., voluntary) and severity (e.g., loss of life) of the incident itself. For the purposes of this effort, we searched for safety reports from one aviation safety reporting system (ASRS) and six aviation/transportation agencies:

- **Aviation Safety Reporting System (ASRS)**: ASRS, managed by the National Aeronautics and Space Administration (NASA), is a voluntary system in which anyone related to aviation operations, including pilots, can self-report human factors or safety concerns they have experienced while operating an aircraft within the United States or Canadian provinces. Pilots are, for the most part, documenting an error or potential situation to err that has occurred during a specific event. Reporters may be granted some level of immunity depending on the violation they committed and the requirement that they disregarded (see AC 00-46D). Since this reporting system is voluntary and not corroborated by a third party, the information in the ASRS reports should not be assumed to be completely unbiased, objective information. We identified 239 ASRS reports of unique events in our safety report assessment describing concerns related to EFB and PED use. Each report of an event was exclusive of all other reports included so that no double counting of any events occurred in our assessment.

- **Federal Aviation Administration (FAA)**

    - **FAA Aviation Accident/Incident Data System (AIDS):** The FAA AIDS database contains commercial and general aviation incidents that have occurred since 1978 that have had an effect or potential effect on operational safety. These incidents do not meet the criteria required for NTSB accident investigation. A narrative summarizing the incident for each aircraft involved in the incident is made publicly available via FAA Aviation Safety Information Analysis and Sharing (ASIAS). Reports prior to 1995 were limited to 115 characters; however, narratives dated in 1995 or later are included in their entirety. We identified two reports from AIDS for our safety report assessment.

    - **FAA Runway Safety Office (RSO):** The FAA RSO investigates and assesses all surface incidents and runway incursions that occur at towered airports in the United Sates (US). These mandatory reports are submitted by air traffic controllers and include a detailed follow-up investigation with all parties involved. The reports are made publicly available via FAA ASIAS. Note that only a narrative summarizing the event is made publicly available. We identified two runway incursion reports for our safety report assessment.

- **National Transportation Safety Board (NTSB)**: The NTSB aviation accident database contains civil aviation accidents and selected incidents that have occurred within the United States jurisdiction since 1962. These reports provide details about the accident, analysis of the factual data, the probable cause(s) of the accident, and related safety recommendations. We identified two NTSB reports for our safety report assessment.

- **Civil Aviation Authority (CAA)**: The CAA is the United Kingdom's (UK) independent aviation regulatory body established in 1972. Safety data involving UK registered aircraft or aircraft operating within UK airspace at the time of the event as well as operational data is collected and evaluated to identify ways to improve aviation safety. This includes voluntary, confidential occurrence reporting and mandatory incident and accident reporting. Although the CAA records aviation accidents, it is not the agency responsible for investigation. Safety data is not made available in any publicly accessible database. We identified 27 CAA reports relevant to our safety report assessment.

- **Australian Transport Safety Bureau (ATSB)**: These reports document the result of independent investigations of accidents and incidents involving civil aircraft in Australia. All accidents and incidents related to flight safety in Australia, and all incidents involving an Australian registered aircraft, are reported to the ATSB. While the ATSB does not investigate all these accidents and incidents, it does record each safety event that occurred. These reports include an in-depth discussion of the incident itself and possible mitigation strategies and best practices learned for factors leading up to the event. We identified three ATSB reports related to our safety report assessment.

- **Transportation Safety Board of Canada (TSB)**: The TSB investigates civil aviation incidents that take place in Canada as well as Canadian registered aircraft in incidents anywhere in the world. These reports include in-depth discussion of the incident itself, possible mitigation strategies and best practices learned for factors leading up to the event. We identified two TSB reports for our safety report assessment.

- **French Bureau of Enquiry and Analysis for Civil Aviation Safety (BEA)**: The BEA is the French authority responsible for safety investigations into accidents or incidents in civil aviation. The BEA publicly releases a technical incident report after the investigation is completed. The report does not mention people by name and only includes information necessary to determine the causes of the accident or incident and to make safety recommendations. We identified only one BEA report for our safety report assessment.

Despite our efforts to pull data from a number of different sources, not all safety reports are available to the public. Therefore, we caution that this report may not be representative of the larger group of unattainable safety reports that exists. Additionally, public databases, such as the ones we considered, may not post all reports in the database or access can be limited by the search functionality provided.

However, the information in these reports may facilitate the collection of information about safety risks regarding the use of Class 3 EFBs installed on the aircraft and/or PEDs providing Class 1 or 2 EFB function as part of a pilot/crewmember's flight kit. In addition, the information collected offers valuable insight into potential human factors and safety concerns that occur in a variety of situations.

2. Method

2.1 Identification of Reports

We searched for safety reports from one aviation safety reporting system (ASRS) and six aviation/transportation agencies (FAA, NTSB, ATSB, CAA, TSB, and BEA). A total of 167 keyword terms were used (see Appendix A), which resulted in over 5,000 reports. The reports ranged in date from March 1994 to January 2014. Our search of these databases was last performed in January 2014. Note that only the keyword "electronic flight bag" was used to search for ATSB, TSB and BEA reports.

Inclusion criteria to determine which of the reports should be included in the final sample of safety data consisted of the following:

1) The safety report cited an EFB or PED used as an EFB as a contributory factor to safety, or cited that the EFB/PED has the potential to be a safety factor in a future event.
2) For ASRS safety reports, the report needed to indicate that it was submitted by pilots or co-pilots who were operating an aircraft under Part 91 (including Park 91K), 121, or 135.

In other words, we excluded reports that simply mentioned an EFB or PED used as an EFB, in which the device did not contribute to an error or lead to a safety concern, or reports that did not give enough information in the narrative or synopsis to verify that the occurrence involved the use of an EFB or PED. (Note: although considered in this assessment, none of the reports that met our criteria involved helicopters).

Two researchers with at least 10 years of human factors research experience in aviation reviewed each report according to these criteria to determine whether it should be included in the final set of safety reports for this effort. For a number of reports, a third researcher was asked to make the final determination. In rare cases, multiple ASRS reports were submitted about one incident (e.g., two reports were about the same incident but reported by the pilot and co-pilot of the same aircraft). In these cases, information from both reports was collected (although we only counted the report once) so that all contributory factors about the specific occurrence could be examined.

On the basis of these criteria, 239 ASRS reports were identified. Table 1 shows the number of reports identified and included for each keyword. Note that within each report narrative, pilots may have used multiple terms to describe the same device, such as "iPad" and "EFB" (refer to Table C-1 in Appendix C for reports by year and hardware device type). In these cases, the more specific keyword was counted (e.g., iPad in the previous example).

Table 1. Summary of ASRS Reports Included.

Keywords	Number of Reports	Time Period
ALPC	1	5/95
Electronic Flight Bag or Electronic FLT Bag or EFB	98	11/02 – 7/13
Electronic chart	3	7/03 – 7/10
Electronic checklist or ECL	4	8/08 – 11/11
Handheld or Hand Held	4	8/02 – 5/05
iPad	65	8/10 – 7/13
iPhone	1	2/12
Moving map	5	12/06 – 6/13
OPC	23	11/02 – 7/08
Performance computer	26	3/94 – 7/13
Tablet	9	4/05 – 8/09
Total	**239**	

2.2 Categorization of EFB/PED Human Factors Concerns

We constructed a taxonomy of potential safety factors for identifying potential human factors concerns in the reports, as noted in Table 2. In addition, we identified each EFB or PED used as an EFB as a *primary factor* or *secondary factor*, based on how the device contributed to or influenced the outcome of each event. A *primary factor* reflects a concern with an EFB or PED that was the leading event to occur and had a direct influence on the outcome. A *secondary factor* reflects a concern with an EFB or PED used as an EFB that had an indirect influence on the outcome, and only exacerbated or contributed to the event. It is important to note that the concerns identified in this report could not be linked directly to a specific root cause because the narratives did not give us direct evidence.

Table 2. Taxonomy of EFB/PED Human Factors Concerns.

Category	Subcategory
Electronic Display Information Elements	**1. Electronic charts** **a. Scrolling/zooming concern:** When scrolling/zooming led to oversight of information or information being displayed incorrectly at certain zoom levels (e.g., text was too small). **b. Presentation inconsistent with paper:** When the information content in electronic and paper versions are the same, but the positioning of information is different, going against expectations. This category also includes unfamiliar labels, icons or symbols. **c. Incorrect information:** When information displayed is incomplete, incorrect, or does not contain the same information as the paper copies. If information is missing, specify_____. **d. Out-of-date:** The chart was described as being out-of-date.

Table 2. Taxonomy of EFB/PED Human Factors Concerns (continued).

Category	Subcategory
Electronic Display Information Elements	**e. Difficulty retrieving electronic chart:** The action of retrieving charts was problematic (e.g., unable to locate a chart or choosing an incorrect chart). **f. Other:** Specify ____ **2. Flight performance calculation concern:** Includes any concern involving the performance calculation software, excluding data entry concerns. (Note: Data entry concerns are classified under *Self-Reported Human Performance Concerns*.) Specify ____ **3. Out-of-date (application not specified):** Software is described as being out-of-date, with no reference to a specific application **4. Electronic documents** **a. Difficulty retrieving electronic document:** The action of retrieving a document was problematic (e.g., unable to locate a document or choosing an incorrect document). **b. Legibility concern:** Documents are difficult to read due to the clarity or quality of the electronic document. **c. Out-of-date:** The document was described as being out-of-date. **d. Incorrect information:** When information displayed is incomplete, missing, incorrect, or do not contain the same information as the paper copies. If information is missing, specify_____. **e. Presentation inconsistent with paper:** When the information content in electronic and paper versions are the same, but the positioning of information is different, going against expectations. This category also includes unfamiliar labels, icons or symbols. **f. Scrolling/zooming concern:** When scrolling/zooming led to oversight of information or information being displayed incorrectly at certain zoom levels (e.g., text was too small). **g. Other:** Specify ____ **5. Electronic checklists** **a. Difficulty retrieving electronic checklist:** The action of retrieving electronic checklists was problematic (e.g., unable to locate a checklist or choosing an incorrect checklist). **b. Inoperable electronic checklist:** When the electronic checklist is not fully functional, or is inoperable.

Table 2. Taxonomy of EFB/PED Human Factors Concerns (continued).

Category	Subcategory
Electronic Display Information Elements	**c. Missing electronic checklist:** When an electronic checklist is missing from the electronic checklist system. **d. Information inconsistent with paper:** When the information content in electronic and paper versions are conflicting. **6. Arrangement of information on the display:** A legibility or functionality concern resulting from the arrangement of information on the display with no reference to a specific application. **7. Lack of feedback** **a. System state indicator** **Missing:** Indication that is not received or delayed. **Presented:** Indication that is presented but is confusing, misleading or incorrect. **b. Error indicator** **Missing:** Indication that is not received or delayed. **Presented:** Indication that is presented but is confusing, misleading or incorrect. **c. Other:** Specify ____ **8. Settings/switching between applications:** Any difficulty switching between applications (e.g., switching between electronic charts to the display settings menu). **9. Sharing information across EFBs/PEDs:** Problems occurred when sharing information from one pilot's device to another pilot's device. **10. Security concern:** Concern with EFB/PED function due to corrupted or malicious software (e.g., viruses, malware, spyware). **11. Integration failure:** When input to one flight system is not automatically updated in other flight deck systems. **12. Other:** Specify____
Hardware	**1. Equipment error/failure** **a. Inoperable or partially operable EFB/PED:** The device was described as not being fully functional or completely inoperable. **b. Screen froze/went black:** Specifically stated as such in the report without the system powering down (e.g., going into sleep mode).

Table 2. Taxonomy of EFB/PED Human Factors Concerns (continued).

Category	Subcategory
Hardware	**c. Unexpected shutdown:** An unexpected, unprompted EFB/PED shutdown. **d. Automatically erased data:** The EFB/PED automatically erased previously entered data. **e. Battery concern:** Any battery concern including speculation of a battery problem. **f. EFB/PED overheated:** Report mentions concerns with EFB/PED equipment over-heating. **g. Unspecified cause:** Reports with no mention of a - f above, but reporter indicates that the EFB/PED hardware failed. **h. EFB/PED smoke/fire:** The EFB/PED, or its components (e.g., battery, charger or wires), emitted smoke or fire on the flight deck. **i. Processor speed or memory concern:** Problems with EFB/PED function related to hardware specifications (e.g., device is slow or screen freezes). **j. Other:** Specify ___ **2. Screen legibility concern** **a. Ambient light/glare:** Concerns with lighting conditions (e.g., sunny, night, glare) that create a less than optimal viewing environment. **b. Ambient light and display brightness:** Report mentions a combination of a and b above. **c. Brightness/contrast:** Concerns with the brightness or contrast on the display itself, with no mention of ambient light conditions. **d. Unspecified cause:** Reports with no mention of a, b or c above, but reporter indicates that screen was difficult to read and did not mention a specific software. **e. Other:** Specify ___ **3. EFB/PED size concern:** Concerns with the size of EFB/PED or its components (e.g., screen size) as being “large/small” or “heavy/light”. However, this category does not include instances of input devices (see section 4 below). **4. Input device concern** **a. Touch screen/soft keys:** Concern related to the touch screen display (e.g., sensitivity) or soft keys (e.g., spacing or size) on the EFB/PED. **b. Hard buttons/keys:** Concerns with the use of hard buttons/keys (e.g., keyboard and bezel buttons) on the EFB/PED.

Table 2. Taxonomy of EFB/PED Human Factors Concerns (continued).

Category	Subcategory
Hardware	**5. Interference with other systems** **a. Electromagnetic:** Report mentions electromagnetic interference with other flight deck systems. **b. Other:** Specify ___ **6. Pressurization/decompression concern:** Report mentions damage or other concerns with EFB/PED due to rapid decompression or other pressurization concerns. **7. Other:** Specify____
Self-Reported Human Performance	**1. Lack of experience/expertise:** Minimal or no experience with EFB functions or software applications/electronic display information elements. **2. Distraction:** Distraction was mentioned due to EFB/PED usage. **3. Over-reliance on an EFB/PED:** Over-reliance on an EFB/PED (or an application) for information. **4. Lack of training or documentation:** Inadequate training or insufficient documentation regarding the EFB/PED is explicitly stated in the narrative. **5. Self-reported data entry/verification concern:** Incorrect data entry, or the failure to detect incorrect data entry in the EFB/PED (e.g., values stored from previous flight). **6. Head-down time:** Increased head-down time was mentioned as a result of EFB/PED usage. **7. Workload:** Workload increased as a result of EFB/PED usage. **8. Memory lapse:** Lapse of memory (e.g., forgetting how to use the EFB/PED). **9. Other:** Specify _____
Placement/Mounting/ Stowage	**1. Placement/location** **a. Poor view of EFB/PED:** Pilot did not have a clear view of the display while in use.

Table 2. Taxonomy of EFB/PED Human Factors Concerns (continued).

Category	Subcategory
Placement/Mounting/ Stowage	**b. Poor view of instruments, controls or out the window:** Pilot did not have a clear view out the window, or of flight deck controls or instruments, due to the EFB/PED obstructing the pilot's field of view. **c. Other**: Specify ___ **2. Stowage:** The actual mention of "stowing" or the action of stowing the EFB/PED was a factor in the event's occurrence (e.g., could not access information due to EFB/PED being stowed). **3. Mounting/securing of an EFB/PED:** Mounting structure/securing solution is mentioned as a concern (e.g., unsecured or mount malfunction). **4. Other**: Specify ___
Other	**Specify _____**
Additional Information Collected for Each Report	**1. Part 91, 121, 135** **2. EFB/PED as a primary or secondary factor** **3. Anomalies, deviations and airspace violations** **4. Phase of flight** **5. EFB/PED hardware**

2.3 Categorization of Potential Software Errors

In addition to the human factors and user interaction issues discussed in the previous section, the FAA was also interested in conducting a separate analysis examining the reports from a software engineering perspective to see if we could provide input as to whether the software related issues reported by pilots are due to an error in the specification of the system requirements or an error in the software processing. The distinction between systems development and software processing is described in Figure 1 below; this figure was excerpted and reprinted with permission from SAE ARP 4754A.

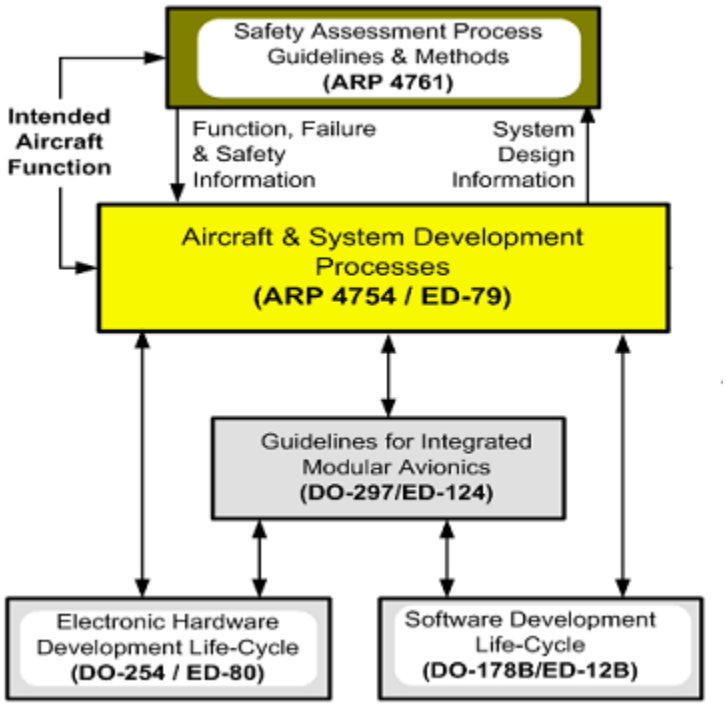

Figure 1. Guideline Documents Covering System Development. Reprinted with permission Copyright (c) 2010 SAE International. No further copying or distribution is permitted without permission from SAE.[1]

The figure highlights that there are two different roles. One is focused on system design (the top half of Figure 1), and the other is focused on the software development (the bottom half of Figure 1). Per RTCA DO-178B, *Software Considerations in Airborne Systems and Equipment Certification*, software requirements are used to develop a software design for implementation into source code (i.e., software programming). These requirements may include operational functions, user interface, system redundancy, security and maintenance. A *system requirement error* can be thought of as any incorrect or incomplete system requirement. As noted in the figure, SAE ARP (Aerospace Recommended Practice) 4754A, *Guidelines for Development of Civil Aircraft and Systems*, proposes one such method for validation.

Once requirements validation is complete, the system requirements are given to a software developer to be implemented (the bottom half of the figure). An error in the software programming or development is considered a *software processing error* (e.g., software compiler or linking error).

Our challenge was to identify why software did not behave the way the pilot or flightcrew expected. In particular, information needed to diagnose a software error requires specific knowledge about how the software was programmed, and the requirements used to develop the software. (Note: CAA safety reports could not be used for this analysis due to the lack of a pilot's narrative and were excluded for consistency). Due to the nature of ASRS, we had no avenue to talk to the reporter and in many cases

[1] Note that Figure 1, excerpted from SAE ARP 4754A, references RTCA DO-178B, but that document has since been revised. The latest version is RTCA DO-178C.

the information about the software type and specific manufacturer of the EFB/PED device was not reported. Thus, the issues noted in the reports could not be linked directly to a specific root cause related to software engineering because the narrative did not give us direct evidence. Instead, we created four categories (*system requirements error*, *software processing error*, *lack of training* or *unsure*) and developed a classification scheme in conjunction with the FAA, as described below.

Table 3. Potential Software Error Categories.

Category	Definition
System Requirements Error	The report mentioned one or more of the following issues – a zooming error, a condition in which symbols overlapped, or that the information displayed on the EFB/PED was confusing to the pilot – and did not mention pilot "inexperience."
Software Processing Error	The report explicitly described incomplete or incorrect software coding or programming (e.g., software compiler or linking error).
Lack of training	The report mentioned a pilot's inexperience with the EFB/PED (regardless of other details in the report).
Unsure	The report mentioned the use of software but did not provide enough information to categorize the report as one of the previous three subcategories.

It is important to note that the software errors section presents the only analysis in this paper that was not based on direct evidence in the overall ASRS report itself.

2.4 Findings

All reports were categorized according to the human factors taxonomy shown in Table 2 and agreed upon by two researchers. As noted above, the concerns identified in this report could not be directly linked to a specific root cause because the narratives did not give us direct evidence. Software-related ASRS reports were also categorized using the potential software error categories defined in Table 3. Examination of the ASRS data included descriptive statistics on a number of different factors including types of concerns reported, potential software errors, type of anomaly/ deviation/airspace violation, and phase of flight. Examination of CAA reports includes frequency data of the concerns described in the reports. Examination of FAA, NTSB, TSB, BAE, and ATSB data were more qualitative, using the description and discussion of each event, rather than overall frequency of occurrence. This is due to the low number of reports found and/or the richness of information in the reports from these agencies. Section 3 discusses the ASRS data and presents key findings. Section 4 provides a summary of FAA runway incursion reports and FAA accident/ incident reports. Section 5 presents findings from the NTSB reports, and Section 6 provides a brief review of the CAA reports, followed by a summary of the TSB, ATSB, and BEA reports.

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3. ASRS Safety Reports

3.1 Report Design and Information Collected

Table 4 provides a list of the data categories included in ASRS and used in the current assessment. Although some of the information provided by the reports was objective, most of the information was subjective, such as describing how the EFB/PED and or additional factors influenced the situation and/or outcome. Thus, because the information in each of these fields is self-reported, the report contains what the reporter deemed important. ASRS gathers the information but does not conduct any investigations to verify the accuracy of the details reported (e.g., from multiple sources). It is important to note that although ASRS screens and prioritizes each submitted report, not all reports are made available in the online database. Additionally, the process for including reports in the online database may be slowed due to the volume of reports received (Chandra & Kendra, 2010).

Table 4. Data Categories Included in ASRS Reports.

ASRS Information	Description	Item(s) Included in Volpe Assessment
Time/Date	Date and local time	• Not included
Place	Locale at time of event	• Airport ID (origin and destination)
Environment	Weather, visibility and work environment	• Not included
Aircraft/Operator	Aircraft make and model, mission, route, flight plan, airspace, maintenance, and type of operator	• Operating Part (91, 121, 135) • Phase of flight
Component	Aircraft component problems	• Not included
Person	Reporter information and human factors problems	• Not included
Events	Anomalies, deviations, violations, incursions, excursions, detections and results	• Conflicts • Violations • Deviations • Incursions
Assessments	Contributing factors and problems identified by ASRS analyst	• Not included
Narrative	Description of the event as written by the reporter	• Narrative
Callback	Description of additional information gathered by ASRS analyst if a callback was initiated	• Callback
Synopsis	Brief summary of the event written by ASRS analyst	• Synopsis

The human factors taxonomy shown in Table 2 provided a template to aid the researcher in extracting this subjective information, to allow a more objective and structured examination of each report reviewed.

The remainder of this section discusses the findings from the ASRS reports, beginning with the types of human factors concerns identified in the reports, followed by a discussion of the anomalies, deviations, and airspace violations that occurred as a result of EFB/PED concerns. Finally, a brief summary of the phase of flight in which the events were reported is presented.

3.2 Human Factors Categories Overview

In reading the ASRS reports, reviewers recorded up to two concerns for each report. Of the 239 reports (115 Part 91 reports[2]; 113 Part 121; 11 Part 135), 69 mentioned at least two unique concerns related to the EFB/PED, while 170 reports mentioned only one concern. Few reports identified more than two concerns. In those cases, only the two concerns deemed most contributory to the event were recorded for consistency since the level of detail included in each narrative varied widely. This resulted in a total of 308 concerns recorded (155 Part 91; 137 Part 121; 16 Part 135).

The human factors concerns reported by pilots were grouped into four categories:

- *Electronic Display Information Elements*. This category includes concerns specific to particular types of applications (e.g., charts, documents, performance calculations), and are related to the presentation, accuracy and currency of displayed information, feedback and settings.
- *Hardware.* This category includes physical problems (e.g., size, equipment failure).
- *Self-Reported Human Performance*. This category captures undesirable effects regarding pilot performance, such as distraction, increased workload and head-down time, inexperience with and over-reliance on EFBs or PEDs used as EFBs, and self-reported data entry errors.
- *Placement/Mounting/Stowage.* This category addresses any concerns related the location or securing solution of the EFB/PED (e.g., difficult to view due to location).

Overall, 37% of human factors concerns were related to *electronic display information elements* concerns, 19% involved *hardware* concerns, 40% were related to *self-reported human performance* concerns, and 5% involved *placement/mounting/stowage* concerns. Figures 2, 3 and 4 show the breakdown for each of the main categories by operation type.

[2] There are several types of operations under Part 91. Although ASRS provides pilots with an option for selecting the specific type of operation, these options are not mutually exclusive. More than one option can apply to pilots who operate under Part 91K (Fractional Ownership Operations); however only one selection can be made. For example “corporate and fractional” may be applicable to the nature of their operations, but only “fractional” or “corporate” may be selected. This lack of mutual exclusivity prevented us from distinguishing the specific type of Part 91 operations, and we looked at all Part 91 reports collectively for the purposes of this analysis.

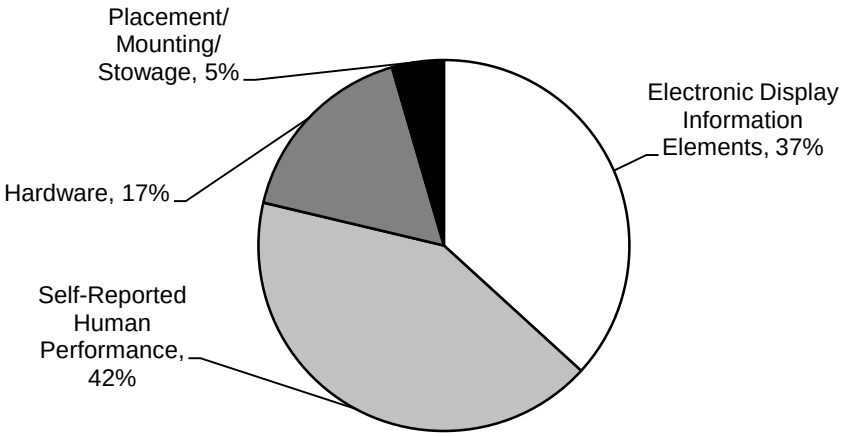

Figure 2. Percent Part 91 Human Factors Concerns Reported.

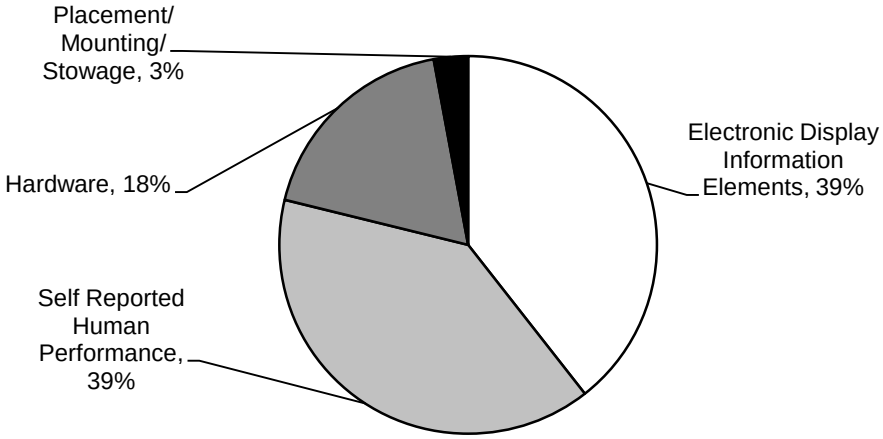

Figure 3. Percent Part 121 Human Factors Concerns Reported.

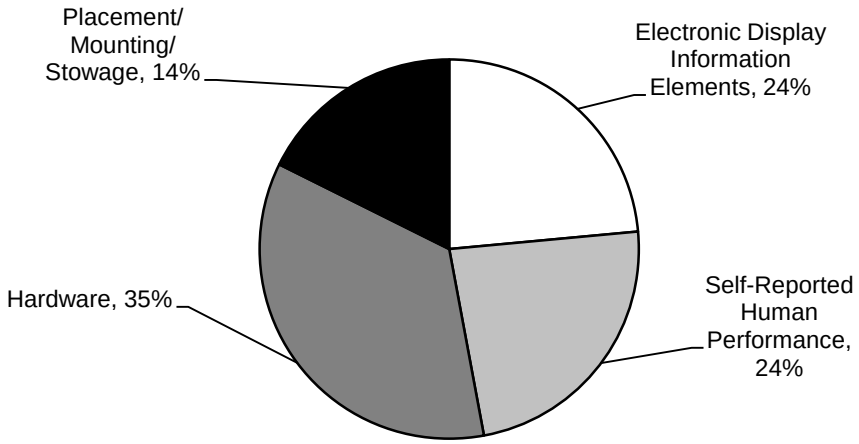

Figure 4. Percent Part 135 Human Factors Concerns Reported.

3.2.1 Electronic Display Information Elements Concerns

Overview

Electronic display information elements concerns address accuracy and currency of displayed information, feedback, and settings. The overall results are shown in Figure 5 (see Table 5 for concerns reported by Part 91, Part 121, and Part 135 pilots).

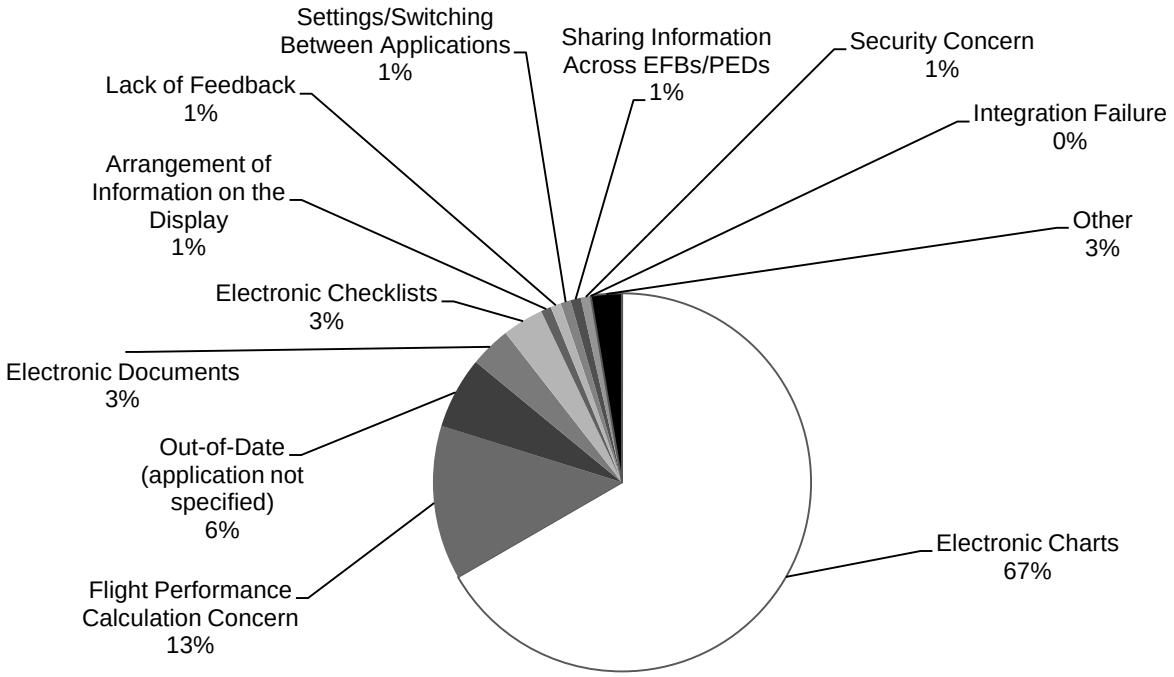

Figure 5. Percent of Electronic Display Information Elements Concerns Reported.

Reports related to *electronic charts* accounted for 67% (76 reports) of all *electronic display information elements* concerns. This category relates to concerns encountered when pilots tried to retrieve and accurately decipher the chart, the way in which information is displayed on the chart, the accuracy and currency of the information presented, or manipulation of the display (e.g., scrolling/zooming).

Table 5. Electronic Display Information Elements Concerns by Type of Operation.

Electronic Display Information Elements Concerns	Part 91	Part 121	Part 135	Total
Electronic charts	**55**	**18**	**3**	**76**
Scrolling/zooming concern	30	3	3	36
Presentation inconsistent with paper	6	5	0	11
Incorrect information	8	2	0	10
Out-of-date	1	4	0	5
Difficulty retrieving electronic chart	3	0	0	3

Table 5. Electronic Display Information Elements Concerns by Type of Operation (continued).

Electronic Display Information Elements Concerns	Part 91	Part 121	Part 135	Total
Other	7	4	0	11
Flight performance calculation concern	**0**	**15**	**0**	**15**
Out-of-date (application not specified)	**0**	**7**	**0**	**7**
Electronic documents	**0**	**4**	**0**	**4**
Difficulty retrieving electronic document	0	1	0	1
Legibility concern	0	1	0	1
Out-of-date	0	1	0	1
Incorrect information	0	0	0	0
Presentation inconsistent with paper	0	0	0	0
Scrolling/zooming concern	0	0	0	0
Other	0	1	0	1
Electronic checklists	**0**	**4**	**0**	**4**
Difficulty retrieving electronic checklist	0	1	0	1
Inoperable electronic checklist	0	1	0	1
Missing electronic checklist	0	1	0	1
Information inconsistent with paper	0	1	0	1
Arrangement of information on the display	**1**	**0**	**0**	**1**
Lack of feedback	**0**	**1**	**0**	**1**
System state indicator	0	1	0	1
Missing	0	1	0	1
Presented	0	0	0	0
Error indicator	0	0	0	0
Missing	0	0	0	0
Presented	0	0	0	0
Other	0	0	0	0
Settings/switching between applications	**1**	**0**	**0**	**1**
Sharing information across EFBs/PEDs	**0**	**1**	**0**	**1**
Security concern	**0**	**1**	**0**	**1**
Integration failure	**0**	**0**	**0**	**0**
Other	**0**	**3**	**0**	**3**
Total	**57**	**54**	**3**	**114**

Part 91 Electronic Display Information Elements Concerns

Ninety-six percent of the 57 e*lectronic display information elements* concerns addressed *electronic charts* (55 reports). Of these, 30 reports pertained to *scrolling/zooming*; pilots primarily cited instances where important information on the chart was outside of the viewing area (23). Other concerns included

difficulty locating information due to an excessive scrolling and zooming required (3), and graphical depictions on the charts became distorted when zoomed in thereby affecting readability (3). An example is provided in the narrative excerpt below:

> *I have a panel mounted 430W GPS and was using it for navigation. I had the sectional displayed on the EFB and was looking to see where the EWR Class B 3,000 FT floor began. I knew it was nearby but it was not showing on the sectional yet. I noticed an airliner pass over head but he was about 2,000 FT above me. Not too unusual. I could see MMU about 7 miles ahead and I knew that MMU was under the 3,000 FT shelf of Newark's space. I looked again on the EFB sectional for the airspace line and still could not see it. I switched to the map page on the 430W and saw that I had penetrated class B space by about 1 or 2 miles. I immediately began a 1,000 FPM descent and turned west to exit the airspace. After clearing the airspace I continued to CDW and landed without incident. After the flight I took the EFB home to determine why I could not see the Class B airspace indication on the sectional. I then saw that when zoomed in on the sectional as I did when flying that in the area where I was located the airspace indication was superimposed on top of an airway line. Both of these indications are the same color. When I zoomed in on the sectional contrast and definition was lost enough that the airspace arc was nearly invisible.* (ACN# 919024)

One *scrolling/zooming concern* involved a possible ownship position inaccuracy on an enroute moving map[3]. In this report, the pilot indicated that ownship position on the moving map display shifted from outside Class D airspace to inside the Class D airspace boundary when the pilot increased the map scale (i.e., zoomed in). This position inaccuracy led to a violation of the Class D airspace. The pilot also noted that the GPS accuracy was indicated to be within five meters. The narrative is as follows (note that this report also captured *over-reliance on the EFB/PED* in the *Self-Reported Human Performance* category, as the pilot also noted that the iPad moving map software was his "primary reference"):

> *During the trip I primarily referenced my iPad's moving map software to provide sufficient clearance from the boundaries of a nearby Class C airspace and CNO's Class D airspace. When passing just a bit north of AJO airport, I decided to change the map's scale for a closer look at CNO's Class D boundary. On the slightly larger map scale that I had been using, the moving 's airplane icon was positioned outside the boundary of CNO's Class D airspace and the iPad's GPS accuracy meter showed five meters. This seemed to comport with the horizontal displacement from AJO airport that I viewed outside the cockpit window. The moment I reduced the map's scale, however, the airplane icon was displaced slightly inside the boundary of CNO's Class D airspace. Since CNO's Class D airspace extends to 2,700 FT MSL, this put me 300 FT below the top of this airspace. When I further reduced the moving map's scale, the airplane icon was further displaced inside Class D airspace. It was clear that the position of the moving map's airplane icon*

[3] Note that this incident was reported by a pilot flying under Part 91 conditions. Ownship in flight is not authorized for aircraft operations conducted under 14 CFR 91 subpart K (91K), 121, 125, 125 letter of deviation holders (LODA) and 135.

shifted noticeably (perhaps by two miles) with variable scale settings… Upon returning home later that evening, I examined my route east and north on the iPad's moving map software. On the medium range scale, my route appears to have taken me clear of Class C airspace and CNO's Class D airspace. Upon reducing the scale, it shows that I might have clipped corners on both of these airspace structures… it's clear that scaling the moving map changes the geographical position of the airplane displayed on the moving map, despite the GPS engine providing accuracy within +/- five meters. (ACN# 916015)

Six *electronic chart* concerns addressed *inconsistencies in the presentation of information* on the electronic chart in comparison to paper charts (i.e., differences in the location/position of information on the electronic chart when compared to the paper chart). Note that this category does not address incorrect information depicted on the chart; this is captured in the *incorrect information* on an electronic chart category, discussed later in this section. In these six cases, the pilots had difficulty locating information due to inconsistency with paper counterparts, or mentioned an inconsistency. Two examples are as follows:

At the time of the event, our company recently purchased electronic flight bags (EFBs) to use on board the aircraft. Both pilots have an EFB to their disposal. There was some confusion in the cockpit during the ARR because we were given a different AR than was planned. During this confusion, the PF had trouble locating the TYSSN 1 ARR on his EFB, and had asked for the paper copy version, which had not been pulled for that trip. (ACN# 729594)

We use Electronic Flight Bags (EFB) mounted on each side of the cockpit for terminal charts, but I had printed off all of the charts for each of the scheduled airports due to all of the text information and difficulty in finding the SIDs and STARs on the EFB as they put several SIDs on each chart and SIDs with the same name but different identifier on several different charts. (ACN# 957115)

Presentation of *incorrect information* was indicated in eight reports. In six of these, the pilots described information presented on the charts that was missing when compared to their paper counterparts, and one report described inconsistent information with paper counterparts. One additional report described conflicting information between two electronic sources. In one example of missing information, the pilot stated that they were "told to hold at MGW" but that the "electronic flight bag [had] no published hold over MGW" (ACN# 678031). A second report involved heading text that disappeared at certain zoom levels (this report was also included in the *Scrolling/zooming concern* category). The "1" digit was omitted from "190" in the departure heading instructions, resulting in a heading deviation. The pilot later discovered that the text was correctly displayed at other zoom levels, and that the error was replicable on other aircraft (ACN# 740010). An example of information inconsistent with paper versions (resulting in the aircraft landing without clearance) is shown in the following excerpt:

In route to the destination airport, the crew determined that the LDA/DME RWY 25 approach plate for Eagle County Regional (KEGE) possessed ambiguous notations for which interpretation

could not be agreed upon. Both EFBs (electronic flight bags) were set up to display Commercial charts for the approach in question, while the FO utilized a handier print-out version (NOS chart). For planning purposes, if utilizing the glide slope, it was observed that the two charts displayed two different geographical points for missed approach initial climb-out. The Commercial chart clearly states CIPKU (I-ESJ 3.5 DME) as the missed approach point (MAP), and that the anticipated missed approach climb-out would commence prior to CIPKU, whereas, the NOS chart shows the missed approach climb-out is anticipated to commence at CIPKU. (ACN# 876221)

An example of conflicting information between electronic sources is shown in the following narrative:

I was talking to Clearance and referencing an iPad with freshly downloaded government charts HI, LOW and APPROACH PLATES. I was not able to find OLIIN on either HI or LOW IFR Enroute charts so I asked clearance for a clarification how to transition from Oliin to J2. OLIIN was shown on the Stanfield 3 Departure but not shown on J2. After 10-15 minutes they came back and advised that CIE VOR had been decommissioned and that Oliin intersection took its place. We had another iPad in the plane with government charts loaded (different source) so I checked it for OLIIN on J2. That set of charts did in fact show that OLIIN was on J2 West of CIE (ACN# 1036925).

Part 121 Electronic Display Information Elements Concerns

Of the 54 Part 121 *electronic display information element* concerns, 33% (18) were related to *electronic charts*. In five of these, pilots described *information presented inconsistently* on electronic charts versus paper versions. An example is as follows:

Cleared to descend on the Dylan 4 arrival. Passing Dupont VOR we were called by New York Center and asked about altitude. Replied that we were passing 17,000 FT. New York told us to check the STAR. The STAR showed that the minimum altitude at Dupont was 20,000 FT. New York told us there was no conflict/problem. The requirement to be at 20k minimum over Dupont was missed by me. Part of the problem may be that we are now using EFB's and the altitude requirement at DQO was in a slightly different format/location than the other altitude requirements on the arrival. (ACN# 926763).

In another example, the pilot cited incorrect/misleading hold line symbols on the electronic chart, resulting in the aircraft inadvertently crossing the hold line, as shown in the following narrative:

While taxing out, both crewmembers reviewed the electronic flight bag (EFB) airport ground chart and noted the CAT 2/3 stop symbol at the end of Taxiway Papa prior to the left turn for entry onto Runway 28. On Taxiway Papa, approaching the CAT 2/3 hold point designated on our airport ground chart, both crewmembers visually observed the hold point markings painted on the taxiway and agreed the markings were the CAT 2/3 hold point depicted on the airport ground chart. Normally the CAT 1 hold point is beyond the CAT 2/3 hold point. The Captain continued taxiing past the CAT 2/3 hold point (as designated on the airport ground chart) and

made the 90 degree left turn at end of Taxiway Papa to hold short of Runway 28. During the turn, the crew noted that there was no hold short line between the aircraft and runway. The Captain immediately stopped the aircraft halfway through the turn and called Ground Control for clarification of the hold point. Ground Control advised that we had taxied past the hold point and informed the crew that the hold point was behind us on Taxiway Papa. This was the point designated as the CAT 2/3 holding point on the airport ground chart… In the Legends and Tables section of EFB, the CAT 2/3 holding symbol includes the definition: 'ILS holding position CAT 2/3, if indicated in AIP. Holding mandatory during LVP, or when instructed by ATC.' Symbology on the airport ground chart appears to be incorrect or at least misleading at this particular spot. (ACN# 946367)

Part 121 pilots also reported four instances of electronic charts that were *out-of date*, including two approach plates, one departure plate, and a chart database.

Part 121 pilots also described concerns with *flight performance calculations* in 15 reports. This category includes concerns with computations, missing data, incorrect data, or other functionality problems, but does not include data entry concerns (which were classified as *Self-Reported Human Performance* concerns). In one report, a pilot indicated that the aircraft did not meet its performance capabilities, and a lower stopping margin was available than what was being calculated in the onboard performance computer (OPC) for landing on a slippery runway (ACN# 717398). See Table C-5 in Appendix C for all Part 121 *electronic display information elements* concerns by device type. Another example of a *flight performance calculation concern* involving a missing intersection takeoff data is as follows:

First Officer checked and entered the performance data using the final weight and balance printout for Runway 28. We actually took off from Runway 28, intersection Charlie which is coded as RW28X in the 'airport notes' section of the flight release. The final weight and balance didn't offer the intersection take-off, only full length. First Officer didn't catch it. Captain didn't request that the data be physically passed over for a full inspection or the error might have been noticed. The physical presentation from the cockpit facing south and looking at all the aircraft taking off from this point is that intersection Charlie is the end of the runway. Even though we always take-off from this intersection, the performance computer did not list RW28X as an option. This runway is extremely deceptive. The taxi out leaves the very strong impression that the aircraft is physically at the end of the runway, when in fact 500 FT more lies to the east by crossing the runway and taxiing back on a semicircular taxiway for full-length departure Runway 28. Tower never used any phrases to indicate taxi to or take-off from Runway 28, intersection Charlie… (ACN# 836269)

Two Part 121 *flight performance calculation* concerns cited incorrect information provided by the software involving discrepancies between the runway lengths presented in the OPC, and the actual available takeoff distance of the runway. In one report, the OPC showed a shorter runway than was actually present (ACN# 574280); in the other report, the OPC presented a shorter distance than the Automatic Terminal Information Service (ATIS) (ACN# 569766).

Seven Part 121 reports addressed a concern with *out-of-date software*, but the narrative did not specify the type of application being used (e.g., document or chart).

Part 121 pilots exclusively reported concerns with *electronic document*s. One pilot reported that the EFB manual was *out-of-date* (ACN# 813670), whereas another described a document that was difficult to read. The narrative is as follows:

> *During takeoff from RNO [I] noticed excessive roll and mushy liftoff. Further review of the OPC data confirmed that the FO had put in the wrong temp for the N1 reduction… During the data entry, the FO input the top line 12/54 instead of the 12/36. During the checklist it looks like the same numbers in the OPC and can be easily confused.* (ACN# 697274)

Four reports cited *electronic checklist* concerns. In one report, the flight crew was unable to obtain any additional information about a smoke detector alert message that was received because the electronic checklist was *inoperable* (ACN# 800759). In the second report, the Emergency Evacuation Checklist was missing, and had not been installed (ACN# 961138). The missing checklist was identified prior to takeoff, and although safety was not affected, the flight incurred a two hour delay. In the third report, the electronic checklist information conflicted with its paper counterpart. In this narrative, the values in the Rejected Takeoff Checklist table with brake temperatures and corresponding cooling times were different than the values in the same table located in the flight manual Rejected Takeoff Checklist (ACN# 981460).

One report was also identified in which the software did not provide enough *feedback* to determine the system state or identify a system error. This report noted that an indication was needed to show that the EFB was out-of-date (note that this report was also captured under the *software out-of-date* category):

> *Over a week after the fact I was informed by the Captain there was a problem with the software load on the Electronic Flight Bag on the aircraft we had flown together. The message, from a Safety Representative, stated that there should have been a red message on the EFB to indicate the software was out of date. This did not occur on my EFB and I had no indications that the software on the EFB was out of date.* (ACN# 945962)

One Part 121 report described a *security concern* in which a downloaded EFB update corrupted the EFB system:

> *After 'update complete', no airports were available and software would not work. Tech Support said the download was corrupted, and advised uninstall and reinstall. This did not help. Arrival at MIA for departure with no chart database. Captain had the same issue…. I suspect the problem was with the server or data. This could result in operational problems if it reoccurs. I don't think the system should erase a good data package and replace it with corruption. If the*

download is no good the system should not continue the process. There seems to be no way to verify or fix download issues other than a complete redo of the installation. I think the 'what-ifs' haven't been adequately considered in the change to full EFB. This needs to be reworked with the Commercial Chart maker. We should have a good backup plan for wide scale data corruption. (ACN# 1089948)

Part 135 Electronic Display Information Elements Concerns

All three Part 135 *Electronic Display Information Elements* concerns involved *electronic chart scrolling/zooming concerns*. See Table C-6 in Appendix C for all Part 135 *electronic display information elements* concerns by device type.

3.2.2 Hardware Concerns

Overview

Fifty-seven *hardware* concerns were reported, accounting for 18% of the 309 concerns identified in the ASRS safety reports. Figure 6 shows the percent each *hardware* concern was reported overall (see **Error! Reference source not found.** for a complete list of *hardware* concerns by type of operation).

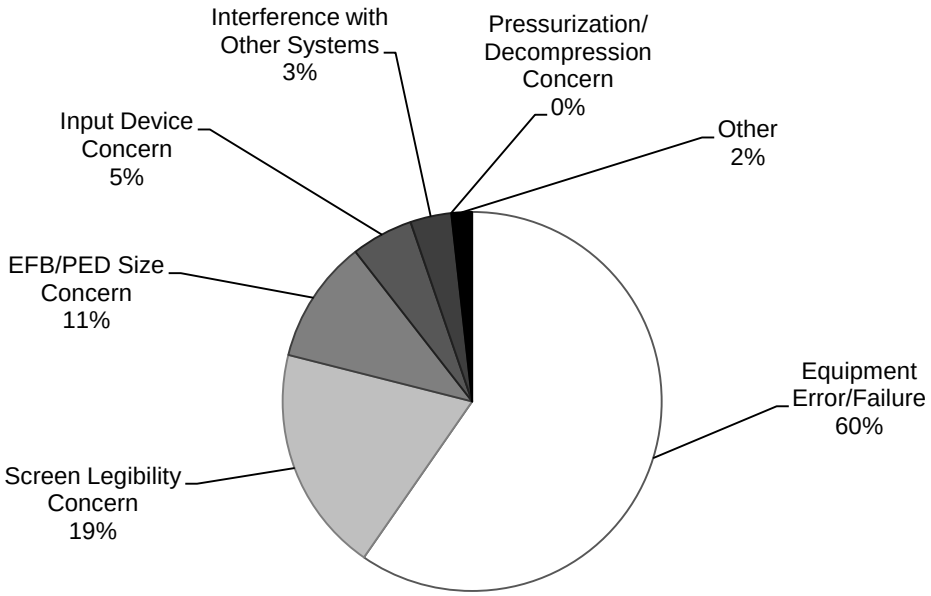

Figure 6. Percent of Hardware Concerns Reported.

As Table 6 shows, the hardware category includes *equipment error/failure* concerns (34), *screen legibility concerns* (11), concerns with the *size of the EFB/PED* (6), *input device concerns* (3), *interference with other systems* (2), and one concern, classified as *other* that described difficulty in starting up a laptop. Overall, approximately half of the *hardware* concerns were reported by Part 91 pilots (46%), followed by 44% by Part 121 pilots, and 11% by Part 135 pilots.

Table 6. Hardware Concerns by Type of Operation.

Hardware Concerns	Part 91	Part 121	Part 135	Total
Equipment error/failure	**17**	**16**	**1**	**34**
Inoperable or partially operable EFB/PED	0	8	0	8
Screen froze/went black	3	4	0	7
Unexpected shutdown	4	0	0	4
Automatically erased data	0	3	0	3
Battery concern	2	1	0	3
EFB/PED overheated	2	0	0	2
Unspecified cause	1	0	1	2
EFB/PED smoke/fire	1	0	0	1
Processor speed or memory concern	0	0	0	0
Other	4	0	0	4
Screen legibility concern	**5**	**3**	**3**	**11**
Ambient light/glare	2	1	2	5
Ambient light and display brightness	2	0	1	3
Brightness/contrast	0	0	0	0
Unspecified cause	1	1	0	2
Other	0	1	0	1
EFB/PED size concern	**2**	**2**	**2**	**6**
Input device concern	**0**	**3**	**0**	**3**
Touch screen/soft keys	0	2	0	2
Hard buttons/keys	0	1	0	1
Interference with other systems	**2**	**0**	**0**	**2**
Electromagnetic	1	0	0	1
Other	1	0	0	1
Pressurization/decompression concern	**0**	**0**	**0**	**0**
Other	**0**	**1**	**0**	**1**
Total	**26**	**25**	**6**	**57**

Part 91 Hardware Concerns

Equipment errors/failures were identified in 65% (17) of Part 91 *hardware* concerns, including: unexpected *shutdown* (4), an EFB/PED screen that *froze/went black* (3), *battery concerns* (2), an iPad *overheating* (2), and an iPad charger that began to smoke (1). Four additional reports did not fit into the defined categories and were classified as *other*, and one additional report described an EFB that failed due to an *unspecified cause*. Two example narratives of *Equipment errors/failures* are presented below.

In one report involving an EFB screen that *froze or went black*, both EFBs on the flight deck malfunctioned at the same time:

> *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)

In the following example of a *battery concern*, a backup EFB was present on the aircraft, but the pilot chose not to utilize the back up because there was not enough time to start the EFB while taxiing in:

> *While starting our taxi, our EFB battery went dead, therefore, I lost our airport chart. We have 2 EFBs, but by the time I got the other EFB up we would be at the ramp. The Controller was busy, so I hated to ask for progressive. My recommendation to crews is -- always print the charts you will need for the day.* (ACN# 819488)

When an EFB/PED fails and a backup is present on an aircraft, a pilot would require adequate cognitive resources and time available to either startup the backup device, or replace a battery in order for the back up to aid in mitigating a violation or deviation. If adequate time and resources are not available, it is possible that additional workload could result from using the backup, as the above excerpt shows.

Part 91 *screen legibility concerns* included comments on lighting conditions, brightness or glare. One report mentioned that the handheld computer "can barely be seen in the daylight by the pilot holding it, let alone the pilot taxiing" (ACN# 595465). *Inadequate size of the EFB/PED* was identified in two reports. In both cases, the screen was too small and required a high level of zooming, which resulted in loss of position awareness (refer to Table C-7 in Appendix C for Part 91 *hardware* concerns by device type).

Electromagnetic interference was reported by one Part 91 pilot. The pilot reported that an iPad caused *electromagnetic interference* with the magnetic compass. The pilot believed this was due to the placement of the iPad on the glare shield (refer to Table C-7 in Appendix C for all Part 91 *hardware* concerns by device type):

> *While conducting the STS VOR DME Runway 14 approach, and while executing the published procedure turn, our ground track crossed over onto the non-protected side, east of the final approach course. The cause for the deviation was the result of an object (an iPad) being placed on the glare shield which caused the magnetic compass to show an erroneous indication, and thus our directional gyro was not correctly referenced. While tracking outbound on the 326 radial, the CDI was centered and we tracked the course properly, however, once we began the procedure turn and turned left to what we believed to be was a heading of 281 as published, we were in fact on a heading closer to 300 degrees. We flew for 1 minute and then turned to the right to join the final approach course. During our turn back to course, the Center Controller advised us that we were east of the final approach course and that we needed to ascend immediately because we were below his MVA for the area we were in. Being that we were in VMC, I immediately canceled our IFR, and we continued VFR into STS to land. After landing we determined that the iPad being placed on the glare shield was the cause for the disturbance to*

the magnetic compass. As a further note, the iPad was not turned on; in fact the battery was fully discharged. The iPad is getting a lot of praise from the aviation industry, as it is certainly a useful tool for pilots, however, I would recommend that some literature be published to warn pilots of the potential danger it could present in the form of interference with other instruments if not mounted or placed in area known not to cause interference. (ACN# 916196)

Similarly, *interference with communications* was reported by one Part 91 pilot. In this case, the pilot believed a dual charger used to charge both an EFB and GPS unit caused interference with radio communications:

I had a new Scosche dual cigarette lighter charger that I purchased from [an aviation supply retail store] to power both the iPad and the GPS unit. I had used this on the way down with no issues. But, once airborne, I noticed that the radio noise was not going away. I began to be concerned that I was having dual radio failure, as this was happening on both of my radios. I was concerned about having total communication loss. I made a call to Tower and they read me loud and clear, but I was still having a very difficult time hearing anything. As I was trouble-shooting this I unplugged the cigarette lighter charger. The noise ceased, and everything was OK. The charger was emitting frequencies that were reading my radio unlistenable. (ACN# 1098330)

Part 121 Hardware Concerns

There were 25 concerns from Part 121 pilots that addressed hardware. Seven of the 16 *equipment error/failures* involved an *inoperable or partially operable EFB/PED*. One of these occurred because the equipment became cold soaked from being left in the aircraft for two days in extremely low temperatures (ACN # 540556).

Other Part 121 *hardware* concerns addressed *input devices* (3) and *screen legibility* (3). For the former, one pilot reported difficulty seeing the hard buttons/keys due to inadequate illumination at night (ACN# 836865); the others were related to touch points on the screen, which the pilot felt were too small and not calibrated properly (ACN# 841916), and did not work properly when touched (ACN# 1068333). For the latter, one pilot reported that glare on the EFB contributed to distraction which led to missing an Air Traffic Control (ATC) clearance, resulting in the pilot taxiing to the wrong runway (note: this report is also categorized as a S*elf-Reported Human Performance* concern under the *Distraction* category):

First flight of day. New Electronic Flight Bag (EFB) installed. Given taxi instructions to Runway XX. Distracted by new EFB and glare on screen. My expectation bias was for departing on Runway YY. During taxi on 'P' I turned on 'C' toward Runway YY. Ground advised us of our mistake. We then did a 180 turn on the ramp and taxied back to Runway XX via 'P'. (ACN# 913370)

Refer to Table C-8 in Appendix C for Part 121 *hardware* concerns by device type.

Part 135 Hardware Concerns

There were six *hardware* concerns from Part 135 pilots. Three involved *screen legibility concerns*: two

described *ambient light/glare* concerns, and one described an *ambient light and display brightness* concern. In one report, the pilot mentioned that although the EFB was large, it was difficult to see because it was held rather than mounted. This report also included opinion that the EFB used was too large for a small flight deck, and was one of two reports by Part 135 operators noting that the *size of the EFB* was a concern. An excerpt of the narrative is as follows:

> *Our EFBs are large, heavy and difficult to read in certain light. When you use them you become a computer operator and it takes most of your attention, especially if you must hold them (they are not mounted)… very impractical in a small corporate cockpit.* (ACN# 715045)

3.2.3 Self-Reported Human Performance Concerns

Overview

This category captures undesirable effects on human performance associated with the use of an EFB or PED being used as an EFB, as well as *self-reported human performance* concerns associated with entering data in the EFB/PED. Figure 7 shows the percent of *self-reported human performance* concerns reported overall. Table 7 shows concerns reported by Part 91, 121 and 135 pilots.

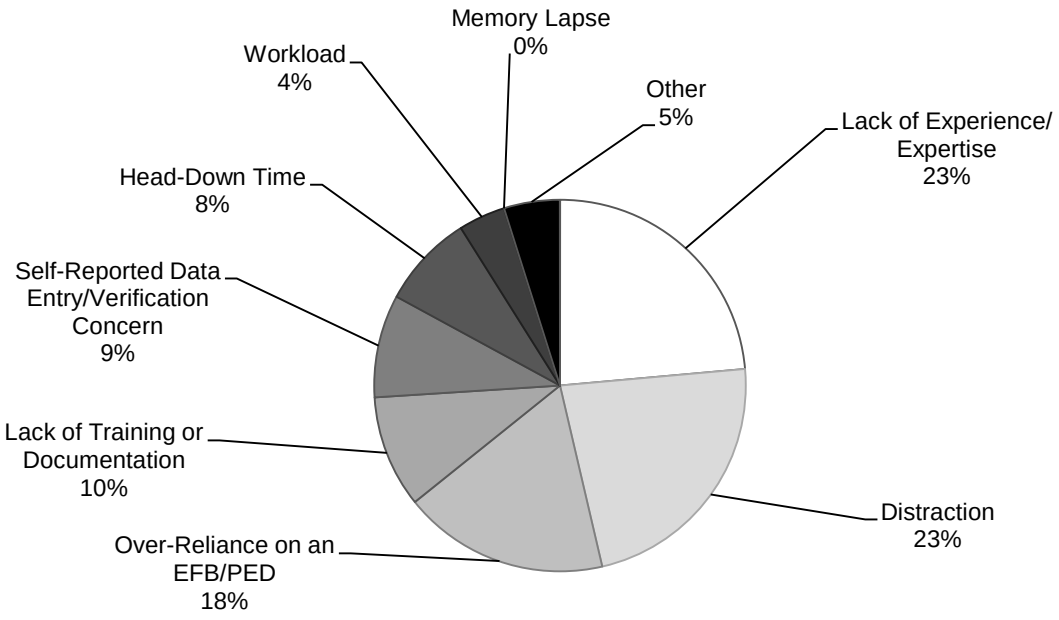

Figure 7. Percent of Self-Reported Human Performance Concerns Reported.

Table 7. Self-Reported Human Performance Concerns by Type of Operation.

Self-Reported Human Performance Concerns	Part 91	Part 121	Part 135	Total
Lack of experience/expertise	22	7	0	29
Distraction	13	14	1	28
Over-reliance on an EFB/PED	21	0	1	22
Lack of training or documentation	1	10	1	12
Self-reported data entry/verification concern	1	9	1	11
Head-down time	3	7	0	10
Workload	2	3	0	5
Memory lapse	0	0	0	0
Other	2	4	0	6
Total	**65**	**54**	**4**	**123**

Part 91 Self-Reported Human Performance Concerns

Thirty-four percent (22 reports) of these concerns reported by Part 91 pilots cited *lack of experience/expertise* as a concern. The reports involved the pilot being unfamiliar with a new application and/or unaware of particular features or data limitations. An excerpt from a report of a pilot who was not aware that Temporary Flight Restrictions (TFRs) were not depicted on the electronic chart is as follows (note that this report also captures *over-reliance on the EFB/PED* and is categorized as such):

> *For my flight to CRQ I received a weather briefing, on my iPad, through the ForeFlight app. I normally use DUATS golden eagle, on my computer, which graphically shows TFR's on the flight plan map. I didn't realize that the ForeFlight app doesn't display TFR's on the moving map. While I was descending from 10,500 msl I saw the smoke from a fire, on the ground, and realized there probably was a TFR in the area. I think I was down to 9000-9500 feet and I pulled up immediately to 11 or 12000. When I got home I checked on DUATS and saw there was a TFR on my flight path with a top of 10000. From now on I'll take my computer with me and also read the TFR NOTAMs or call FSS.* (ACN# 962082).

Thirteen reports from Part 91 pilots identified *distraction* caused by the EFB/PED. In these cases, pilots reported focusing on the EFB/PED, consequently missing important information (e.g., ATC transmission, autopilot malfunction) and/or a loss of position awareness.

Twenty-one reports involved an *over-reliance on the EFB/PED*, and described pilots using an EFB or PED as a primary source of information, failing to crosscheck the information with other flight deck sources. It is important to note that over-reliance was often reported in conjunction with *lack of experience/expertise* (4 reports), *scrolling/zooming concerns* (5), or the *arrangement of information* on the display (1). The following narrative illustrates an *over-reliance* concern and *inexperience* with a new iPad application (refer to Table C-10 in Appendix C for all Part 91 *self-reported human performance* concerns by device type):

In the week prior to the trip, I purchase a new application for my iPhone/iPad and a GPS receiver for the device. This application provides moving map display of the aircraft on Sectional Charts and Displays positional data for various airspaces. I also utilized other iPhone/iPad apps as well as Internet data to obtain airport information, weather observations, forecasts, and flight planning data. This was my first trip using this new application and I was excited in knowing the situational awareness and relative position to airspace would be easily viewed. I was also able to plot my exact route using GPS coordinates and noted the various ATC agencies from which I would need to obtain clearances. I headed out over the open ocean to the south tip of Catalina Island… upon exiting the aircraft, a local pilot asked me from which direction I came and advised me of the nearby TFR. Upon reviewing my flight path and the TFR… Based on my post flight review of my GPS Data and flight path, I likely entered the TFR on the 100 degree radial of the Santa Catalina VOR (SXC) at approximately 34 NM and exited the TFR on the 110 radial of the Santa Catalina VOR (SXC) at approximately 7 NM. This would have placed me approximately 3.75 NM inside the 60 NM diameter TFR at the deepest point... Being excited about the new situational awareness capability of the device I was using, I made the error of assuming all airspace was portrayed, including any TFRs. Upon review of the application I used for navigation, I discovered my error in that it does NOT graphically display TFRs. The resolution to this problem is that I simply will never rely on new technology as the sole means of my flight planning data. Instead, I will continue the practice I used in my previous 25 years of flying and call Flight Service for a briefing. I will use the iPad/iPhone applications only as supplements to my flight planning data and not as the sole source of that data. (ACN# 995263).

Part 121 Self-Reported Human Performance Concerns

In 7 reports, *lack of experience/expertise* was cited as a concern. Seven of these reports explicitly mentioned inadequate EFB/PED training. Lack *of experience/expertise* led to difficulty locating important information (4 reports), entering incorrect information into FMS (2), and contributed to distraction, workload or head down time (3). The following excerpts illustrate difficulty locating information due to inadequate training:

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)

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)

In 14 reports, pilots considered an EFB/PED a *distraction*; for example, pilots were preoccupied with performance calculations (7 reports), setting up a new EFB system (1), EFB malfunction (1), or EFB use in general (5). In two of the 14 reports, the pilot mentioned a general safety concern while being distracted during critical phases of flight. In the remaining 12 reports, pilots reported failing to perform other tasks, or performing them incorrectly, such as setting an incorrect speed, or entering a new altitude into the Flight Management System (FMS) or maintaining position awareness. For example:

We both expected to taxi to runway 26. When I called for taxi we were given a choice between runways 21 and 26. Runway 21 was closer so we requested runway 21 and we were cleared to taxi to 21 and apparently told to hold short runway 26. We crossed runway 26 without conflict but were told after we had crossed the hold short that we had not been cleared. We taxied to runway 21 and took off without incident. I was distracted by setting up the performance computer for the new runway and did not properly back up the captain. (ACN# 507712)

Part 121 pilots explicitly mentioned lack of training or insufficient reference material for the EFB/PED. An example is as follows:

This is a report regarding the lack of proper training surrounding the implementation of the iPad to the pilot group… 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 marginal 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)

A self-reported *data entry/verification* concern was cited in nine reports. These include erroneous inputs (5 reports), missing inputs (2), and failure to verify current entries from the previous flight (2) as illustrated in the following narratives:

Gate agent gave the fight crew the load sheet with an error, listing the number of passengers as 5 instead of 45. Neither the captain nor FO noticed the error. In cruise flight dispatch sent the ZFW and GWT via ACARS. The new numbers were entered into the FMC and OPC for new landing data. I will give a more thorough check of the load sheet against what is on the napkin. Load sheet listed 5 passengers when there [were] 45 passengers. (ACN# 726238)

We accepted the aircraft in HOU with the OPC already on and up to date. Referencing the new EBF regarding wingletted 300's, we missed the fact that the AM crew had selected the database as if the aircraft was wingletted, which it wasn't. Prior to descent, we noticed our error and made the correction to use the database for a non-wingletted (N) aircraft. Follow the RBF and verify the correct prefix is selected for the type of plane we are flying. We had the W prefix selected on the OPC, rather than the N. (ACN# 723592)

Part 121 pilots cited that head-down time due to EFB use contributed to an event in seven reports. In one report, the captain missed a hold-short instruction, and the first officer was heads-down computing performance calculations instead of monitoring taxi progress out the window, leading to the aircraft crossing a runway without clearance (ACN# 603224). Another example of increased *head-down time* is as follows (note that this report also includes a *flight performance calculation concern*):

> *When taking off to the North, the primary departure is runway 35L not runway 36R, when departing to the South it is runway 17R not runway 18L. The takeoff performance computer and FMS seems to put in the incorrect runways… [This can result in] unnecessary heads-down time by one of the pilots typing in the correct data… This is a setting for potential error during a critical phase of flight.* (ACN# 709369)

Three Part 121 reports described an increase in *workload* as a result of EGB/PED use. *Lack of experience/expertise* also contributed to two of these reports, as in the following example:

> *The electronic flight bag that we were using was recently installed in our aircraft type and had caused a change in my habit pattern, causing me to not change the SID for our new takeoff runway. This was the main contributing factor. Another contributing factor is that the 727 has several non integrated systems (Dual EFB, Dual GPS, Performance Data computer) that increase workload during runway changes.* (ACN# 920841)

Four reports were categorized as *other*, including two cases of a pilot misreading critical information (e.g., runway number), and two cases of a pilot failing to consult electronic documents for the minimum equipment list (MEL). Refer to Table C-11 in Appendix C for Part 121 *self-reported human performance* concerns by device type.

Part 135 Self-Reported Human Performance Concerns

Four reports from Part 135 pilots noted an concern related to human performance: one in which the pilot entered an incorrect heading (220 instead of 280), resulting in a heading deviation and missing an altitude crossing restriction (ACN# 688281); one in which the pilot became *distracted* by a new EFB failing (ACN# 866666); one involving incorrect use of an EFB due to lack of *experience/expertise*, as the company did not provide pilots with an operating guide for the newly installed EFBs (ACN# 881702); and one involving *over-reliance on an EFB* in which the pilot stated the "exclusive use of the electronic flight bag (EFB) program to review the departure" was a factor in missing an altitude restriction on departure (ACN# 690199). Refer to Table C-12 in Appendix C for Part 135 *self-reported human performance* concerns by device type.

3.2.4 Placement/Mounting/Stowage Concerns

Overview

There were only 14 concern reported addressing the *placement, mounting and stowage* of EFBs.

Figure 8 shows the percent of these concerns reported overall (see Table 8 for concerns as reported by Part 91, 121 and 135 pilots).

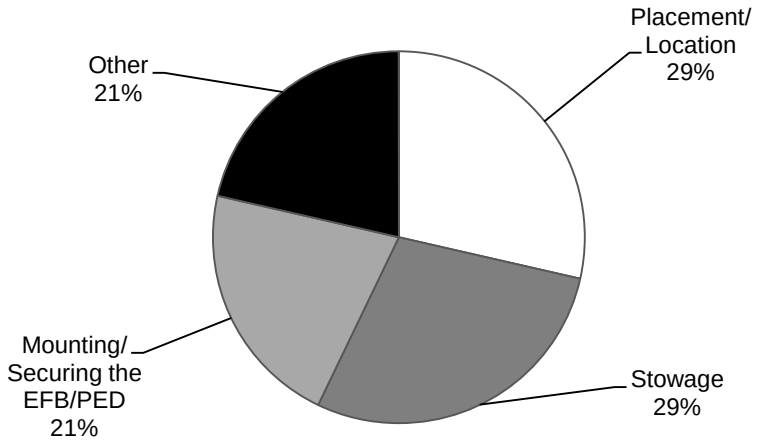

Figure 8. Percent of Placement/Mounting/Stowage Concerns Reported.

Table 8. Placement/Mounting/Stowage Concerns by Type of Operation.

Placement/Mounting/Stowage Concerns	Part 91	Part 121	Part 135	Total
Placement/Location	3	0	1	4
Poor view of EFB/PED	1	0	1	2
Poor view of instruments, controls or out the window	1	0	0	1
Other	1	0	0	1
Stowage	3	0	1	4
Mounting/securing the EFB/PED	1	1	1	3
Other	0	3	0	3
Total	**7**	**4**	**3**	**14**

Part 91 Placement/Mounting/Stowage Concerns

Three reports involved the *placement/location* of the EFB/PED. In one of these, the pilot describes a situation where the handheld method of using the EFB tablet makes it difficult to view the EFB:

> *While confusion with the airplane taxiing ahead of us didn't help, it was a minor factor compared with the handheld electronic charts. The Fujitsu unit we use can barely be seen in daylight by the pilot holding it, let alone the pilot taxiing… As the PF cannot simply look over and review the chart, he has to rely on memory or his SIC to help, or pull out his own unit to review – which is often impractical when your attention is diverted during busy taxi or flying times…* (ACN# 595465)

In a second report, a pilot described engaging the rudder and yoke locks due to high winds. An iPad was

attached to a yoke mount, which obstructed the pilot's view of the yoke. Thus, the pilot failed to remove the yoke gust lock during preflight, which ultimately resulted in a runway excursion (ACN# 1097696).

In a third report, the pilot unintentionally disengaged the autopilot by inadvertently activating pitch trim with the EFB resting on the yoke. An excerpt from the narrative is as follows:

> *I was updating the fuel flow numbers on the FMS keyboard while the First Officer (pilot not flying) was working with the tablet computer (EFB) resting on his yoke… When I looked up at the flight instruments, I noted a 20-25 degree bank, 3-4 degree nose down pitch and a 250 FT altitude loss. The autopilot was disconnected. I immediately initiated aggressive roll and pitch inputs to recover heading and altitude. After I recovered heading and altitude, the First Officer re-engaged the autopilot on my call… Discussion with the First Officer led to the conclusion that he inadvertently activated the pitch trim, which causes the autopilot to disconnect without an aural annunciation. The momentary trim activation was not long enough to activate the audible trim-in-motion [annunciation].* (ACN# 849256)

Three Part 91 reports involved *stowage* of the EFB/PED. One described safety concerns, unrelated to a specific event, regarding the act of stowing an EFB and removing a stowed EFB, as the pilot felt this can be awkward and distracting.

> *We approached SMO from southeast. We were concerned, and flew, direct DARTS. Before crossing DARTS, we were turned inside DARTS by no more than 1 mile and were told to intercept GPS-A approach course. The GPS-A approach had been entered into the FMS well before this point and the autopilot was engaged, and aircraft intercepted course and was established inbound. We were cleared for the approach and handed off to SMO Tower, who cleared us to land and told us that the preceding aircraft went missed. We descended to 2600 FT to cross BEVEY, looked at the FMS FPL page, and saw Runway 21 as the next point, and therefore dialed in 680 FT in the altitude selector... The next transmission from tower was "Callsign, low altitude alert, altimeter 29.97, you are 0.2 miles from CULVE, we show you at 750 FT, altitude at CULVE is 1120." PM replied "altimeter 29.97, roger, field in sight". Tower responded with "Roger." Both pilot flying and pilot not flying looked at the MFD and did not see CULVE displayed, or listed on the FPL page of the FMS... When loading the SMO GPS-A approach, FMS does not load CULVE. 2) Very high workload during approach to landing phase. 3) Crew reliance on using FMS / MFD as primary data source. (Pulling out a stowed EFB during approach in low visibility conditions is awkward and not conducive to safe operations; pilot not flying is looking for runway and monitoring instruments, pilot flying has hands full.) 4) After initial briefing of the approach plate on the EFB by both crewmembers, the FMS was used as primary source, therefore not prompting crew of CULVE and its crossing altitude during high workload environment.* (ACN# 835726)

A second *stowage* concern involved the pilots missing important information on an electronic chart due to the EFB being stowed, and contributed to a heading deviation:

> *An additional contributing factor was the use of the new Electric Flight Bag (EFB) which arrived*

about two weeks before the incident. Both EFBs were on line and programmed for the departure but set aside next to each Pilot's arm rest during the initial aircraft climb out. Normally the paper departure would have been in full view during the climb, but the new EFB was used instead and, as noted, were not in view due to being stowed. (ACN# 868611)

One report involving the *securing solution* of the EFB was identified. In this report, the EFB was not mounted, and slipped off of the pilot's knee during takeoff. This was specifically cited as one of several contributing factors to a heading deviation (ACN# 944330). Refer to Table C-13 in Appendix C for Part 91 *placement/mounting/stowage* concerns by device type.

Part 121 Placement/Mounting/Stowage Concerns

Four repots cited concerns with the placement, mounting or stowing of an EFB or PED. One report submitted by a Part 121 pilot cited safety concerns regarding *mounting/securing the EFB*. In this report, an iPad mount separated from the window, and as the pilot attempted to catch it, the aircraft banked, resulting in slight heading deviation (ACN# 1077488).

Two reports submitted by Part 121 pilots were related to the installation of EFB mounts before the EFBs were available/functional. In these cases, EFBs mounts were installed where the paper chart holders and clips used to be. There is limited space available on the flight deck; thus, if the EFB with electronic charts is not available, and there is no longer dedicated space for placing paper charts, then viewing paper charts may be difficult. Two pilots noted this concern in the narratives below:

The chart holder on the yoke does not hold the chart where it is visible so that a pilot can divide their attention inside and outside the aircraft. In fact, the current situation dictates that even the cleverest pilot still must take their attention completely away from the outside to refer to his/her chart… as we transition to the approach phase, it becomes critical to safety that both pilots have quick, viewing access to their charts without taking all of their attention away from looking outside and flying the airplane… We as pilots have had to resort to our own ingenuity but many folks simply don't refer to their charts as much. This is because they have chosen to FLY the airplane first and rely more heavily on their flying partner and their memory. We all look forward to functional EFB's but there should not be a safety compromise in the mean time. (ACN# 921736)

…an ergonomically challenging factor we have all been dealing with is having an Electronic Flight Bag (EFB) mounting bracket for a chart holder. There is no convenient place to have your charts visible at a glance for easy reference, especially at night. Many times while flying and taxiing my charts are not visible because they are on the floor, my flight bag, the little trash can, or clipped down between my legs where I don't have a prayer of reading them without a total distraction. There has to be some chart holder modification that can be mounted over this bracket until the EFBs finally start working. (ACN# 952490)

One additional report described a similar concern with EFB brackets used to hold paper charts while EFBs are stowed:

Pilot flying was hand flying, pilot not flying put 23000 in FCP altitude window. Then all the altitude constraints programmed in the FMS disappeared from the FMS flight plan and the NAV display. The FMS directed an immediate climb. Absent the FMS guidance, pilot not flying tried to reference the Commercial paper charts, but the airplane has an Electronic Flight Bag (EFB) bracket instead of a paper holder clip (EFB's are deactivated and placed in the closet) so the paper charts had fallen out of sight. By the time the pilot not flying could reference paper Commercial Charts, the aircraft had climbed to 11,000 FT. The constraint at the next point HURDL is at or below 10,000 FT… The paper charts don't work very well with the EFB bracket installed and tend to fall to the floor on takeoff. This was a mistake that happened very quickly and the lack of a handy chart was a player. (ACN# 1076926)

Part 135 Placement/Mounting/Stowage Concerns

Three reports were identified, including one *placement/location* concern, in which the position of the EFB was not easily viewable for the either of the two pilots (ACN# 710292). The second report involved an EFB that was stowed during takeoff so that the departure procedure was not in view/accessible; this contributed to the aircraft climbing through an altitude restriction (ACN# 833378). The third report described an unsecured iPad on the pilot's knee that was tossed out of the flight deck during intense updrafts and downdrafts (ACN# 1079717).

3.3 Potential Software Errors

ASRS reports were also examined for potential software errors, in addition to the human factors concerns previously discussed. The results are presented in this section.

Potential software errors were grouped into four categories:

- *System requirements error.* The report mentioned one or more of the following issues – a zooming error, a condition in which symbols overlapped, or that the information displayed on the EFB/PED was confusing to the pilot – and did not mention pilot "inexperience."
- *Software processing error.* The report explicitly described incomplete or incorrect software coding or programming (e.g., software compiler or linking error).
- *Lack of training.* The report mentioned a pilot's inexperience with the EFB/PED (regardless of other details in the report).
- *Unsure*. The report mentioned the use of software but did not provide enough information to categorize the report as one of the previous three subcategories.

The 112 ASRS safety reports related to EFB/PED use that mentioned software include 56 Part 91 reports, 53 Part 121 reports, and three Part 135 reports. Fifty-two were classified as *system requirements errors*. These reports included zooming errors, or cited that the information displayed on the EFB/PED was confusing to the pilot. Note that *lack of experience* or *lack or training* was not mentioned in these reports. The following narrative presents an example of a *system requirements error*, in which heading

information was displayed incorrectly at certain zoom levels, contributing to a heading deviation:

> *Presentation of electronic chart info on aircraft display omitted the display of a "1" in "190" of the textual departure heading instructions… It was later discovered that at other zoom levels, the text was displayed correctly.* (ACN# 740010)

Forty-one reports were classified as *unsure* because the report did not give enough information. Nineteen reports were coded as *lack of training* because the report included wording related to the pilot's inexperience with the EFB. No reports met our criteria for a s*oftware processing error.* See Figure 9Figure 9 for a graphical representation of the findings.

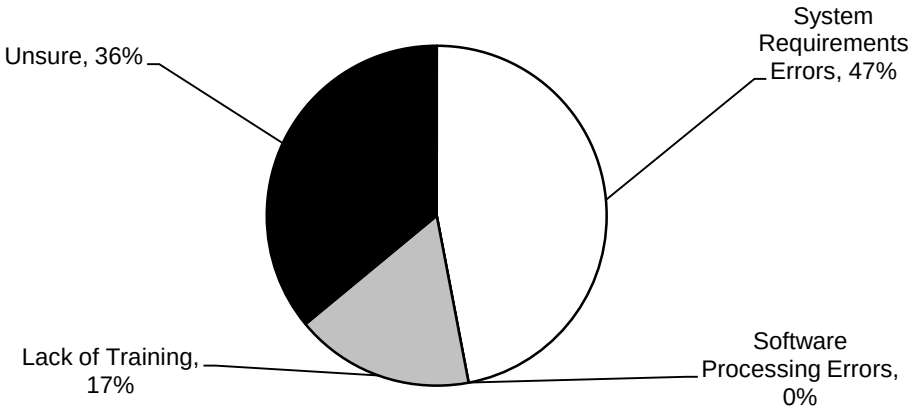

Figure 9. Percent of Potential Software Error Sources Identified.

3.4 EFBs as a Safety Factor

The extent to which the EFB or PED concerns affected the outcome of each report was identified by categorizing the EFB/PED as being either a primary or secondary factor in the event. Any deviations, airspace violations, surface incidents or runway incursions that resulted were also noted. The results are presented in this section.

3.4.1 EFB as a Primary or Secondary Factor by Type of Operation

Figure 10 shows the percent of Part 91, 121 and 135 reports that involve an EFB or PED used as an EFB as a primary factor (i.e., having a direct influence on the outcome of the event), or a secondary factor (i.e., having an indirect influence on the event and only exacerbating or contributing to the event). In some cases, reports described general safety concerns and did not result in a negative outcome. These reports were captured as *no specific event*.

For Part 91 operations, the EFB/PED was a primary factor in 57% (65) of these reports and a secondary factor in 37% (42). General safety concerns were reported in 7% (8) of the reports. In Part 121 reports, the EFB/PED was a primary factor in 19% (22) of the reports, and a secondary factor in 34% (38). Part 121 pilots also reported a general safety concern that did not lead to a negative outcome in 47% (53) of reports. The EFB/PED was a primary factor in 33% (4) of Part 135 reports, and was a secondary factor in 42% (5). Part 135 pilots reported a general safety concern that did not lead to a negative outcome in 25% (3) of reports. Refer to Table C-3 in Appendix C for a breakdown of EFB/PEDs as a primary or secondary factor by device type.

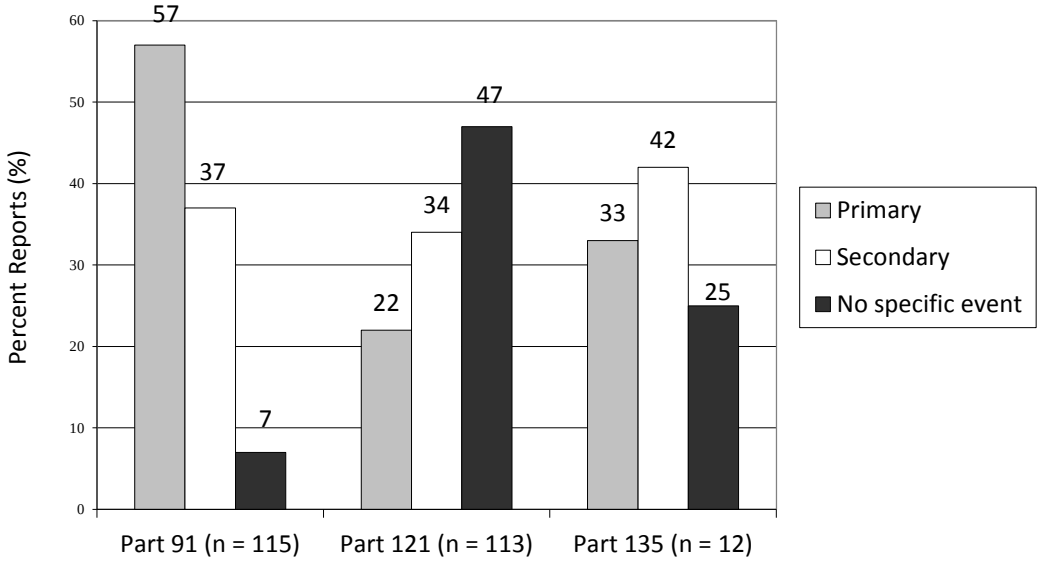

Figure 10. Percent Part 91, 121 and 135 Reports with EFB or PED as A Primary or Secondary Factor.

3.4.2 Anomalies, Deviations and Airspace Violations

All anomalies, deviations and airspace violations that occurred in relation to a potential safety concern involving the use of an EFB or PED being used as an EFB were noted. Figure 11 depicts the results overall. Altitude, heading and speed deviations occur when a pilot fails to meet or maintain the altitude, heading or speed assigned to the aircraft by ATC. For example, if ATC assigns an aircraft to flight level (FL) 120, but the pilot mistakenly climbs to FL150. Runway incursions are a specific type of incident defined by the FAA as "any occurrence at an aerodrome involving the incorrect presence of an aircraft, vehicle or person on the protected area of a surface designated for the landing and take-off of aircraft" (FAA, 2011a). Surface incidents currently include any unauthorized activity on the movement area of the airport surface other than a surface intended for the take-off and landing of aircraft (e.g., taxiways)[4]. The type of anomaly that resulted from each event was tallied by type of operation, as presented in Table 9.

[4] Prior to October 1, 2007, runway incursions and surface incidents were defined using different definitions, affecting the categorization of these events. Refer to the FAA 2011 ATO Safety *National Runway Safety Plan* for additional information.

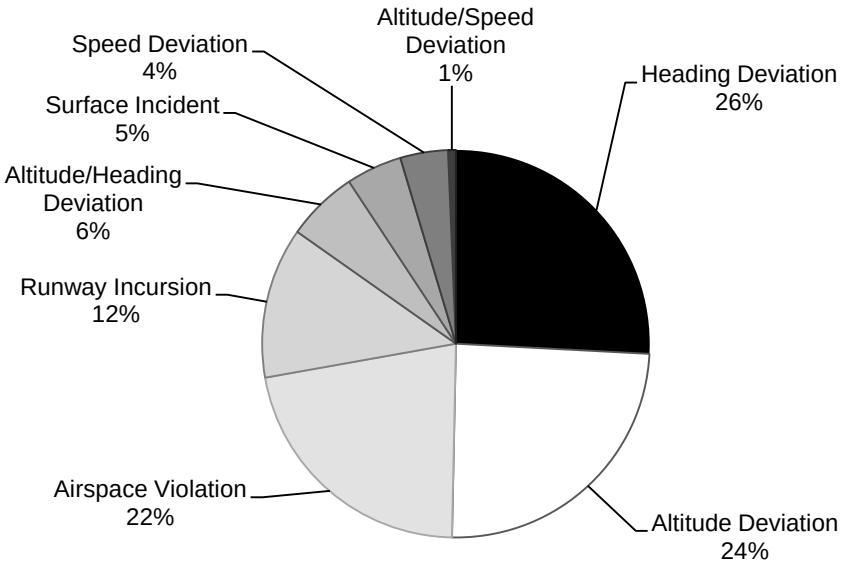

Figure 11. Percent of Anomalies, Deviations and Airspace Violations.

Overview

An EFB/PED contributed to an anomaly, deviation or airspace violation in 63% (151) of the 239 ASRS reports. One heading deviation and one altitude deviation occurred in addition to a conflict (i.e., loss of required separation), and eight reports included a heading and altitude deviation. Heading deviations were cited in 48 reports, including one conflict and nine altitude/heading deviations; this accounted for 32% of all anomalies. An EFB/PED was a factor in 46 altitude deviations (30% of all anomalies) including one conflict and nine altitude/heading deviations.

Table 9. Anomalies, Deviations and Airspace Violations by Type of Operation.

Anomalies, Deviations and Airspace Violations	Part 91	Part 121	Part 135	Total
Heading Deviation	27	9	3	39
Altitude Deviation	18	16	3	37
Airspace Violation	33	0	0	33
Runway Incursion	10	8	1	19
Altitude/Heading Deviation	8	0	1	9
Surface Incident	0	7	0	7
Speed Deviation	5	1	0	6
Altitude/Speed Deviation	0	1	0	1
Total	**101**	**42**	**8**	**151**

Part 91 Anomalies, Deviations and Airspace Violations

One hundred one of the 115 Part 91 reports cited an anomaly in which EFB/PED use was a contributing factor. Airspace violations were exclusively cited by Part 91 pilots, accounting for 33% (33) of anomalies.

EFB/PED use contributed to a heading deviation in 27% (27 reports), while altitude deviations were cited in 17% (17). An altitude and heading deviation combined were reported in another 8% (8) of the reports. A runway incursion was indicated in 10% (10), and a speed deviation was cited in 5% (5).

Part 121 Anomalies, Deviations and Airspace Violations

Of the 42 anomalies related to EFB/PED use that were reported by Part 121 pilots, an EFB/PED concern contributed to altitude deviations in 38% (16 reports), and contributed to heading deviations in 21% (9). Runway incursions were also cited in 19% (8) of reports. Overall, Part 121 reports accounted for 58% of all runway incursions and surface incidents. In these cases, use of the EFB contributed to the incident during taxi – for example, the pilot was distracted by entering data into the performance computer (4 reports), distracted/head-down by the electronic airport chart (5), misled/confused by the electronic airport chart (3), could not find information due to the small size of the EFB screen (1), could not send charts to the pilot flying due to inoperable EFB (1), or led to a delayed takeoff due to the performance computer automatically erasing flight data (1).

Part 135 Anomalies, Deviations and Airspace Violations

There were only 11 Part 135 reports identified. Of these, an EFB or PED being used as an EFB contributed to four altitude deviations and four heading deviations (including one report that resulted in both altitude and heading deviations), and one runway incursion.

3.5 Phase of Flight

We examined the phase of flight in which the concern occurred. Pilots could note the phase of flight in two ways in the ASRS report: one was in the "phase of flight" field and the other was in the narrative. In some reports, the two did not match. That is, the EFB or PED concern was not consistent with the information in the ASRS phase of flight field, in some cases because the EFB concern did not occur at the same time as an anomalous event (e.g., altitude or heading deviation). To provide consistency in examining the phase of flight, we used the following seven categories: parked/pre-flight, taxi (rolling), taxi (hold short), departure, enroute, landing, and arrival. The results are presented in Figure 12.

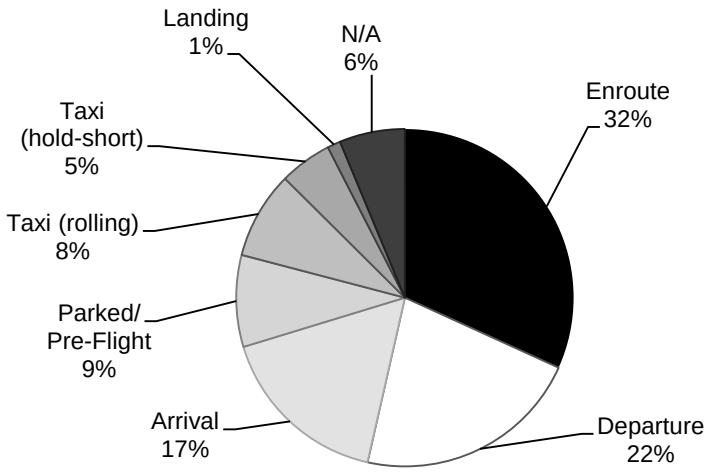

Figure 12. Percent of Phase of Flight In Which Concerns Occurred.

Pilots reported an EFB/PED concern that occurred in the enroute and departure phases of flight in 32% (76 reports) and 22% (52) of all ASRS reports, respectively. Concerns occurred in the arrival phase in 17% (40) of reports. Taxiing aircraft were involved in 13% (20 rolling and 12 holding short or involving a hold-short instruction), and only 9% (21) of reports involved aircraft that were parked during pre-flight. Three reports described EFB/PED concern during landing. Additionally, there were 15 reports in which the concern described was a general safety concern but not related to a specific event during the flight (refer to Table C-2 in Appendix C for the phase of flight for each type of operation by device type). Table 10 shows phase of flight by type of operation).

Table 10. Phase of Flight Reported by Type of Operation.

Phase of Flight	Part 91	Part 121	Part 135	Total
Enroute	48	26	2	76
Departure	32	16	4	52
Arrival	20	17	3	40
Parked/Pre-flight	2	19	0	21
Taxi (rolling)	5	15	0	20
Taxi (hold-short)	6	5	1	12
Landing	2	1	0	3
N/A	0	14	1	15
Total	**115**	**113**	**11**	**239**

The ASRS report findings demonstrate that potential safety concerns exist involving the use EFBs and PEDs being used as an EFB. The following sections discuss similar types of concerns, including distraction and head-down time, as cited in FAA runway incursion and accident/incident reports.

4. FAA Reports

4.1 Runway Incursion Reports

The FAA Runway Safety Office (RSO) assesses all runway incursions that occur at towered airports in the United Sates (US). As described in the previous section, the FAA defines a runway incursion as "any occurrence at an aerodrome involving the incorrect presence of an aircraft, vehicle or person on the protected area of a surface designated for the landing and take-off of aircraft" (FAA, 2011a). When an incursion occurs, a mandatory report is initially filed by ATC, followed by an official FAA investigation. A narrative summarizing the incursion, excluding any personally identifiable information, is made publically available in the Runway Incursion database accessible on the FAA Aviation Safety Information Analysis and Sharing (ASIAS) website.

Two runway incursion reports involved the use of an EFB/PED. In one report, a pilot became distracted and crossed the hold short line, after being instructed to hold short, when his iPad indicated he was in the vicinity of a hot spot (i.e., an area of the airport surface prone to incidents or accidents that requires additional caution from pilots and vehicle drivers) (Event # 11549). In a separate but similar report, a pilot was head-down with an airport diagram on his iPad , and crossed a hold short line after being instructed to hold short (Event # 11017).

4.2 Accident/Incident Data System Reports

The FAA Accident/Incident Data System (AIDS) database contains all aviation incidents that have occurred since 1978. The incidents do not meet the criteria required for NTSB accident investigation, but either compromised or had the potential to compromise the safety of operations. Each incident is investigated, and causal factors are identified. A narrative summarizing each incident is made publicly available in the FAA AIDS database on the ASIAS website. Note that reports prior to 1995 include a summary narrative, while reports from 1995 or later include a full-length narrative.

Two AIDS reports identified an EFB/PED as a factor in the incident. In one report, a pilot became distracted by an iPad. The pilot dropped a flashlight that knocked the iPad off the pilot's leg onto the floor. The pilot was head-down and taxied the aircraft across the runway into the grass; both aircraft props struck the runway (Report # 20120821025749I). In a second report, the flightcrew was unable to maintain airspeed due to incorrect parameters that were entered into the onboard performance computer (OPC), as the following excerpt illustrates:

> *OPC indicated FL350 was available at their weight; however outside air temperature was 20° warmer than anticipated at 350. Outside air temperature at FL310 was apparently not used to update the OPC thus giving invalid data for maximum available FL.* (Report # 200007100252091)

The incident resulted in flightcrew counseling and training, and review of OPC use and dispatch procedures.

5. NTSB Accident Reports

The National Transportation Safety Board (NTSB) maintains a publicly available online database of aviation accidents and selected incidents that have occurred since 1962[5]. The database includes basic information about each accident (e.g., airline involved, date, time, facility, etc.) and a summary narrative. When an investigation is completed, a final report is issued that provides the details of the event, any testing and analysis that were conducted, and their conclusions and safety recommendations to mitigate similar future events. The completed full-length reports are available at the NTSB website. A link to each report is provided in the References section.

Two NTSB accident reports identified an EFB as a contributory factor, both of which involved performance calculations (note that the NTSB reports did not involve PEDs being used as an EFB). Each accident and the recommendations made in response to the concern are discussed briefly below. Note that these reports were also identified in *Review of Safety Reports Involving Electronic Flight Bags* (Chandra & Kendra, 2010).

In one accident (NTSB/AAR-00/02), the NTSB found that the flight crew had incorrectly calculated the available landing distance despite being experienced in using a performance computer (airport performance laptop computer, or ALPC). In this accident, a McDonnell Douglas (MD-11) aircraft, operated by Federal Express, Inc. (FedEx) crashed during landing at Newark, New Jersey on July 31, 1997 at approximately 1:30 AM Eastern Daylight Time[6]. Both crew members and two passengers onboard were able to exit the aircraft successfully, but the aircraft was destroyed by fire. While preparing for landing, the first officer calculated the aircraft's landing distance using the ALPC approximate landing distance values and erroneously compared the values to the after-glideslope touchdown distance on the instrument approach plate. The erroneous calculation resulted in a 780 foot stopping margin for medium braking and a 1,830 foot stopping margin for maximum braking, which was significantly lower than the correct stopping margin (1,680 for medium braking and 2,730 feet for maximum braking). At the time of the accident, the aircraft had one inoperative thrust reverser, and several past autobrake failures. These concerns, combined with the incorrect landing distance, led the captain to a false sense of urgency to touchdown early on the runway, resulting in actions inconsistent with landing procedures, causing an unstable landing. Rather than initiating a go-around, the flight crew attempted to salvage the landing which exacerbated the situation, resulting in the crash. NTSB recommendation A-00-95 regarding the use of performance computers proposes that Part 121 aircraft carrier principal operations inspectors be required to ensure that the procedures and training related to the use of these devices, including data interpretation (e.g., landing distance), are sufficient.

The second NTSB report (NTSB/AAR-07/06) also involved landing distance concerns related to a

[5] Complete narratives are not always available prior to 1993, or for accidents currently under revision and where the NTSB is not the primary investigator.

[6] At the time of this accident, the ALPC was not specifically identified by the FAA as an EFB. However, the flight performance calculation function is considered an EFB function; thus we included this accident in our report.

performance computer (onboard performance computer, or OPC); however this time the outcome was fatal. The flight crew was unaware of the underlying assumptions used in landing distance calculations, and erroneously expected a longer stopping margin than was available at that time. On December 8, 2005 at approximately 7:00 PM Central Standard Time, a Boeing 737 operated by Southwest Airlines (SWA) experienced a runway overrun while landing at Chicago Midway International Airport in Chicago, Illinois. Subsequent to the overrun, the aircraft continued to roll onto a roadway and crashed into a vehicle before coming to a stop. Vehicle occupant injuries ranged from minor to severe, and one child was killed. Aircraft crew and passengers sustained only minor injuries. In this case, the OPC calculated available landing distance based on a smaller tailwind (8 knots) than was actually present (11 knots), providing the flight crew with a stopping margin that was greater than what existed at that time. Thus, the OPC calculations were optimistic, while the pilots believed the calculations to be conservative. Also found to be contributory was the failure of the airline to provide crews with adequate guidance, training and procedures related to landing calculations. NTSB recommendation A-07-58 suggests that all Part 121 and 135 operators be required to ensure all electronic computing devices onboard the aircraft display critical performance calculation assumptions clearly and automatically.

6. International Safety Reports

6.1 Overview

Both ASRS and NTSB safety reports address the types of potential safety concerns related to EFBs and PEDs (used as an EFB) use in the United States only. We were interested in gathering international safety reports to better understand these potential safety concerns and risk factors from a global perspective.

As previously stated, the number of reports discussed is not representative of the number of incidents that have occurred involving an EFB or an alternative electronic device used as an EFB, both nationally and internationally. In addition to providing information about safety concerns involving EFB use, the recommendations resulting from internationally reported events may also be applicable to safety concerns regarding EFBs in the United States, as well as the aviation community at large.

Our search identified 27 reports from the United Kingdom's (UK) aviation regulatory entity, the Civil Aviation Authority (CAA), two reports from the Transportation Safety Board of Canada (TSB), one from the French Bureau of Enquiry and Analysis for Civil Aviation Safety (BEA) of France, and three reports from the Australian Transport Safety Bureau (ATSB). The findings will be discussed by the agency providing the report.

6.2 CAA Reports

6.2.1 Report Design and Information Collected

The CAA is the UK's independent aviation regulatory entity, established in 1972. The CAA collects safety and operational data involving UK registered aircraft or aircraft operating within UK airspace at the time of the incident. The data includes both voluntary, confidential safety reports and mandatory incident and accident reports, although the CAA is not responsible for accident investigation. This data is used to identify ways to improve aviation safety both within the UK and abroad. However, the data is not made available through any publicly accessible database, and must be accessed by submitting a formal inquiry. The CAA reports included in this effort were voluntary safety reports, as no incident or accident reports were retrieved.

The findings from the CAA reports are presented separately from the other international reports because they are voluntary occurrence reports. Thus, these reports were examined using the taxonomy shown previously in Table 2. A sample report is provided below:

> *During [Computerized Take-Off Performance] CTOP calculation prior to flight a difference was*

observed with CTOP v42 and CTOP v41. When take-off performance was calculated crew were presented with two different V1 speeds. On further investigation it appeared that v42 did not change V1 for wet or dry performance. Lower V1 was selected and v41 used for take-off performance. Subsequent investigation revealed that when CTOP version 9.1 was released on 7 Jun 2010 an error was made in programme source code that caused programme to calculate dry runway performance when wet runway was selected. Updated version 9.2 has now been released to correct error and an Operations Notice had been published to advise crews not to use previous version 9.1 for wet take-off performance calculations. Quality checking processes to be assessed.

6.2.2 Results

Overview

Fourteen voluntary occurrence reports involving an EFB/PED were retrieved from the CAA. An EFB was found to directly contribute to or influence 27 of these and were included for review. These reported incidents occurred between June 2006 and January 2014. An overview of the findings is shown in Table 11. Eight of the CAA reports identified a laptop as the device type; two were called an "EFB" and four were referred to as a "Less Paper Cockpit," or "LPC". Three reports did not specify the device type.

Table 11. CAA Safety Report Concerns.

Concerns	Total
Electronic Display Information Elements Concerns	**18**
Flight performance calculation concern	10
Integration failure	3
Electronic documents	3
Difficulty retrieving electronic document	3
Electronic charts	2
Incorrect information	2
Hardware Concerns	**5**
Equipment Error/Failure	4
Overheating/Battery concern (fire/smoke)	2
Inoperable or partially operable EFB/PED	1
Other	1
Faulty components (fire/smoke)	1
Interference with other aircraft systems	1
Self-Reported Human Performance Concerns	**2**
Data entry/verification concern	1
Distraction	1
Placement/Mounting/Stowage Concerns	**2**
Placement/Location	1
Mounting/Securing the EFB/PED	1
Total	**27**

Electronic Display Information Elements Concerns

Eighteen reports identified *electronic display information elements* concerns; most of which were related to *performance calculations* (10). Five of these reports involved discrepancies in take-off performance values. In one report, each pilot calculated take-off performance using their laptop, and each laptop displayed a different result, despite having been synchronized. The pilots checked in with dispatch and received yet another result. Upon investigation, it was discovered that the captain's computer had become corrupted[7]. A similar report also involved discrepancies among several information sources. While entering information into the LPC, the pilot noticed the aircraft would be 700 kilograms above the Maximum Take-Off Weight (MTOW). The pilot checked for erroneous values and found three different MTOW values from three separate sources. The reason for this discrepancy is unknown, as the pilots stated that no alterations had been made to the laptop. In a third *performance calculation concern*, the flight crew noticed that take-off performance calculations were the same for both wet and dry runway conditions in Computerized Take-Off Performance (CTOP). An investigation revealed an error in the laptop source code, which caused the faulty calculations, and a software update was released to correct the problem. In a fourth report, the crew noticed that the LPC laptop calculations had automatically updated to a different airport while en route. The cause of this was not determined.

Three *electronic display information elements* concerns involved *integration failures*, in which the EFB failed to synchronize with other flight systems. In one report, this affected NOTAMs and weather data. In the second report, sector data was not downloaded even though the EFB showed the data sync was successful. In the third report, a software bug caused severe system lag, and prevented performance data from the current airport being loaded into the EFB. Fortunately, the erroneous values (from the previous airport) were identified prior to departure.

Three reports involved *electronic document retrieval*. In all of these, a pilot was unable to access the MEL. Finally, two *electronic display information elements* concern addressed the presentation of *incorrect information* on an electronic chart. In one report, the chart application used on an LPC laptop displayed an incorrect landing distance, different from what is shown on the 10-9 chart (airport diagram). As stated in the report, the laptop chart may have included the stopway distance (overrun area), while the 10-9 did not. In the second report, the chart application did not show the updated airspace organization.

Hardware Concerns

Three *hardware* concerns involved the EFB smoking and/or catching fire. One of these involved a battery overheating and smoke coming from the EFB within five minutes of turning on the EFB (laptop). Once the battery was removed, the smoke stopped. The EFB had been submitted for an upgrade and was damaged during the process (Note: the report did not state the specific components that were

[7] The crew was unaware that the dispatch calculations are generic, and only use full-thrust values in take-off performance calculations. Subsequently, the company issued a notice informing flight crews of the nature of dispatch calculations, and required a copy of these calculations be present on each flight.

damaged). Another report identified faulty external ports that became damaged from day-to-day use and began to smoke. Again the smoke stopped once the battery was removed. The third report involved a power cord on an LPC that became damaged and caused flames to burst out of the cord. The LPC laptop was left on the flight deck unattended, and when the new crew entered the laptop was moved. After approximately 30 seconds, one of the pilots noticed flames and immediately disconnected the power cord. Following the incident, the airline prohibited leaving an LPC laptop unattended, and an improved power cord was manufactured for use. A fourth *hardware* concern was identified in which the EFB laptop wireless signal might have interfered with the aircraft pressurization system. This caused an unexpected cabin pressure change while the flight crew was working with the EFB laptop. The flight crew could not verify that the EFB wireless capability was turned on at the time of the incident; however, the wireless capability has since been disabled as a precaution. Finally, a fifth report involved a failure of both EFBs located on the aircraft.

Self-Reported Human Performance Concerns

Two *self-reported human performance* concerns were reported. One report addressed a *self-reported data entry error*, in which a pilot entered an incorrect weight into the performance computer. The other pilot noticed the anomalous value, but the report stated that the pilot did not take any action to correct it, possibly due to being distracted by a conversation regarding a problem with the FMGC. The second report cited *distraction* due to "extended start up and 'syncing' time [that] resulted in rushed EFB usage."

Placement/Mounting/Stowage Concerns

One report identified related to the *placement* of the EFB stated that flight controls were restricted due to the placement of the first officer's EFB bracket. One additional report related to *securing the EFB* described an unsecured EFB that slipped and hit the Right Fuel Control Switch, which moved the switch to the Cutoff position, while being handed from the first officer to the captain.

6.3 TSB, BEA, and ATSB Reports

6.3.1 Overview

Six full length safety reports were identified from TSB (2), BEA (1), and ATSB (3). All the reports described incidents in which a data entry error occurred during flight performance calculations. However, they differ in the factors contributing to the incident and the outcome. Summary reports are not included in this document because the descriptions did not allow us to understand the incident at the same level as a full length report. Descriptions of the five full length incident reports are provided below.

One TSB report described an accident in Halifax, Nova Scotia in October, 2004, in which the flight performance take-off data from the previous airport was erroneously used in the weight performance

calculations for take-off. This created a situation in which the Boeing 747-244 was heavier than indicated. The Boeing Laptop Tool (BLT), used in the incident, stores the information from the previous flight. The report noted that the airline did not implement formal training for the BLT, so the pilots may not have fully understood the logic behind the flight performance calculations, and the gross error check required by the airline's Standard Operating Procedure (SOP) was not performed. This mistake created a situation in which the aircraft was too heavy, using the erroneous thrust setting, and was not able to safely take-off. All seven crew members on board perished in the accident.

One of the main safety recommendations from the TSB proposed the inclusion of a take-off performance monitoring system, specifically: "The Department of Transport, in conjunction with the International Civil Aviation Organization, the Federal Aviation Administration, the European Aviation Safety Agency, and other regulatory organizations, establish a requirement for transport category aircraft to be equipped with a take-off performance monitoring system that would provide flight crews with an accurate and timely indication of inadequate take-off performance."

The second TSB report described an incident in Edmonton, Alberta in July 2006, in which an Embraer 190-100 operated by Air Canada took off with too little fuel. The first officer initially entered the incorrect fuel weight, using the current fuel weight (3700 kg) rather than the larger fuel weight (10200 kg) expected at the time of take-off. The situation was complicated by the fact that the first officer's laptop was not working, so the first officer used the captain's laptop. Consequently, verification by the captain or first officer, as stated by the SOP, did not occur. The incorrect information was then entered into the FMS. The SOP does not specify that the flight crew compare the fuel gauge level on board with the fuel on board entry on the EFB, thus the discrepancy was not caught. The TSB recommended the use of a safety monitoring system.

The safety report from BEA described an incident at Charles de Gaulle Airport in Paris, France, in August 2008, in which the flight crew did not take into account the reduced runway distance due to construction on the runway when calculating the take-off parameters. The Boeing 737-800, operated by Aircraft Maintenance Company Airlines (AMC), was equipped with an onboard performance tool (OPT), a laptop powered by the aircraft's electrical power supply. The available distance on the runway was decreased by 1,240 feet. This restriction should have been manually entered into the calculations, but the crew had not accounted for the Notice To Airmen (NOTAM) warning of the reduced runway length. The BEA noted that it was also a possibility – although less likely – that the crew might have used a calculation from their previous flight, which led to the miscalculation of the take-off, thrust level.

There were three ATSB reports. One documented an incident at the Melbourne airport in Victoria, Australia in March 2009, in which an Airbus A380-541 operated by Emirates Airways experienced a tail strike and runway overrun, damaging the instrument landing system (ILS), due to an incorrect take-off weight entered into the EFB. The first officer incorrectly entered 262.9 tonnes instead of 362.9 tonnes, and thus, performance take-off parameters were incorrectly calculated. Investigating further, the report reveals that the error remained uncorrected despite several opportunities during routine crosschecks. Note that the EFB was stowed prior to the final crosscheck. In this incident (which is reminiscent of

others previously discussed) the error was not detected until the take-off roll had commenced, but the aircraft could not lift off because it was not going fast enough. Fortunately, the aircraft was able to regain stability and fly back to Melbourne safely.

A second ATSB report documents another incident at the Melbourne airport in Victoria, Australia in November 2011. The incident involved a Boeing 737-476 operated by Qantas Airways in which the first officer inadvertently inserted the full length runway distance when the flight plan was to take off at a taxiway intersection. The captain did cross check the calculations, but the captain also miscalculated using the distance for a full length departure. Although this error was not caught until take-off was in progress, the captain was able to compensate by rotating earlier than specified by their pre-flight take-off performance calculations. The EFB software used in this incident for selecting the take-off runway automatically entered the full runway length as the default intersection value. Since this incident, Qantas Airways has corrected this default setting, and now the calculations cannot be computed until the runway intersection field is selected as full or another intersection is specified.

A third ATSB report documented an incident at Brisbane Airport in Queensland, Australia in November 2007. A Gulfstream G-IV aircraft, on a charter flight, departed on a taxiway parallel to the departure runway. Prior to taxiing, the EFB of the pilot in charge became inoperable, and the pilot in charge opted not to utilize the backup EFB on the aircraft for taxi as he believed it was unnecessary due to the "simple" layout of the airport. It was the expectation of the pilot in charge that the copilot would monitor the taxi route, but failed to brief the taxi route. The pilot in charge erroneously turned onto the taxiway parallel to the runway instead of crossing that taxiway. Both pilots were unaware of their position, as the copilot did not look out the window during taxi. Believing the aircraft was at the holding point for the runway, takeoff commenced. ATC then canceled the takeoff clearance, and notified the crew that they had departed on a taxiway. After investigation, the ATSB concluded that one of the three key contributing safety factors in the incident was that the pilot in charge did not utilize the available resources to aid in taxiing the aircraft after his EFB became inoperable.

Safety considerations in a 2008 BEA publication provide a summary report of 10 events involving incorrect take-off parameters that occurred between 1990 and 2006. Three of these events involved the use of a laptop to complete performance calculations, while the remaining were either manual or Aircraft Communications Addressing and Reporting System (ACARS) queries. As shown in the five incidents described above, increased workload overall or from a last minute change can result in errors during take-off performance calculations. Although the take-off performance calculation procedure has an automated component, making it less of an interactive process and more of a find-and-select procedure, it still requires the flight crew to double check the numbers presented. The addition of recognition cues for the flight crew entering information is an added safety measure that could offset the potential for errors (BEA, 2008). For example, the use of a visual message that displays the word "recheck" or the like may remind the crew that they still need to recheck the entered number. This type of warning could remain visible until the recheck is complete. Visual warning reminders can also be important in the case of numerous interruptions or unexpected changes that could interrupt a crew member's train of thought. Although this may resolve some incidents, a visual reminder may not be

helpful in mitigating certain types of incidents, as in one report described above. In this case, the data crosscheck did occur between the captain and first officer, but because both made the same error, the incorrect runway length was not detected.

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7. Summary of Overall Safety Report Findings

The purpose of this assessment is to provide the FAA with a better understanding of known and potential human factors safety concerns related to the use of EFBs and PEDs. Safety events involving an EFB or PED that were deemed a factor in each event were identified and examined for both incident and accident reports from a variety of safety reporting agencies around the world, including ASRS, NTSB, ATSB, CAA, TSB, and BEA. The findings from this research may contribute to a better understanding of the concerns documented in safety reports and the variety of factors for each situation that may contribute to safety risks when incorporating EFBs into the flight deck.

The 456 potential safety concerns, including 343 human factors concerns and 112 potential software errors, were identified in this effort from all seven agencies/reporting system is summarized is this section. An overview of these concerns is provided in Table 12. Overall, most human factors concerns pertained to the use of electronic charts, and in particular scrolling and zooming. Pilots also noted the presentation of incorrect or out-of-date information, and information presented differently on electronic charts than on paper charts. Additional human factors concerns were related to inexperience/lack of expertise and distraction with the PED/EFB, and misinterpreted or erroneous aircraft performance parameters. These findings are consistent with Joslin (2013) and ASRS (2010), which both identified concerns related to scrolling/zooming/panning; out-of-date chart information; inexperience, inadequate training, and data entry/reading/selection errors.

Table 12. Overall Safety Report Findings.

EFB/PED Concerns	Total
Electronic Display Information Elements Concerns	**132**
Electronic charts	78
Scrolling/zooming concern	36
Presentation inconsistent with paper	11
Incorrect information	12
Out-of-date	5
Difficulty retrieving electronic chart	3
Other	11
Difficulty locating information on chart	3
Course line covered airspace information	2
Chart application did not update properly	1
Chart application would not initialize properly	1
Charts missing	1

Table 12. Overall Safety Report Findings (continued).

EFB/PED Concerns	Total
Confusing taxi chart	1
Confusion about whether to follow paper or electronic chart	1
Ownship position symbol not visible after landing	1
Flight performance calculation concern	25
Out-of-date (application not specified)	7
Electronic documents	7
Difficulty retrieving electronic document	4
Legibility concern	1
Out-of-date	1
Incorrect information	0
Presentation inconsistent with paper	0
Scrolling/zooming concern	0
Other	1
Color does not appropriately highlight mandatory MEL items	1
Electronic checklists	4
Difficulty retrieving electronic checklist	1
Inoperable electronic checklist	1
Missing electronic checklist	1
Information inconsistent with paper	1
Arrangement of information on the display	1
Lack of feedback	1
System state indicator	1
Missing	1
Presented	0
Error indicator	0
Missing	0
Presented	0
Other	0
Settings/switching between applications	1
Sharing information across EFBs/PEDs	1
Security concern	1
Integration failure	3
Other	3
Applications automatically close while in use	3
Hardware Concerns	**63**
Equipment error/failure	39

Table 12. Overall Safety Report Findings (continued).

EFB/PED Concerns	Total
Inoperable or partially operable EFB/PED	10
Screen froze/went black	7
Unexpected shutdown	4
Automatically erased data	3
Battery concern	3
EFB/PED overheated	2
Unspecified cause	2
EFB/PED smoke/fire	4
Processor speed or memory concern	0
Other	4
GPS failed	3
EFB went offline	1
Screen legibility concern	11
Ambient light/glare	5
Ambient light and display brightness	3
Brightness/contrast	0
Unspecified cause	2
Other	1
Night mode made procedure look more cluttered	1
EFB/PED size concern	6
Input device concern	3
Touch screen/soft Keys	2
Hard buttons/keys	1
Interference with other systems	3
Electromagnetic	1
Other	2
Charger caused static interference with radio communications	1
Wireless interference with cabin pressurization	1
Pressurization/decompression concern	0
Other	1
Pilot had trouble starting up the EFB	1
Self-Reported Human Performance Concerns	**134**
Distraction	30
Lack of experience/expertise	29
Over-reliance on an EFB/PED	22

Table 12. Overall Safety Report Findings (continued).

EFB/PED Concerns	Total
Head-down time	12
Lack of training or documentation	12
Self-reported data entry/verification concern	12
Data entry/verification concern	6
Workload	5
Memory lapse	0
Other	6
Pilot misread information on EFB/PED	3
Failed to consult electronic document	2
Inadvertently switched the departure displayed on the screen	1
Placement/Mounting/Stowage Concerns	**16**
Placement/Location	5
Poor view of EFB/PED	2
Poor view of instruments, controls or out the window	1
Other	2
Pilot inadvertently activated controls with tablet EFB resting on yoke	1
Controls were restricted due to the placement of the EFB bracket	1
Stowage	4
Mounting/securing the EFB/PED	4
Other	3
Mounting solution took up space previously used for paper charts	3
Potential Software Errors	**113**
System requirement error	53
Lack of training	19
Software processing error	0
Unsure	41
Total	**456**

A summary of each type of EFB/PED concern identified is provided below, with each concern category having its own subsections. A brief description of the concerns in each category is provided, with the number of reports listed beside each concern if multiple types of concerns were identified. FAA regulatory and guidance material currently address many of the concerns identified in this effort, and are listed in Appendix D. Any open concerns that existing guidance does not currently address are identified within the relevant subsection.

7.1 Electronic Display Information Elements Concerns

Total concerns identified: 132 (114 ASRS; 18 CAA)

7.1.1 Electronic Charts

Total concerns identified: 78 (76 ASRS; 2 CAA)

Several types of concerns were identified involving use of electronic charts, including:

- Scrolling/zooming concern (36 ASRS)
- Presentation inconsistent with paper (11 ASRS)
- Incorrect information (10 ASRS; 2 CAA)
- Out-of-date chart (5 ASRS)
- Difficulty retrieving electronic charts (3 ASRS)
- Difficulty locating information (3 ASRS)
- Course line covered up airspace information (2 ASRS)
- Chart application did not update TFRs properly (1 ASRS)
- iPad chart application would not initialize properly (1 ASRS)
- Charts missing from iPad (1 ASRS)
- Confusing taxi chart (1 ASRS)
- Confusion about whether to follow paper or electronic chart (1 ASRS)
- Ownship position symbol not visible after landing (1 ASRS)

7.1.2 Flight Performance Calculations

Total concerns identified: 25 (15 ASRS; 10 CAA)

These reports involved performance calculations that were incorrect, and certain values or other information that were missing or incorrect, for example runway length (refer to *Self-Reported Human Performance Concerns* for data entry concerns).

Open concerns

- Missing values in performance calculation software

Missing values (e.g., a missing runway-taxiway intersection for departure) in flight performance are not currently addressed in FAA guidance material. It may be beneficial to include this in procedures and training, for example handling a missing airport, runway, or taxiway intersection for takeoff.

7.1.3 Out-of-Date (application not specified)

Total concerns identified: 7 ASRS

These reports mention that the EFB/PED was out-of-date and do not mention a specific application (e.g., charts or documents).

7.1.4 Electronic Documents

Total concerns identified: 7 (4 ASRS; 3 CAA)

Several concerns involving electronic documents were identified including:

- Difficulty retrieving electronic document (1 ASRS, 3 CAA)
- Legibility concern (1 ASRS)
- Out-of-date document (1 ASRS)
- Color coding does not appropriately highlight mandatory MEL items (1 ASRS)

7.1.5 Electronic Checklists

Total concerns identified: 4 ASRS

Several concerns involving electronic checklists were identified including:

- Difficulty retrieving electronic checklist (1)
- Inoperable electronic checklist (1)
- Missing electronic checklist (1)
- Information inconsistent with paper (1)

7.1.6 Arrangement of Information

Total concerns identified: 1 ASRS

Due to the layout of TFR information, the pilot missed critical TFR boundary information. Several empty lines between lines of text led the pilot to believe the end of the TFR was reached. The missed information contributed to an altitude and heading deviation.

7.1.7 Lack of Feedback

Total concerns identified: 1 ASRS

- Lack of system state indication

These reports included lack of an indication that EFB software was out-of-date, or lack of an indication that an aircraft was about to depart with an illegal configuration.

Open concerns

- Lack of system state indication

Feedback when the aircraft configuration is abnormal or unacceptable is not currently addressed in FAA guidance documents, but may be useful to include. An indication or prompt for pilot confirmation could mitigate any concerns arising from an aircraft departing with an illegal configuration. It may also be beneficial to provide an indication when the EFB/PED system or application is out-of-date.

7.1.8 Settings/Switching Between Applications

Total concerns identified: 1 ASRS

This report involved distraction as a result of the actions required to adjusting the brightness setting. The moving map application needed to be closed in order to adjust the brightness setting, requiring the pilot to close and re-open the moving map application and resulting in distraction.

7.1.9 Sharing Information across EFBs/PEDs

Total concerns identified: 1 ASRS
This report involved an aircraft that departed without EFBs that were able to transfer data (i.e., communicate) with each other.

7.1.10 Security Concern

Total concerns identified: 1 ASRS
This report described a corrupted EFB database after downloading an update.

7.1.11 Integration Failure

Total concerns identified: 3 CAA
These reports involved failure of automated download and synchronization between the EFB and other systems, including NOTAMs, weather and airport information.

7.1.12 Other

Total concerns identified: 3 ASRS
These reports cited applications that automatically close while in use (e.g., charts, search function).

7.2 Hardware Concerns

Total concerns identified: 63 (57 ASRS; 5 CAA; 1 ATSB)

7.2.1 Equipment Error/Failure

Total concerns identified: 39 (34 ASRS, 4 CAA, 1 ATSB)
Problems include concerns with an EFB or PED being inoperable at the beginning of a flight while the aircraft was parked, or failing at any point while the flight is in progress. These reports include smoke/fire due to a faulty battery, connector or wire causing overheating, and leading to smoke and fire on the flight deck. Identified reasons for failure:

- Inoperable or partially operable EFB/PED (8 ASRS, 1 CAA, 1 ATSB)
- Screen froze/went back (7 ASRS)

- Unexpected shutdown (4 ASRS)
- Automatically erased data (3 ASRS)
- Battery failed (3 ASRS)
- iPad overheated (2 ASRS)
- Unspecified cause (2 ASRS)
- EFB/PED smoke/fire (1 ASRS, 3 CAA)
- iPad GPS failed (3 ASRS)
- EFB went offline (1 ASRS)

Open concerns

- Inoperable or partially operable EFB/PED - cold-soaked (1)

Current FAA guidance does not address procedures for storage or removal of the performance computer when temperature extremes may be damaging. Guidance may be beneficial to ensure the procedures are in place to ensure that the EFB will not be either temporarily or permanently damaged.

7.2.2 Screen Legibility Concern

Total concerns identified: 11 ASRS

Reports involved EFBs that were difficult to read due to glare and/or display brightness (or lacking brightness).

- Ambient light/glare (5)
- Ambient light and display brightness (3)
- Unspecified cause (2)
- Night mode made procedure look more cluttered difficult to read (1)

7.2.3 EFB/PED Size Concern

Total concerns identified: 6 ASRS

In these reports, the EFB was either too small, requiring what pilots felt to be an excessive amount of zooming/scrolling, or the EFB was too large and heavy.

- Screen too small (4)
- Too large and heavy (2)

7.2.4 Input Device Concern

Total concerns identified: 3 ASRS

In these reports, buttons or touch points were difficult to see, difficult to use, or did not operate correctly.

- Buttons difficult to see at night (1)
- Touch points on the screen were too small and close together, making the touch screen difficult to use (1)
- Touch points did not operate correctly when touched (1)

7.2.5 Interference with Other Systems

Total concerns identified: 3 (2 ASRS; 1 CAA)

In these reports, the EFB/PED caused interference with other flight deck systems. Types of interference identified include:

- Electromagnetic interference with compass (1 ASRS)
- Charger caused severe static and interfered with radio communications (1 ASRS)
- Wireless interference with cabin pressurization (1 CAA)

Open concerns

- Wireless interference with cabin pressurization

FAA guidance currently does not specifically address EFB wireless interference with aircraft cabin systems; however, general interference with flight deck systems is addressed in AC 120-76C, 11.f, and FAA Order 8900.1, Volume 4, Chapter 15, Section 1, Paragraph 4-1644, C.

7.2.6 Other

Total concerns identified: 1 ASRS

The pilot noted difficulty with starting the EFB.

7.3 Self-Reported Human Performance Concerns

Total concerns identified: 134 (123 ASRS, 4 FAA, 2 CAA, 2 NTSB, 1 BEA, 2 ATSB)

7.3.1 Distraction

Total concerns identified: 230 (28 ASRS, 1, FAA, 1 CAA)

In these reports, pilots reported being distracted by EFB use (e.g., performance calculations or searching for information), consequently missing important information, failing to complete other duties, or losing position awareness.

7.3.2 Lack of Experience/Expertise

Total concerns identified: 29 ASRS

These reports involved pilots that were unaware of or unfamiliar with functionality of a new EFB/PED, application, or data limitations (e.g., electronic map does not depict TFRs).

7.3.3 Over-reliance on an EFB/PED

Total concerns identified: 22 ASRS

These reports described pilot over-reliance on the EFB or PED for information, or failure to crosscheck

information presented on the EFB/PED.

7.3.4 Lack of Training or Documentation

Total concerns identified: 12 ASRS

These reports involved reports explicitly stating that felt that had insufficient training and/or documentation regarding the use of the EFB/PED.

7.3.5 Head-down Time

Total concerns identified: 12 (10 ASRS, 2 FAA)

- Pilots experienced excessive head-down time due to EFB use (10 ASRS)
- Pilot lost position awareness due to being head-down with an iPad (2 FAA)

7.3.6 Self-Reported Data Entry/Verification Concern

Total concerns identified: 12 (11 ASRS; 1 CAA)

- Erroneous inputs (7 ASRS; 1 CAA)
- Missing inputs (2 ASRS)
- Failure to verify current entries, default values or values from previous flight (2 ASRS)

7.3.7 Data Entry/Verification Error

Total concerns identified: 6 (2 NTSB, 1 FAA, 1 BEA, 2 ATSB)

These reports involved data entry errors documented by an aviation or transportation authority, and were not self-reported. These included entry of incorrect weight or temperature, data misinterpretation due to hidden assumptions underlying performance calculations, and use of values or calculations from the previous flight.

7.3.8 Workload

Total concerns identified: 5 ASRS

In these reports, pilots described an increase in workload due to EFB/PED use.

7.3.9 Other

Total concerns identified: 6 ASRS

- Misread information presented on the EFB that was not attributed to a legibility concern (3)
- Failed to consult electronic document for information (e.g., MEL) (2)
- Inadvertently switched the departure displayed on an iPad (1)

7.4 Placement/Mounting/Stowage Concerns

Total concerns identified: 16 (14 ASRS, 2 CAA)

7.4.1 Placement/Location

Total concerns identified: 5 (4 ASRS, 1 CAA)

These report included concerns of the pilot flying having a poor view of the EFB/PED or inadvertent activation or restriction of controls due to placement.

- Poor view of EFB/PED (2 ASRS)
- Poor view of instruments or out the window (1 ASRS)
- Pilot inadvertently disengaged autopilot by activating a control with an EFB tablet that was resting on the yoke (1 ASRS)
- Controls were restricted due to the placement of the EFB bracket (1 CAA)

7.4.2 Stowage

Total concerns identified: 4 ASRS

These reports included instances of missed information (e.g., on an electronic chart) due to the EFB/PED being stowed, and expressed the potential for distraction due to stowing an EFB/PED and removing a stowed EFB/PED.

7.4.3 Mounting/Securing the EFB/PED

Total concerns identified: 4 (3 ASRS, 1 CAA)

- Unsecured EFB (2 ASRS, 1 CAA)
- iPad mount separated from window (1 ASRS)

One report involved an unsecured EFB that slid off the pilot's knee during takeoff, contributing to a heading deviation.

Open concerns

- Unsecured EFB

Current FAA guidance and regulatory material does not address unsecured EFBs while in use on the flight deck. Guidance pertaining to the use of unsecured EFBs, or procedures to mitigate potentially hazardous situations while using unsecured EFBs in flight may be beneficial.

7.4.4 Other

Total concerns identified: 3 ASRS

- Mounting solution took up space previously used to hold paper charts

In these reports, mounting solutions for EFBs that were not yet functional/available took up space that was previously used to hold paper charts on the flight deck, and made viewing paper charts more

difficult.

Open concerns

- Mounting solution took up space previously used to hold paper charts

Recommendations for new EFB installation should consider means to ensure that securing solutions do not interfere with access to paper charts due to lack of space when installed in the aircraft prior to the deployment of an EFB system.

7.5 Potential Software Errors

Total concerns identified: 113 ASRS

7.5.1 System Requirements Error

Total concerns identified: 53 ASRS

These reports describe software concerns, including zooming errors, any condition in which symbols overlapped, or that some other information displayed was confusing to the pilot. These reports did *not* mention pilot inexperience or lack of training.

7.5.2 Lack of Training

Total concerns identified: 19 ASRS

These reports mention a software concern, as well as pilot inexperience or lack of training, and could *not* be categorized as either a system requirements error or software processing error.

7.5.3 Unsure

Total concerns identified: 41 ASRS

There reports included a software concern, but not enough information was provided in the report to determine whether the cause was a system requirements error or software processing error.

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Appendix A: Complete List of Keyword Search Terms Used

Keyword Search Terms	Number of Reports Found
4PilotPro	0
Acrobat	1
ACSS	0
Adobe	0
ADRF	0
Advanced Data Research Florida	0
Aera	2
Aeroplanner	0
Aircraft Management Technologies	0
AirGator	0
Airport moving map	0
Airport performance computer	0
Airport performance laptop computer	0
Airport surface MM	0
Airport surface moving map	0
Airport surface movingmap	0
ALPC	1
Amazon	7
AMM	0
AMMD	0
AMT	0
Android	0
Anywhere Map	2
Anywheremap	0
APC	73
APLC	1
Apple	38
ASMM	0
Astronautics	0
auxil% performance computer	0
auxil% performance laptop computer	0
Bad Elf	0
Bendix	32
Bendix King	11
Bezel	4
Blackberry	6
Blue tooth	0

Keyword Search Terms	Number of Reports Found
Bluetooth	1
CDTI	1
Cell phone	629
Cellphone	5
Cellular phone	93
Chartbook	0
ChartCase	0
ChartKey	0
CMC	14
Cockpit display of traffic information	0
Computer display	21
Computer screen	25
CrewMate	1
Custom display	0
echart%	0
eChecklist%	0
ECL	15
edoc%	0
edocument%	0
EFB	155
EFD	66
Electronic chart%	27
Electronic check list%	6
Electronic chk list	0
Electronic checklist%	9
Electronic device	63
Electronic display	12
Electronic doc%	1
Electronic document%	1
Electronic Flight Bag	29
Electronic flight display	0
Electronic flt bag	20
Electronic flt display	1
Electronic map	3
Flight man	0
Flight performance calculation%	0
Flight performance computer	0
Flight Prep	3
FlightDeck	4
Flightman	0
FlightPrep	0

Keyword Search Terms	Number of Reports Found
Flite Deck	0
FliteDeck	0
FlySmart	0
Fore Flight	1
Fore Flite	0
ForeFlight	33
ForeFlite	0
fpc	0
Garmin	300
Gen X	0
GenX	0
Hand held	553
Handheld	397
Honeywell	87
I pad	109
ichart%	1
IMS	5
iPad	126
iPhone	11
iPod	4
iTouch	0
Jeppesen	4
JeppView	0
Kindle	0
Lap top	7
Laptop	115
Lido	1
Maptech	0
Mount	377
Moving map	286
Nav Pad	0
Navaero	0
NavAir	0
NavPad	0
Nook	0
Notebook computer	2
OBDS	0
Onboard performance computer	11
OPC	110
Palm	302
Paperless	7

Keyword Search Terms	Number of Reports Found
PC	84
PDA	11
PED	36
Performance computer	106
Performance laptop computer	2
Personal computer	10
Personal Data Assistant	0
Personal digital assistant	2
Personal Electronic Device	8
Personal nav computer	0
Personal navigation computer	0
Personnel Digital Assistant	0
Pilot view	0
Pilotview	0
Plc	1
Pnc	12
Portable	424
Portable Electronic Device	11
Portable nav computer	0
portable navigation computer	0
Safe taxi	51
SafeRoute	0
SafeTaxi	0
Sky tab	0
Sky vision	0
Skytab	0
Skyvision	0
Smart display	0
Smart phone	2
Smartdisplay	0
SMM	0
Sportys	0
Stylus	0
Surface moving map	0
Tablet	33
Teledyne	5
TerraVision	0
Touch screen	12
Touchscreen	2
tPad	0
Universal Avionics	1

Keyword Search Terms	Number of Reports Found
Virtual flight bag	1
Wifi	1
Wing X	2
WingX	0
Wireless	5
WSI	28
WxWorx	1
TOTAL	**5083**

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Appendix B: ASRS Report ACN Numbers

527957	712648	889298	712591	943890	1101386	598643
564468	1068700	1084677	912244	913370	1000831	870051
869135	507712	683801	706697	953305	580128	841916
925220	981460	961138	800759	715045	696563	709804
927261	725329	729594	926763	932854	716555	946367
946368	948785	957115	963731	709587	876221	837609
841281	841624	805593	853194	853232	854449	855006
789543	869334	873576	875078	919024	787678	924393
877023	881956	766736	911343	914478	916015	965291
740010	696289	740001	922168	924172	1029517	1036925
659652	1097775	1094659	1092725	1092427	558392	661418
1091191	1026086	1081403	1099797	977421	587591	706138
1076928	1091324	1002908	1010799	688029	697274	685210
854449	1097834	678031	690199	1010658	541522	1068232
727694	813670	1102783	304082	1100537	866666	819488
1084179	1084769	540556	857567	454270	832562	566944
1095390	794108	1098429	654927	968028	1043606	954629
674001	656745	935885	722105	614340	836269	1045781
1065118	733615	915367	1069114	1068333	717398	569766
699668	893564	658615	937439	265798	1101763	736751
545067	574280	777240	597777	478621	925881	729825
614924	709369	735929	603224	906617	979653	939665
836865	1098330	916196	936737	995263	1071582	976947
1006812	935884	633372	969004	1043846	881702	1076044
1076604	1081317	540941	1092911	1022123	1079717	735404
920841	927459	920078	945962	944330	1022557	1077488
952490	921736	1076926	966424	1022749	928015	1061889
569273	817419	1030180	706693	701247	1027927	890187
492219	492310	920949	533318	1091530	947983	843044
1041951	1040638	1032665	942384	1009732	1097696	896384

1102259	962082	995466	849256	710292	1089948	1028909
876080	726022	840384	920838	595465	725049	694068
688281	756881	726238	586019	649353	835726	723815
934431	723592	937056	868611	580562	572343	833378
793272						

Appendix C: ASRS Device Type Data

The specific type of EFB/PED device was examined in each ASRS report. The results are presented in this section. In some cases, different terminology was used to describe the EFB/PED in a single report. In these cases, the more specific term was used to classify the device. For example, if "performance computer" and "laptop" were used to describe the device, the device would be classified as a laptop. In other cases, only the term "EFB" was used to describe the device; these devices are classified as "unspecified EFB".

Table C-1. Reports by Device Type and Year.

Year	Handheld Computer	iPad	Other Tablet	Laptop	Performance Computer	Smart Phone/ iPhone	Unspecified EFB	Total
1994	0	0	0	0	1	0	0	1
1995	0	0	0	1	0	0	0	1
1999	0	0	0	0	1	0	0	1
2000	0	0	0	1	2	0	0	3
2001	0	0	0	0	3	0	0	3
2002	2	0	0	0	5	0	1	8
2003	1	0	0	1	7	0	1	11
2004	0	0	0	0	1	0	2	3
2005	1	0	3	0	3	0	1	8
2006	0	0	4	2	7	0	12	25
2007	0	0	0	0	9	0	7	16
2008	0	0	0	0	2	0	6	9
2009	0	0	3	1	2	0	14	20
2010	0	7	1	1	1	0	24	34
2011	0	14	1	0	0	1	16	35
2012	0	18	1	0	0	1	3	23
2013	0	28	0	0	2	0	8	38
Total	**4**	**67**	**13**	**7**	**46**	**2**	**95**	**239**

Table C-2. Phase of Flight and Device Type Reported For Each Type of Operation.

Part	Device	Phase of Flight								Total
		Parked/ Pre-Flight	Taxi (rolling)	Taxi (hold short)	Departure	Enroute	Arrival	Landing	N/A	
Part 91	Handheld Computer	0	0	1	2	0	0	0	0	**3**
	iPad	2	1	4	5	30	7	1	0	**50**
	Other Tablet	0	0	1	4	5	2	0	0	**12**
	Laptop	0	0	0	1	1	1	0	0	**3**
	Performance Computer	0	0	0	0	0	0	0	0	**1**
	Smart Phone/ iPhone	0	1	0	0	1	0	0	0	**2**
	Unspecified	0	3	0	20	11	10	1	0	**45**
	Total	**2**	**5**	**6**	**32**	**48**	**20**	**2**	**0**	**115**
Part 121	Handheld Computer	0	0	0	0	0	0	0	1	**1**
	iPad	2	1	0	0	7	1	0	5	**16**
	Other Tablet	0	0	0	0	0	1	0	0	**1**
	Laptop	2	0	0	0	1	0	1	0	**4**
	Performance Computer	9	5	3	14	8	4	0	3	**46**
	Smart Phone	0	0	0	0	0	0	0	0	**0**
	Unspecified	6	9	2	2	10	11	0	5	**45**
	Total	**19**	**15**	**5**	**16**	**26**	**17**	**1**	**14**	**113**
Part 135	Handheld Computer	0	0	0	0	0	0	0	0	**0**
	iPad	0	0	0	0	1	0	0	0	**1**
	Other Tablet	0	0	0	0	0	0	0	0	**0**
	Laptop	0	0	0	0	0	0	0	0	**0**
	Performance Computer	0	0	0	0	0	0	0	0	**0**
	Smart Phone	0	0	0	0	0	0	0	0	**0**
	Unspecified	0	0	1	4	1	3	0	1	**10**
	Total	**0**	**0**	**1**	**4**	**2**	**3**	**0**	**2**	**12**
Total		**21**	**20**	**12**	**52**	**76**	**40**	**3**	**15**	**239**

Table C-3. EFB/PED as A Primary or Secondary Factor for Each Type of Operation by Device Type.

Part	Device	Device Type							Total
		Handheld Computer	iPad	Other Tablet	Laptop	Performance Computer	Smart Phone/ iPhone	Unspecified EFB	Total
Part 91	Primary	2	35	9	1	0	2	16	**65**
	Secondary	1	10	3	2	0	0	26	**42**
	No specific event	0	5	0	0	0	0	3	**8**
Part 121	Primary	0	3	1	1	5	0	12	**22**
	Secondary	1	3	0	0	19	0	15	**38**
	No specific event	0	10	0	3	22	0	18	**53**
Part 135	Primary	0	1	0	0	0	0	3	**4**
	Secondary	0	0	0	0	0	0	5	**5**
	No specific event	0	0	0	0	0	0	2	**2**
Total		**4**	**67**	**13**	**7**	**46**	**2**	**100**	**239**

Table C-4. Part 91 Electronic Display Information Elements Concerns Reported for Each Device Type.

Electronic Display Information Elements Concerns	Handheld Computer	iPad	Other Tablet	Laptop	Performance Computer	Smart Phone/ iPhone	Unspecified EFB	Total
Electronic charts	1	19	7	1	0	0	27	**55**
Scrolling/ zooming concern	1	8	4	1	0	0	16	**30**
Presentation inconsistent with paper	0	1	2	0	0	0	3	**6**
Incorrect information	0	3	0	0	0	0	5	**8**
Out-of-date	0	1	0	0	0	0	0	**1**
Difficulty retrieving electronic chart	0	2	1	0	0	0	0	**3**
Other	0	4	0	0	0	0	3	**7**
Chart application would not initialize properly	0	1	0	0	0	0	0	**1**
Course line covered airspace information	0	2	0	0	0	0	0	**2**
Chart application did not update properly	0	1	0	0	0	0	0	**1**
Difficulty locating information on the cart	0	0	0	0	0	0	3	**3**
Flight performance calculation concern	0	0	0	0	0	0	0	**0**
Out-of-date (application not specified)	0	0	0	0	0	0	0	**0**

Electronic Display Information Elements Concerns	Handheld Computer	iPad	Other Tablet	Laptop	Performance Computer	Smart Phone/ iPhone	Unspecified EFB	Total
Electronic documents	0	0	0	0	0	0	0	**0**
Difficulty retrieving electronic document	0	0	0	0	0	0	0	**0**
Legibility concern	0	0	0	0	0	0	0	**0**
Out-of-date	0	0	0	0	0	0	0	**0**
Incorrect information	0	0	0	0	0	0	0	**0**
Presentation inconsistent with paper	0	0	0	0	0	0	0	**0**
Scrolling/ zooming concern	0	0	0	0	0	0	0	**0**
Other	0	0	0	0	0	0	0	**0**
Electronic checklists	0	0	0	0	0	0	0	**0**
Difficulty retrieving electronic checklist	0	0	0	0	0	0	0	**0**
Inoperable electronic checklist	0	0	0	0	0	0	0	**0**
Missing	0	0	0	0	0	0	0	**0**
Information inconsistent with paper	0	0	0	0	0	0	0	**0**
Arrangement of information on the display	0	0	0	0	0	1	0	**1**
Lack of feedback	0	0	0	0	0	0	0	**0**
System state indicator	0	0	0	0	0	0	0	**0**
Missing	0	0	0	0	0	0	0	**0**
Presented	0	0	0	0	0	0	0	**0**
Error indicator	0	0	0	0	0	0	0	**0**
Missing	0	0	0	0	0	0	0	**0**
Presented	0	0	0	0	0	0	0	**0**
Other	0	0	0	0	0	0	0	**0**
Settings/switching between applications	0	1	0	0	0	0	0	**1**
Sharing information across EFBs/PEDs	0	0	0	0	0	0	0	**0**
Security concern	0	0	0	0	0	0	0	**0**
Integration failure	0	0	0	0	0	0	0	**0**
Other	0	0	0	0	0	0	0	**0**
Total	**1**	**20**	**7**	**1**	**0**	**1**	**27**	**57**

Table C-5. Part 121 Electronic Display Information Elements Concerns Reported for Each Device Type.

Electronic Display Information Elements Concerns	Handheld Computer	iPad	Other Tablet	Laptop	Performance Computer	Smart Phone/ iPhone	Unspecified EFB	Total
Electronic charts	0	4	0	0	0	0	14	**18**
Scrolling/ zooming concern	0	2	0	0	0	0	1	**3**
Presentation inconsistent with paper	0	1	0	0	0	0	4	**5**
Incorrect information	0	0	0	0	0	0	2	**2**
Out-of-date	0	0	0	0	0	0	4	**4**
Difficulty retrieving electronic chart	0	0	0	0	0	0	0	**0**
Other	0	1	0	0	0	0	3	**4**
Charts missing	0	1	0	0	0	0	0	**1**
Confusing taxi chart	0	0	0	0	0	0	1	**1**
Confusion about whether to follow paper or electronic chart	0	0	0	0	0	0	1	**1**
Ownship position symbol not visible after landing	0	0	0	0	0	0	1	**1**
Flight performance calculation concern	1	0	0	1	11	0	2	**15**
Out-of-date (application not specified)	0	0	0	2	2	0	3	**7**
Electronic documents	0	1	0	0	2	0	1	**4**
Difficulty retrieving electronic document	0	1	0	0	0	0	0	**1**
Legibility concern	0	0	0	0	1	0	0	**1**
Out-of-date	0	0	0	0	0	0	1	**1**
Incorrect information	0	0	0	0	0	0	0	**0**
Presentation inconsistent with paper	0	0	0	0	0	0	0	**0**
Scrolling/ zooming concern	0	0	0	0	0	0	0	**0**
Other	0	0	0	0	1	0	0	**1**
Color does not appropriately highlight mandatory MEL items	0	0	0	0	1	0	0	**1**
Electronic checklists	0	0	0	0	0	0	4	**4**
Difficulty retrieving electronic checklist	0	0	0	0	0	0	1	**1**
Inoperable electronic checklist	0	0	0	0	0	0	1	**1**
Missing electronic checklist	0	0	0	0	0	0	1	**1**
Information inconsistent with paper	0	0	0	0	0	0	1	**1**
Arrangement of information on the display	0	0	0	0	0	0	0	**0**

Electronic Display Information Elements Concerns	Handheld Computer	iPad	Other Tablet	Laptop	Performance Computer	Smart Phone/ iPhone	Unspecified EFB	Total
Lack of feedback	0	0	0	0	0	0	1	**1**
System state indicator	0	0	0	0	0	0	1	**1**
Missing	0	0	0	0	0	0	1	**1**
Presented	0	0	0	0	0	0	0	**0**
Error indicator	0	0	0	0	0	0	0	**0**
Missing	0	0	0	0	0	0	0	**0**
Presented	0	0	0	0	0	0	0	**0**
Other	0	0	0	0	0	0	0	**0**
Integration failure	0	0	0	0	0	0	0	**0**
Sharing information across EFBs/PEDs	0	0	0	0	0	0	1	**1**
Security concern	0	0	0	0	0	0	1	**1**
Settings/switching between applications	0	0	0	0	0	0	0	**0**
Other	0	3	0	0	0	0	0	**3**
Applications automatically close while in use	0	3	0	0	0	0	0	**3**
Total	**1**	**8**	**0**	**3**	**15**	**0**	**27**	**54**

Table C-6. Part 135 Electronic Display Information Elements Concerns Reported for Each Device Type.

Electronic Display Information Elements Concerns	Handheld Computer	iPad	Other Tablet	Laptop	Performance Computer	Smart Phone/ iPhone	Unspecified EFB	Total
Electronic charts	0	0	0	0	0	0	3	**3**
Scrolling/ zooming concern	0	0	0	0	0	0	3	**3**
Presentation inconsistent with paper	0	0	0	0	0	0	0	**0**
Incorrect information	0	0	0	0	0	0	0	**0**
Out-of-date	0	0	0	0	0	0	0	**0**
Difficulty retrieving electronic chart	0	0	0	0	0	0	0	**0**
Other	0	0	0	0	0	0	0	**0**
Flight performance calculation concern	0	0	0	0	0	0	0	**0**
Out-of-date (application not specified)	0	0	0	0	0	0	0	**0**
Electronic documents	0	0	0	0	0	0	0	**0**
Difficulty retrieving electronic document	0	0	0	0	0	0	0	**0**
Legibility concern	0	0	0	0	0	0	0	**0**

Electronic Display Information Elements Concerns	Handheld Computer	iPad	Other Tablet	Laptop	Performance Computer	Smart Phone/ iPhone	Unspecified EFB	Total
Out-of-date	0	0	0	0	0	0	0	**0**
Incorrect information	0	0	0	0	0	0	0	**0**
Presentation inconsistent with paper	0	0	0	0	0	0	0	**0**
Scrolling/ zooming concern	0	0	0	0	0	0	0	**0**
Other	0	0	0	0	0	0	0	**0**
Electronic checklists	0	0	0	0	0	0	0	**0**
Difficulty retrieving electronic checklist	0	0	0	0	0	0	0	**0**
Inoperable electronic checklist	0	0	0	0	0	0	0	**0**
Missing electronic checklist	0	0	0	0	0	0	0	**0**
Information inconsistent with paper	0	0	0	0	0	0	0	**0**
Arrangement of information on the display	0	0	0	0	0	0	0	**0**
Lack of feedback	0	0	0	0	0	0	0	**0**
System state indicator	0	0	0	0	0	0	0	**0**
Missing	0	0	0	0	0	0	0	**0**
Presented	0	0	0	0	0	0	0	**0**
Error indicator	0	0	0	0	0	0	0	**0**
Missing	0	0	0	0	0	0	0	**0**
Presented	0	0	0	0	0	0	0	**0**
Other	0	0	0	0	0	0	0	**0**
Settings/switching between applications	0	0	0	0	0	0	0	**0**
Sharing information across EFBs/PEDs	0	0	0	0	0	0	0	**0**
Security concern	0	0	0	0	0	0	0	**0**
Integration failure	0	0	0	0	0	0	0	**0**
Other	0	0	0	0	0	0	0	**0**
Total	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**3**

Table C-7. Part 91 Hardware Concerns Reported for Each Device Type.

Hardware Concerns	Handheld Computer	iPad	Other Tablet	Laptop	Performance Computer	Smart Phone/ iPhone	Unspecified EFB	Total
Equipment error/failure	0	8	3	1	0	0	5	17
Inoperable or partially operable EFB/PED	0	0	0	0	0	0	0	**0**
Screen froze/went black	0	0	1	0	0	0	2	**3**
Unexpected shutdown	0	1	1	1	0	0	1	**4**
Automatically erased data	0	0	0	0	0	0	0	**0**
Battery concern	0	1	0	0	0	0	1	**2**
EFB/PED overheated	0	2	0	0	0	0	0	**2**
Unspecified cause	0	0	1	0	0	0	0	**1**
EFB/PED smoke/fire	0	1	0	0	0	0	0	**1**
Processor speed or memory concern	0	0	0	0	0	0	0	**0**
Other	0	3	0	0	0	0	1	**4**
GPS failed	0	0	0	0	0	0	1	**1**
EFB went offline	0	3	0	0	0	0	0	**3**
Screen legibility concern	2	1	0	0	0	0	2	**5**
Ambient light/glare	1	0	0	0	0	0	1	**2**
Ambient light and display brightness	1	1	0	0	0	0	0	**2**
Brightness/contrast	0	0	0	0	0	0	0	**0**
Unspecified cause	0	0	0	0	0	0	1	**1**
Other	0	0	0	0	0	0	0	**0**
EFB/PED size concern	0	0	1	0	0	0	1	**2**
Input device concern	0	0	0	0	0	0	0	**0**
Touch screen/soft keys	0	0	0	0	0	0	0	**0**
Hard buttons/keys	0	0	0	0	0	0	0	**0**
Interference with other systems	0	2	0	0	0	0	0	**2**
Electromagnetic	0	1	0	0	0	0	0	**1**
Other	0	1	0	0	0	0	0	**1**
Charger caused static interference with radio communications	0	1	0	0	0	0	0	**1**
Pressurization/ decompression concern	0	0	0	0	0	0	0	**0**
Other	0	0	0	0	0	0	0	**1**
Total	**2**	**11**	**4**	**1**	**0**	**0**	**8**	**26**

Table C-8. Part 121 Hardware Concerns Reported for Each Device Type.

Hardware Concerns	Handheld Computer	iPad	Other Tablet	Laptop	Performance Computer	Smart Phone/ iPhone	Unspecified EFB	Total
Equipment error/failure	0	3	0	1	9	0	3	**16**
Inoperable or partially operable EFB/PED	0	0	0	1	5	0	2	**8**
Screen froze/went black	0	2	0	0	1	0	1	**4**
Unexpected shutdown	0	0	0	0	0	0	0	**0**
Automatically erased data	0	1	0	0	2	0	0	**3**
Battery concern	0	0	0	0	1	0	0	**1**
EFB/PED overheated	0	0	0	0	0	0	0	**0**
Unspecified cause	0	0	0	0	0	0	0	**0**
EFB/PED smoke/fire	0	0	0	0	0	0	0	**0**
Processor speed or memory concern	0	0	0	0	0	0	0	**0**
Other	0	0	0	0	0	0	0	**0**
Screen legibility concern	0	1	0	0	0	0	2	**3**
Ambient light/glare	0	0	0	0	0	0	1	**1**
Ambient light and display brightness	0	1	0	0	0	0	0	**1**
Brightness/ contrast	0	0	0	0	0	0	0	**0**
Unspecified cause	0	0	0	0	0	0	0	**0**
Other	0	0	0	0	0	0	1	**1**
Night mode made procedure look more cluttered	0	0	0	0	0	0	1	**1**
EFB/PED size concern	0	0	0	0	1	0	1	**2**
Input device concern	0	0	0	0	1	0	2	**3**
Touch screen/soft keys	0	0	0	0	1	0	1	**2**
Hard buttons/keys	0	0	0	0	0	0	1	**1**
Interference with other systems	0	0	0	0	0	0	0	**0**
Electromagnetic	0	0	0	0	0	0	0	**0**
Other	0	0	0	0	0	0	0	**0**
Pressurization/ decompression concern	0	0	0	0	0	0	0	**0**
Other	0	0	0	1	0	0	0	**1**
Pilot had trouble starting up the EFB	0	0	0	1	0	0	0	**1**
Total	**0**	**4**	**0**	**2**	**11**	**0**	**8**	**25**

Table C-9. Part 135 Hardware Concerns Reported for Each Device Type.

Hardware Concerns	Handheld Computer	iPad	Other Tablet	Laptop	Performance Computer	Smart Phone/ iPhone	Unspecified EFB	Total
Equipment error/failure	0	0	0	0	0	0	1	**1**
Inoperable or partially operable EFB/PED	0	0	0	0	0	0	0	**0**
Screen froze/went black	0	0	0	0	0	0	0	**0**
Unexpected shutdown	0	0	0	0	0	0	0	**0**
Automatically erased data	0	0	0	0	0	0	0	**0**
Battery concern	0	0	0	0	0	0	0	**0**
EFB/PED overheated	0	0	0	0	0	0	0	**0**
Unspecified cause	0	0	0	0	0	0	1	**1**
EFB/PED smoke/fire	0	0	0	0	0	0	0	**0**
Processor speed or memory concern	0	0	0	0	0	0	0	**0**
Other	0	0	0	0	0	0	0	**0**
Screen legibility concern	0	0	0	0	0	0	3	**3**
Ambient light/glare	0	0	0	0	0	0	2	**2**
Ambient light and display brightness	0	0	0	0	0	0	1	**1**
Brightness/ contrast	0	0	0	0	0	0	0	**0**
Unspecified cause	0	0	0	0	0	0	0	**0**
Other	0	0	0	0	0	0	0	**0**
EFB/PED size concern	0	0	0	0	0	0	2	**2**
Input device concern	0	0	0	0	0	0	0	**0**
Touch screen/soft keys	0	0	0	0	0	0	0	**0**
Hard buttons/keys	0	0	0	0	0	0	0	**0**
Interference with other systems	0	0	0	0	0	0	0	**0**
Electromagnetic	0	0	0	0	0	0	0	**0**
Other	0	0	0	0	0	0	0	**0**
Pressurization/ decompression Concern	0	0	0	0	0	0	0	**0**
Other	0	0	0	0	0	0	0	**0**
Total	**0**	**0**	**0**	**0**	**0**	**0**	**6**	**6**

Table C10. Part 91 Self-Reported Human Performance Concerns Reported for Each Device Type.

Self-Reported Human Performance Concerns	Handheld Computer	iPad	Other Tablet	Laptop	Performance Computer	Smart Phone/ iPhone	Unspecified EFB	Total
Lack of experience/expertise	1	10	2	1	0	1	7	**22**
Distraction	0	4	2	1	0	0	6	**13**
Over-reliance on an EFB/PED	0	13	2	1	0	2	3	**21**
Lack of training or documentation	0	1	0	0	0	0	0	**1**
Self-reported data entry/verification concern	0	1	0	0	0	0	0	**1**
Head-down time	0	2	0	0	0	0	1	**3**
Workload	0	0	0	0	0	0	2	**2**
Memory lapse	0	0	0	0	0	0	0	**0**
Other	0	2	0	0	0	0	0	**2**
Pilot misread information on EFB/PED	0	2	0	0	0	0	0	**2**
Inadvertently switched the departure displayed on the screen	0	2	0	0	0	0	0	**2**
Total	**1**	**33**	**6**	**3**	**0**	**3**	**19**	**65**

Table C-11. Part 121 Self-Reported Human Performance Concerns Reported for Each Device Type.

Self-Reported Human Performance Concerns	Handheld Computer	iPad	Other Tablet	Laptop	Performance Computer	Smart Phone/ iPhone	Unspecified EFB	Total
Lack of experience/expertise	0	1	0	0	0	0	6	**7**
Distraction	0	2	0	0	6	0	6	**14**
Over-reliance on an EFB/PED	0	0	0	0	0	0	0	**0**
Lack of training or documentation	0	6	0	1	0	0	3	**10**
Self-reported data entry/verification concern	0	0	0	0	9	0	0	**9**
Head-down time	0	0	0	0	4	0	3	**7**
Workload	0	0	0	0	1	0	2	**3**
Memory lapse	0	0	0	0	0	0	0	**0**
Other	0	0	1	0	3	0	0	**4**
Failed to consult electronic document	0	0	0	0	2	0	0	**2**
Pilot misread information on EFB/PED	0	0	1	0	1	0	0	**2**
Total	**0**	**9**	**1**	**1**	**23**	**0**	**20**	**54**

Table C-12. Part 135 Self-Reported Human Performance Concerns Reported for Each Device Type.

Self-Reported Human Performance Concerns	Handheld Computer	iPad	Other Tablet	Laptop	Performance Computer	Smart Phone/ iPhone	Unspecified EFB	Total
Lack of experience/expertise	0	0	0	0	0	0	0	**0**
Distraction	0	0	0	0	0	0	1	**1**
Over-reliance on an EFB/PED	0	0	0	0	0	0	1	**1**
Lack of training or documentation	0	0	0	0	0	0	1	**1**
Self-reported data entry/verification concern	0	0	0	0	0	0	1	**1**
Head-down time	0	0	0	0	0	0	0	**0**
Workload	0	0	0	0	0	0	0	**0**
Memory lapse	0	0	0	0	0	0	0	**0**
Other	0	0	0	0	0	0	0	**0**
Total	**0**	**0**	**0**	**0**	**0**	**0**	**4**	**4**

Table C-13. Part 91 Placement/Mounting/Stowage Concerns Reported for Each Device Type.

Placement/ Mounting/Stowage Concerns	Handheld Computer	iPad	Other Tablet	Laptop	Performance Computer	Smart Phone/ iPhone	Unspecified EFB	Total
Placement/location	1	1	1	0	0	0	0	**3**
Poor view of EFB/PED	1	0	0	0	0	0	0	**1**
Poor view of instruments, controls or out the window	0	1	0	0	0	0	0	**1**
Other	0	0	1	0	0	0	0	**1**
Pilot inadvertently activated controls with tablet EFB resting on yoke	0	0	1	0	0	0	0	**1**
Stowage	0	0	0	0	0	0	3	**3**
Mounting/securing the EFB/PED	0	0	0	0	0	0	1	**1**
Other	0	0	0	0	0	0	0	**0**
Total	**1**	**1**	**1**	**0**	**0**	**0**	**4**	**7**

Table C-14. Part 121 Placement/Mounting/Stowage Concerns Reported for Each Device Type.

Placement/ Mounting/Stowage Concerns	Handheld Computer	iPad	Other Tablet	Laptop	Performance Computer	Smart Phone/ iPhone	Unspecified EFB	Total
Placement/location	0	0	0	0	0	0	3	**3**
Poor view of EFB/PED	0	0	0	0	0	0	0	**0**
Poor view of instruments or out the window	0	0	0	0	0	0	0	**0**
Other	0	0	0	0	0	0	3	**3**
Mounting solution took up space previously used for paper charts	0	0	0	0	0	0	3	**3**
Stowage	0	0	0	0	0	0	0	**0**
Mounting/securing the EFB/PED	0	1	0	0	0	0	0	**1**
Other	0	0	0	0	0	0	0	**0**
Total	**0**	**1**	**0**	**0**	**0**	**0**	**3**	**4**

Table C-15. Part 135 Placement/Mounting/Stowage Concerns Reported for Each Device Type.

Placement/ Mounting/Stowage Concerns	Handheld Computer	iPad	Other Tablet	Laptop	Performance Computer	Smart Phone/ iPhone	Unspecified EFB	Total
Placement/location	0	0	0	0	0	0	1	**1**
Poor view of EFB/PED	0	0	0	0	0	0	1	**1**
Poor view of instruments or out the window	0	0	0	0	0	0	0	**0**
Other	0	0	0	0	0	0	0	**0**
Stowage	0	0	0	0	0	0	1	**1**
Mounting/securing the EFB/PED	0	1	0	0	0	0	0	**1**
Other	0	0	0	0	0	0	0	**0**
Total	**0**	**1**	**0**	**0**	**0**	**0**	**2**	**3**

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Appendix D: FAA Regulation and Guidance Material, and Other Recommendations

This appendix lists the current FAA regulation and guidance material as it relates to the concerns identified in this effort. Each concern category is broken down into two subsections. The first subsection presents the concerns identified, and the second subsection lists the existing FAA regulation and guidance material pertaining to those concerns, and any additional recommendations from other aviation or transportation authorities.

D.1 Electronic Display Information Elements Concerns

D.1.1 Electronic Charts

FAA Regulatory and Guidance Material

General

- Electronic aeronautical charts should provide a level of information comparable to paper charts. [AC 120-76C, 13d(1)]
- Visual, instrument, and aerodrome charts (refer to International Civil Aviation Organization (ICAO) Annex 4) that are depicted should contain the information necessary, in appropriate form, to conduct the operation at a level of safety that is at least equivalent to that provided by paper charts. [AC 120-76C, 13d(1a)]
- The screen size and resolution must be demonstrated to display information in a comparable manner to paper aeronautical charts and the data it is intended to replace. The information should be equally readable to the paper chart it is replacing, in both light and dark conditions. [AC 120-76C, 13d(1a)]
- Aeronautical navigation charts (i.e., visual flight rules (VFR) navigation charts, low and high altitude en route charts, and terminal procedure publications) will need to be evaluated for operational suitability. [AC 120-76C, 13d(1c)]
- Aerodrome charts must include all information useful for airport operation. [AC 120-76C, 13d(1c)

Presentation of Information

- The screen must display an approach chart in an acceptable aeronautical chart format similar to a published paper approach chart. [FAA Order 8900.1, Volume 4, Chapter 15, Section 1, Paragraph 4-1644, A1] (See also: AC 120-76C, 13d(1b) and AC 20-173, 5.d(2))
- Display information representing the same thing on more than one display on the same flight deck should be consistent. Acronyms and labels should be used consistently, and messages/annunciations should contain text in a consistent way. Inconsistencies should be evaluated to ensure that they are not susceptible to confusion or errors, and do not adversely impact the intended function of the system(s) involved. [AC 25-11A, 31.b]

Incorrect/Conflicting Information

- The operator should provide evidence demonstrating that the EFB operating system and hosted application software can perform the intended function and do not provide false or hazardously misleading information. [AC 120-76C, 11.d(7)]
- Data contained in the data files should be of sufficient integrity to perform the intended functions without producing false or hazardously misleading information. [AC 120-76C, 13.p]
- Flightcrew procedures will ensure that the flightcrew knows what aircraft system to use for a given purpose, especially when both the aircraft and EFB are providing similar information. Procedures should also be designed to define the actions to be taken when information provided by an EFB does not agree with that from other flight deck sources or when one EFB disagrees with another. If an EFB simultaneously displays information that an existing cockpit automation displays, procedures to identify which information source will be primary and which source will be secondary need to be developed (as well as procedures to identify under what conditions to use the backup source). [AC 120-76C, 13.d(3a)]

Data Revision/Update Procedures

- Class 1 or 2 EFBs must have a reliable means for revising the EFB databases. Each method of data revision must ensure integrity of the data being loaded and not negatively impact the reliability of EFB operation. [FAA Order 8900.1, Volume 4, Chapter 15, Section 1, Paragraph 4-1644, G] (See also: AC 120-76C, 12d(1e))
- Procedures must exist to protect the EFB from corruption, especially when internet and/or wireless means are used. [FAA Order 8900.1, Volume 4, Chapter 15, Section 1, Paragraph 4-1644, G] (See also: AC 120-76C, 14.i(1))
- Application software and/or operating system program changes must be controlled and tested prior to use in flight. [FAA Order 8900.1, Volume 4, Chapter 15, Section 1, Paragraph 4-1644, G] (See also: AC 120-76C, 14.i(1))
- Database and/or application software changes may not be performed during operations (taxi, takeoff, in flight, landing). [FAA Order 8900.1, Volume 4, Chapter 15, Section 1, Paragraph 4-1644, G] (See also: AC 120-76C, 14.i(1))
- The operator should have a procedure in place to allow flightcrews to confirm the revision numbers and/or dates of EFB flight databases and software installed on their units for each flight. Procedures should specify what action to take if the applications or databases loaded on an EFB are out-of-date. [AC 120-76C, 14.d(3b)]
- The operator needs to establish a method for revising EFB databases. The method of data revision should ensure integrity of the data that the operator loads and not negatively impact the integrity of the EFB operation. Especially when using internet and/or wireless means, procedures must exist to protect the EFB data from corruption. [AC 120-76C, 14.i(1)]
- Application software and/or operating system program changes must be controlled and tested prior to use in flight. [AC 120-76C, 14.i(1)]
- Operators should not perform database and/or application software changes during operations (taxi, takeoff, in-flight, and landing). [AC 120-76C, 14.i(1)]
- Operators also need to establish revision control procedures so that flightcrews and others can ensure that the contents of the database are current and complete. These revision control

procedures may be similar to the revision control procedures used for paper or other storage media. [AC 120-76C, 14.i(2)]

- For data that is subject to a revision cycle control process, it should be readily evident to the user which revision cycle is currently loaded into the EFB. [AC 120-76C, 14.i(2)]
- …it is the responsibility of the pilot in command (PIC) to verify that any EFB depiction of an en route, terminal area, approach, airport map, or sectional is current and up-to-date. [AC 120-76C, 14.j(1)]

Scrolling/Zooming

- Any active manipulation (e.g., zooming, panning, or decluttering) should be easily returned to the default position. [AC 120-76C, 13d(1c)]
- If the document segment is not visible in its entirety in the available display area, such as during "zoom" or "pan" operations, the existence of off-screen content should be clearly indicated in a consistent way. For some intended functions it may be unacceptable if certain portions of documents are not visible. The basis of this evaluation should be on the application and intended operational function. [AC 120-76C, 13.h]
- The default position should be easily accessible after any active manipulation (e.g., zooming, panning, or decluttering). [AC 120-76C, 13.h]
- Design the application to include a maximum zoom limitation to help visually constrain and highlight the display of own-ship position is insufficient to directly support maneuvering. The level of zoom should be limited to providing supplemental position awareness only. Ensure the range of display zoom level is compatible with the position accuracy of the ownship symbol. [AC 120-76C, 13.f(6)]

D.1.2 Flight Performance Calculation Concerns

FAA Regulatory and Guidance Material

Performance Data Application/System Considerations

- The operator should provide evidence demonstrating that the EFB operating system and hosted application software can perform the intended function and do not provide false or hazardously misleading information. [AC 120-76C, 11e(4b)]
- The system must account for all pertinent variables such as temperature, weight, thrust, runway condition, and obstacles. [FAA Order 8900.1, Volume 3, Chapter 3, Section 3, Paragraph 4-546, C2]
- The system must be reliable in that identical answers must be generated each time the process is entered with identical parameters. [FAA Order 8900.1, Volume 3, Chapter 3, Section 3, Paragraph 4-546, C5]
- The system must be accurate in that it generates performance data that agrees with AFM data within the degree of accuracy inherent in the original AFM data. [FAA Order 8900.1, Volume 3, Chapter 3, Section 3, Paragraph 4-546, C6]
- The system should be relatively simple, easy to use, and not error-prone. [FAA Order 8900.1, Volume 3, Chapter 3, Section 3, Paragraph 4-546, C7]

- Type A W&B software applications may accomplish basic mathematics but must not use algorithms to calculate results. Type A W&B software applications must retrieve and apply existing published information. [FAA Order 8900.1, Volume 4, Chapter 15, Section 1, Paragraph 4-1645, A1]
- Type A software applications for performance may retrieve and apply existing published information. Type A performance software applications must not use algorithms to calculate results. [FAA Order 8900.1, Volume 4, Chapter 15, Section 1, Paragraph 4-1645, A2]
- Type B W&B applications adhere to existing approved data and must be validated for accuracy in the entire aircraft operating envelope. [AC 120-76C, 12e(4e)] (See also: FAA Order 8900.1, Volume 4, Chapter 15, Section 1, Paragraph 4-1645, B3)
- Type B W&B applications may use algorithms to calculate W&B results or may use basic mathematics combined with data spreadsheets to determine W&B results. Algorithms may have the ability to interpolate data but must not extrapolate, and therefore must be tested and proven accurate by the manufacturer or operator to represent the AFM- or Rotorcraft Flight Manual (RFM)-approved data. [AC 120-76C, 11e(4e)]
- Type B performance applications must adhere to this published data [existing published data as found in the FAA-approved flight manual, POH, or performance manual for an aircraft] and must be validated for accurate determination of aircraft performance for the entire operating envelope. [AC 120-76C, 11e(4f)] (See also: FAA Order 8900.1, Volume 4, Chapter 15, Section 1, Paragraph 4-1645, B3)
- Type B aircraft performance applications may use algorithms to calculate results or may use data spreadsheets to determine results. Algorithms may have the ability to interpolate but must not extrapolate beyond the information contained in the current published data. These algorithms have to be tested and verified to meet existing FAA-approved AFM performance data. Type B performance applications must not extrapolate or project results not represented by the AFM-approved data point's envelope of conditions including, but not limited to, pressure, altitude, temperature, and weight. [AC 120-76C, 11e(4f)]
- Type B W&B and/or performance software applications require validation testing prior to EFB operational use. [AC 120-76C, 11e(4g)]
- Applications using data spreadsheets where each data point is entered into software data and then referenced for output must be verified for accurate data selection. [AC 120-76C, 11e(4g)]
- Applications based on algorithms that calculate output must be verified to accurately represent the AFM data they replace. [AC 120-76C, 11e(4g)]
- Creation of a new algorithmic method to replace AFM data is not allowed in Type B applications. [AC 120-76C, 11e(4g)]
- Type B algorithms must adhere to the same data methodology as the AFM-approved data. [AC 120-76C, 11e(4g)]
- The Type B application must always be demonstrated to be traceable to the paper AFM-approved data. [AC 120-76C, 11e(4g)]
- These Type B applications must not allow entry input or output of data outside the AFM data envelope(s). Sufficient data points based on application architecture must be tested and documented to show that the applications accurately adhere to and are limited to the AFM-approved data envelope segments and, for performance, must represent net climb gradients

with considerations including, but not limited to, level-off, acceleration, transitions, and engine takeoff power time limits. [AC 120-76C, 11e(4g)]

- Type B applications for performance must accurately address engine inoperative gradients and obstacle clearance plane and/or weight limits. [AC 120-76C, 11e(4g)]
- Type B applications are suitable only insofar as they accurately reproduce the paper AFM data. [AC 120-76C, 11e(4g)]

Type B W&B and/or performance applications must meet the approval criteria listed in FAA Order 8900.1, Volume 4, Chapter 3, Section 3, Approval of Performance Data Sections of CFMs. [AC 120-76C, 12e(4g)]

Performance Calculation Procedures

- When simplifying assumptions are made, those assumptions must be clearly and completely stated in the operator's CFM or general operations manual (GOM) as operator-imposed limitations. When the assumptions cannot be met, the actions to be taken by the flightcrew, flight followers, and dispatchers must be clearly specified. In such cases, operations must be prohibited or alternate procedures specified. [FAA Order 8900.1, Volume 3, Chapter 3, Section 3, Paragraph 4-546, C8]
- The flightcrew procedures for generating, obtaining, and verifying data must be thoroughly described in the procedures section of the CFM. In the case of the same procedure applying to all airplanes, the flightcrew procedures must be described in a section of the GOM. [FAA Order 8900.1, Volume 3, Chapter 3, Section 3, Paragraph 4-546, C9]
- The operator should develop procedures that define any new roles that the flightcrew and dispatch may have in creating, reviewing, and using performance calculations supported by EFBs. [AC 120-76C, Paragraph 14.d(3d)]

Other Recommendations

Performance Calculation Training

- Require principal operations inspectors assigned to Part 121 carriers that use auxiliary performance computers to review and ensure the adequacy of training and procedures regarding the use of this equipment and the interpretation of the data generated, including landing distance data. [NTSB Recommendation A-00-95]
- 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 Recommendation A-07-58]
- The Australian Transport Safety Bureau requests that the Flight Safety Foundation consider developing guidance to assist flight crews form appropriate mental models in respect of the weight and corresponding take-off performance parameters for a particular flight. The use by operators of mixed fleet flying increases the importance of that guidance. [ATSB Safety Advisory Notice AO-2009-012-SAN-086]
- The Australian Transport Safety Bureau requests the International Air Transport Association to encourage its members to develop guidance to assist their flight crews form appropriate mental models in respect of the weight and corresponding take-off performance parameters for a particular flight. The application by operators of mixed fleet flying increases the need for that

guidance. [ATSB Safety Advisory Notice AO-2009-012-SAN-087]

Performance Calculation Procedures

- Require all 14 Code of Federal Regulations Part 121, 135, and 91 subpart K operators to accomplish arrival landing distance assessments before every landing based on a standardized methodology involving approved performance data, actual arrival conditions, a means of correlating the airplane's braking ability with runway surface conditions using the most conservative interpretation available, and including a minimum safety margin of 15 percent. [NTSB Recommendation A-07-61]
- The Directorate General for Civil Aviation, in the context of the State Safety Plan, should consider the risks associated with operators introducing new computer tools. The European Aviation Safety Agency should conduct a study on the standards that should be taken into account during certification of onboard performance calculation systems, in order to ensure that their ergonomics and procedures for use are compatible with the requirements of safety. [BEA, 2008a]

D.1.3 Out-of-Date (application not specified)

FAA Regulatory and Guidance Material

Data Revision/Update Procedures

- Class 1 or 2 EFBs must have a reliable means for revising the EFB databases. Each method of data revision must ensure integrity of the data being loaded and not negatively impact the reliability of EFB operation. [FAA Order 8900.1, Volume 4, Chapter 15, Section 1, Paragraph 4-1644, G] (See also: AC 120-76C, 14.i(1))
- Procedures must exist to protect the EFB from corruption, especially when internet and/or wireless means are used. [FAA Order 8900.1, Volume 4, Chapter 15, Section 1, Paragraph 4-1644, G] (See also: AC 120-76C, 14.i(1))
- Application software and/or operating system program changes must be controlled and tested prior to use in flight. [FAA Order 8900.1, Volume 4, Chapter 15, Section 1, Paragraph 4-1644, G] (See also: AC 120-76C, 14.i(1))
- Database and/or application software changes may not be performed during operations (taxi, takeoff, in-flight, landing). [FAA Order 8900.1, Volume 4, Chapter 15, Section 1, Paragraph 4-1644, G] (See also: AC 120-76C, 14.i(1))
- The operator should have a procedure in place to allow flightcrews to confirm the revision numbers and/or dates of EFB flight databases and software installed on their units for each flight... Procedures should specify what action to take if the applications or databases loaded on an EFB are out-of-date. [AC 120-76C, 14.d(3b)]
- Operators also need to establish revision control procedures so that flightcrews and others can ensure that the contents of the database are current and complete. These revision control procedures may be similar to the revision control procedures used for paper or other storage media. For data that is subject to a revision cycle control process, it should be readily evident to the user which revision cycle is currently loaded into the EFB. [AC 120-76C, 14.i(2)]

- …it is the responsibility of the pilot in command (PIC) to verify that any EFB depiction of an en route, terminal area, approach, airport map, or sectional is current and up-to-date. [AC 120-76C, 14.j(1)]

D.1.4 Electronic Documents

FAA Regulatory and Guidance Material

Legibility

- Text displayed on the EFB should be legible to the typical user at the intended viewing distance(s) and under the full range of lighting conditions expected on a flight deck, including use in direct sunlight. [AC 120-76C, 13.c]
- Consideration should be given to long-term display degradation as a result of abrasion and aging. [AC 120-76C, 13.c]
- Regardless of the font type, size, color, and background, text should be readable in all foreseeable lighting and operating conditions from the flightcrew station (§ 25.1321(a)). [AC 25-11A, 31.c(1)(a)]
- Information elements (text, symbol, etc.) should be large enough for the pilot to see and interpret in all foreseeable conditions relative to the operating environment and from the flightcrew station (see related regulation). [AC 25-11A, 31.a(1)]

Data Revision/Update Procedures

- Operators also need to establish revision control procedures so that flightcrews and others can ensure that the contents of the database are current and complete. These revision control procedures may be similar to the revision control procedures used for paper or other storage media. For data that is subject to a revision cycle control process, it should be readily evident to the user which revision cycle is currently loaded into the EFB. [AC 120-76C, 14.i(2)]

D.1.5 Electronic Checklists

FAA Regulatory and Guidance Material

Checklist Retrieval

- [Type B ECL] applications must be available for use during all phases of flight. [FAA Order 8900.1, Volume 4, Chapter 15, Section 1, Paragraph 4-1645 B2]
- A current paper backup checklist must be carried on board the aircraft and be readily accessible to the crew. [AC 120-64, 9.a]

Presentation of Information

- The ECL and the paper checklist should be consistent. Minor differences, however, may exist. [AC 120-64 6c(3)(iv)(A)]

Other Recommendations

Checklist Retrieval

- Accessing the checklist should be at least as quick and accurate as with a paper-based checklist. [CAP 708, 5.2.1]

Presentation of Information

- Conventions sued in paper checklists (such as indicating memory items) should be considered to provide consistency where appropriate. [CAP 708, 4.3.6]

D.1.6 Lack of Feedback

FAA Regulatory and Guidance Material

System Feedback

- The system should provide feedback to the user when user input is accepted. [AC 120-76C, 13.g]
- If the system is busy for an atypical time with internal tasks that preclude immediate processing of user input (e.g., calculations, self-test, or data refresh), the EFB should display a "system busy" indicator (e.g., clock icon) to inform the user that the system is occupied and cannot process inputs immediately. [AC 120-76C, 13.g]
- The timeliness of system response to user input should be consistent with an application's intended function. The feedback and system response times should be predictable to avoid flightcrew distractions and/or uncertainty. [AC 120-76C, 13.g]
- If an application is fully or partially disabled, or is not visible or accessible to the user, it may be desirable to have a positive indication of its status available to the user upon request. [AC 120-76C, 13.m]
- EFB status and fault messages should be prioritized and the message prioritization scheme evaluated and documented. [AC 120-76C, 13.m]
- The EFB system should be capable of alerting the flightcrew of probable EFB application/system failures. [AC 120-76C, 13.o(2)]

D.1.7 Sharing Information across EFBs

FAA Regulatory and Guidance Material

Loss of EFB Function

- If one or more onboard EFBs fail, resulting in loss of function or the presentation of false or hazardously misleading information, a contingency plan or process will need to be in place to provide the required information. [AC 120-76C, 14.g]

D.2 Hardware Concerns

D.2.1 Equipment Error/Failure

FAA Regulatory and Guidance Material

EFB Failure Procedures

- Abnormal procedures must be established to address likely EFB function failures. [FAA Order 8900.1 Volume 4, Chapter 15, Section 1, Paragraph 4-1647, B2]

Battery/Power Sources

- For Class 1 or 2 EFBs where the primary power source is a battery, useful battery life must be established and documented for the EFB. When procedures are not established for aircraft power to provide battery recharging during flight operations, at least one fully charged spare battery or EFB must be provided for each EFB that is providing a paperless source of aeronautical information or other software applications pertinent to the safe operation of the aircraft. When EFB battery charging is not possible in the aircraft, either additional charged EFB battery/batteries, spare EFB(s), or a pertinent paper backup must be available to ensure operational performance for the planned duration of the flight, plus one hour. [FAA Order 8900.1 Volume 4, Chapter 15, Section 1, Paragraph 4-1644, E1] (See also: AC 120-76C, 12.c)
- EFB battery maintenance needs to be addressed as either a maintenance or operating procedure to ensure battery life, change intervals, and safety. EFB batteries, including those carried as spares, must be maintained in an appropriate state of charge. Batteries must be replaced at the EFB manufacturer's recommended interval. [FAA Order 8900.1 Volume 4, Chapter 15, Section 1, Paragraph 4-1644, E2]
- EFBs that do not have a battery power source and that are used in place of paper products required by the operating rules are required to have at least one EFB connected to an aircraft power bus. [AC 120-76C, 12.b]
- Each battery powered EFB providing aeronautical information or software applications pertinent to the safe operation of the aircraft must have at least one of the following before departing the gate: [AC 120-76C, 12.c]

  (1) An established procedure to recharge the battery from aircraft power during flight operations;

  (2) A battery or batteries with a combined useful battery life to ensure EFB is operational during taxi and flight operations to include diversions and expected delays; or

  (3) An acceptable mitigation strategy, authorized by the principal inspector (PI) with certificate oversight responsibility with concurrence from Air Transportation Division (AFS-200), to ensure products that contain aeronautical charts, checklists, or other data required by the operating rules are available. The certificate holder must submit a plan to the FAA PI assigned with oversight responsibility for subsequent coordination and review with geographically responsible AFS Regional Office (RO) and AFS-200.
- In the case of a replaceable battery, if the EFB manufacturer has not specified a battery replacement interval, then the original battery (or cell) manufacturer's specified replacement interval should be adhered to. [AC 120-76C, 12.d]

- We recommend the rechargeable lithium-type battery design be compliant with the provisions of the Institute of Electrical and Electronic Engineers (IEEE) 1625-2004, IEEE Standard for Rechargeable Batteries for Portable Computing. [AC 120-76C, 12.e(2)]
- Operators should have documented maintenance procedures for their rechargeable lithium-type batteries. These procedures should meet or exceed the [Original Equipment Manufacturer] OEM's recommendations. These procedures should address battery life, proper storage and handling, and safety. [AC 120-76C, 12.e(6)]
- There should be methods to ensure that the rechargeable lithium-type batteries are sufficiently charged at proper intervals and have periodic functional checks to ensure that they do not experience degraded charge retention capability or other damage due to prolonged storage. These procedures should include precautions to prevent mishandling of the battery, which could cause a short circuit or other unintentional exposure or damage that could result in personal injury or property damage. [AC 120-76C, 12.e(6)]

Backups

- When certain Type B applications (e.g., approach charts, aeronautical charts, ECLs, and flight manuals) are utilized on Class 1 or 2 EFBs to replace aeronautical charts or data required by regulation, risk mitigation is required per AC 120-76. Such mitigation methods may be satisfied by use of multiple EFB hardware and software applications or backup paper aeronautical charts and data. Redundancy in the form of traditional paper aeronautical charts or data. When determining the need for redundancy, take into consideration that no single failure or common mode error can cause the loss of required aeronautical information or data. The need for redundancy should also consider independent power sources or battery backup for the EFB. [FAA Order 8900.1 Volume 4, Chapter 15, Section 1, Paragraph 4-1647, E]
- Two or more operational EFBs are required to remove paper products that contain Type B software applications for in-flight use (e.g., aeronautical charts, checklists, emergency procedures, etc.). [AC 120-76C, 12.a]
- If one or more onboard EFBs fail, resulting in loss of function or the presentation of false or hazardously misleading information, a contingency plan or process will need to be in place to provide the required information. [AC 120-76C, 14.g]

Other Recommendations

- RTCA DO-160G defines a series of minimum standard environmental test conditions and test procedures for airborne equipment. Tests for both high and low ground survival temperature tests and temperature variation test are included in sections 4 and 5 of the document.

D.2.1.1 EFB/PED Smoke/Fire

FAA Regulatory and Guidance Material

Procedures

- In support of safe aircraft operations, rechargeable lithium batteries should never exceed 300 watt-hours (Wh) in a portable (Class 1 or Class 2) EFB or battery backup device.. [FAA Order 8900.1 Volume 4, Chapter 15, Section 1, Paragraph 4-1644, E3]

- The aircraft operator must have documented evidence of required testing for portable (Class 1 or Class 2) EFBs utilizing lithium batteries, as well as procedures for their maintenance, storage, and functional checks. [FAA Order 8900.1 Volume 4, Chapter 15, Section 1, Paragraph 4-1644, E4]
- These procedures should meet or exceed Original Equipment Manufacturer (OEM) recommendations. Procedures must address battery lifespan, proper storage, handling, and safety. There should be methods to ensure the rechargeable lithium type batteries are sufficiently charged at proper intervals and have periodic functional checks to ensure they do not experience degraded charge retention capability or other damage due to prolonged storage. [FAA Order 8900.1 Volume 4, Chapter 15, Section 1, Paragraph 4-1644, E4]
- Battery lifespan must be addressed to ensure replacement at proper intervals (i.e., specified time period for replacement, battery no longer holds minimum voltage after charge, minimum percentage of charge retention compared to original capacity, etc.) per the OEM's recommendations. [FAA Order 8900.1 Volume 4, Chapter 15, Section 1, Paragraph 4-1644, E4]
- Procedures should include precautions to prevent mishandling of the battery, which could cause a short circuit or other unintentional exposure or damage that could result in personal injury or property damage. [FAA Order 8900.1 Volume 4, Chapter 15, Section 1, Paragraph 4-1644, E4]
- All replacements for rechargeable lithium batteries must be sourced from the OEM and repairs must not be made. [FAA Order 8900.1 Volume 4, Chapter 15, Section 1, Paragraph 4-1644, E4]
- Where the EFB primary power source is a battery, procedures may be established to use aircraft power for battery recharging during flight operations. [FAA Order 8900.1 Volume 4, Chapter 15, Section 1, Paragraph 4-1644, E5]
- When an EFB [Class 2 only] uses aircraft power as the primary power source, design approval is required for this connection and power source by TC, amended TC, or STC. [FAA Order 8900.1 Volume 4, Chapter 15, Section 1, Paragraph 4-1644, E6]
- In the case of a replaceable battery, if the EFB manufacturer has not specified a battery replacement interval, then the original battery (or cell) manufacturer's specified replacement interval should be adhered to. [AC 120-76C, 12.d]
- We recommend the rechargeable lithium-type battery design be compliant with the provisions of the Institute of Electrical and Electronic Engineers (IEEE) 1625-2004, IEEE Standard for Rechargeable Batteries for Portable Computing. [AC 120-76C, 12.e(2)]
- Operators should have documented maintenance procedures for their rechargeable lithium-type batteries. These procedures should meet or exceed the [Original Equipment Manufacturer] OEM's recommendations. These procedures should address battery life, proper storage and handling, and safety. [AC 120-76C, 12.e(6)]
- There should be methods to ensure that the rechargeable lithium-type batteries are sufficiently charged at proper intervals and have periodic functional checks to ensure that they do not experience degraded charge retention capability or other damage due to prolonged storage. These procedures should include precautions to prevent mishandling of the battery, which could cause a short circuit or other unintentional exposure or damage that could result in personal injury or property damage. [AC 120-76C, 12.e(6)]
- All replacements for rechargeable lithium batteries must be sourced from the OEM and repairs must not be made. [AC 120-76C, 12.e(6)]

D.2.2 Screen Legibility Concern

FAA Regulatory and Guidance Material

Lighting Conditions

- When a Type B software application is available on an EFB during certain critical phases of flight (e.g., taxi, takeoff, approach, and landing): [FAA Order 8900.1, Volume 4, Chapter 15, Section 1, Paragraph 4-1644, A and A2]

  - The display must be proven to be readable in all anticipated lighting conditions by each pilot/crewmember and in each aircraft in which it is to be used.
  - The display must have a dimming capability that would prevent the EFB from being a distraction or impairment to night vision in a night flight deck environment.
  - The display must also be demonstrated to be readable on the flight deck in direct sunlight.
  - Display brightness must be equally adjustable whether the EFB is operating on battery or aircraft power.
  - Users should be able to adjust the screen brightness of an EFB independently of the brightness of other displays on the flight deck. (See also: AC 120-76C, 13.c]
  - When automatic brightness adjustment is incorporated, it should operate independently for each EFB on the flight deck.
  - Buttons and labels should be adequately illuminated for night use. (See also: AC 120-76C, 13.c)

- Text displayed on the EFB should be legible to the typical user at the intended viewing distance(s) and under the full range of lighting conditions expected on a flight deck, including use in direct sunlight. [AC 120-76C, 13.c]
- Brightness should be adjustable in fine increments. [AC 120-76C, 13.c]
- Consideration should be given to long-term display degradation as a result of abrasion and aging. [AC 120-76C, 13.c]
- The EFB should not produce objectionable glare or reflections that could adversely affect the pilot's visual environment. [AC 120-76C, 13.c] (See also: AC 25-11A, 16b(4))
- Information should be readable over a wide range of ambient illumination under all foreseeable conditions relative to the operating environment, including but not limited to: [AC 25-11A, 16.a(3)]

  • Direct sunlight on the display,
  • Sunlight through a front window illuminating white shirts (reflections),
  • Sun above the forward horizon and above a cloud deck in a flightcrew member's eyes, and
  • Night and/or dark environment.

- For low ambient conditions, the display should be dimmable to levels allowing for the flightcrew's adaptation to the dark, such that outside vision and an acceptable presentation are maintained. [AC 25-11A, 16.a(3)(a)]
- Operation of [automatic luminance adjustment] systems should be satisfactory over a wide range of ambient light conditions, including the extreme cases of a forward low sun and a quartering rearward sun shining directly on the display. [AC 25-11A, 16.a(3)(b)]
- Some manual adjustment should be retained to provide for normal and non-normal operating differences so that the luminance variation is not distracting and does not interfere with the flightcrew's ability to perform their tasks. [AC 25-11A, 16.a(3)(b1)]

- The installation of the display equipment must not cause glare or reflection, either on the displays or on the flight deck windows, that could interfere with the normal duties of the minimum flightcrew (§ 25.773 (a)(2)) under all foreseeable conditions. [AC 25-11A, 16.a(4)]
- Each pilot compartment must be free of glare and reflections that could interfere with the normal duties of a minimum flightcrew. This must be shown in day and night flight tests under non-precipitation conditions (§ 25.773(a)(2)). [AC 25-11A, 16.a(11)]
- For all display configurations, all foreseeable conditions relative to lighting should be considered. Foreseeable lighting considerations should include failure modes such as lighting and power system failure, the full range of flight deck lighting and display system lighting options, and the operational environment (for example, day and night operations). [AC 25-11A, 31.a(1)]
- If a visual indicator is provided to indicate a malfunction of an instrument, it must be effective under all foreseeable lighting conditions (§ 25.1321(e)). [AC 25-11A, 31.a(1)]
- Regardless of the font type, size, color, and background, text should be readable in all foreseeable lighting and operating conditions from the flightcrew station (§ 25.1321(a)). [AC 25-11A, 31.c(1)(a)]
- Pilot compartment view considerations include glare, reflection, and visual field. [AC 20-173, 5.d(1)]
- Information elements (text, symbol, etc.) should be large enough for the pilot to see and interpret in all foreseeable conditions relative to the operating environment and from the flightcrew station (see related regulation). [AC 25-11A, 31.a(1)]

D.2.3 EFB/PED Size Concern

FAA Regulatory and Guidance Material

EFB Size

- The following display requirements are specified when a Type B application is available on an EFB during certain critical phases of flight (e.g., taxi, takeoff, approach, and landing): [FAA Order 8900.1, Volume 4, Chapter 15, Section 1, Paragraph 4-1644, A and A1]
  - The screen size and resolution must be proven to display information in a comparable manner to the aeronautical charts and data it is intended to replace. (See also: AC 20-173, 5.d(2))
  - The screen must be large enough to show an entire instrument approach procedure (IAP) chart at once with the equivalent degree of legibility and clarity as a paper chart. (See also: AC120-76C, 13.d(1a and b))
- A display should be large enough to present information in a form that is usable (for example, readable or identifiable) to the flightcrew from the flightcrew station (see related regulation) in all foreseeable conditions, relative to the operational and lighting environment and in accordance with its intended function(s). [AC 25-11A, 16.a(1)]

D.2.4 Input Device Concern

FAA Regulatory and Guidance Material

- Buttons and labels should be adequately illuminated for night use. [FAA Order 8900.1, Volume 4, Chapter 15, Section 1, Paragraph 4-1644, A2]
- If a touch screen is used, it must be evaluated for ease of operation. The touch screen must be responsive and not require multiple attempts to make a selection, but not be so sensitive that erroneous selections occur. [FAA Order 8900.1, Volume 4, Chapter 15, Section 1, Paragraph 4-1644, A6]
- Buttons and labels should have adequate illumination for night use. All controls must be properly labeled for their intended function. Consideration should be given to long-term display degradation as a result of abrasion and aging. [AC 120-76C, 13.c]
- …consider integrating an associated support for stabilizing the pilot's hand, and for providing a reference point when positioning fingers, if appropriate. Ensure that touch screens do not result in unacceptable levels of workload, error rates, speed, and accuracy. [AC 20-175, 3-5.a]
- Ensure that touch screens resist scratching, hazing, or other damage that can occur through normal use. Demonstrate that the system will continue to provide acceptable performance after long-term use and exposure to skin oils, perspiration, environmental elements (e.g., sun), impacts (e.g., clipboard), chemical cleaners that might be used in the flight deck, and any liquids that might be brought onboard by flightcrew members (e.g., coffee). [AC 20-175, 3-5.b]
- If a touch screen's calibration can drift or degrade, provide touch screen calibration procedures and other maintenance-related items to ensure proper calibration and operation. Include these procedures in the instructions for continued airworthiness, per § 2X.1529. [AC 20-175, 3-5.c]
- The location of the pilot's finger touch, as sensed by the touch screen, should be predictable and obvious. [AC 20-175, 3-5.d]

D.2.5 Interference with Other Systems

FAA Regulatory and Guidance Material

Interference with Other Flight Deck Systems

- **(a)** Except as provided in paragraph (b) of this section, no person may operate, nor may any operator or pilot in command of an aircraft allow the operation of, any portable electronic device on any of the following U.S.-registered civil aircraft:(1) Aircraft operated by a holder of an air carrier operating certificate or an operating certificate; or (2) Any other aircraft while it is operated under IFR.

  (b) Paragraph (a) of this section does not apply to—

  (1) Portable voice recorders;
  (2) Hearing aids;
  (3) Heart pacemakers;
  (4) Electric shavers; or

(5) Any other portable electronic device that the operator of the aircraft has determined will not cause interference with the navigation or communication system of the aircraft on which it is to be used.

(c) In the case of an aircraft operated by a holder of an air carrier operating certificate or an operating certificate, the determination required by paragraph (b)(5) of this section shall be made by that operator of the aircraft on which the particular device is to be used. In the case of other aircraft, the determination may be made by the pilot in command or other operator of the aircraft. [14 CFR § 91.21; § 121.306; and § 135.144]

- It is necessary to demonstrate that any Class 1 or Class 2 EFB used in aircraft flight operations will have no adverse impact on other aircraft systems (non-interference). [AC 120-76C, 12.f]
- It is the user's/operator's responsibility to determine that the operation of a portable electronic device (PED) will not interfere, in any way, with the operation of aircraft equipment. [FAA Order 8900.1, Volume 4, Chapter 15, Section 1, Paragraph 4-1644, C]
- Class 1 and Class 2 EFBs should demonstrate that they meet appropriate industry-adopted environmental qualification standards for radiated emissions for equipment operating in an airborne environment (RTCA/DO-160, Environmental Conditions and Test Procedures for Airborne Equipment, or its equivalent). [AC 120-76C, 12.f]
- In order to operate a PED in other than a noncritical phase of flight, the user/operator is responsible for ensuring that the PED will not interfere in any way with the operation of aircraft equipment. [FAA Order 8900.1, Volume 4, Chapter 15, Section 1, Paragraph 4-1644, C1] (See also: AC 120-76C, 12.f(1) and (2))
- In order to operate a T-PED [transmitting portable electronic device] in other than a noncritical phase of flight, the user/operator is responsible to ensure the T-PED will not interfere with the operation of the aircraft equipment in any way. [FAA Order 8900.1, Volume 4, Chapter 15, Section 1, Paragraph 4-1644, C2] (See also: AC 120-76C, 12.f(3))
- The design must include a means to ensure EFB operation, malfunction, or failure does not adversely affect safe and continued operation of other installed aircraft systems to which connection is made. [AC 20-173, 5.c(2)(b)]

Other Recommendations

Electromagnetic Interference

- RTCA DO-160G defines a series of minimum standard environmental test conditions and applicable test procedures for airborne equipment. Testing magnetic effect is described in section 15 of the document.
- RTCA DO-294C defines and recommends a process by which aircraft operators and/or manufacturers may assess the risk of interference due to T-PED technology within any aircraft type and model.

D.3 Self-Reported Human Performance Concerns

FAA Regulatory and Guidance Material

Data Entry and Error Checking

- If user-entered data is not of the correct format or type needed by the application, the EFB should not accept the data. [AC 120-76C, 13.n]
- The EFB should provide an error message that communicates which entry is suspect and specifies what type of data it expects. [AC 120-76C, 13.n]
- The EFB system and application software should incorporate input error checking that detects input errors at the earliest possible point during entry, rather than on completion of a possibly lengthy invalid entry. [AC 120-76C, 13.n]
- The system design should minimize the occurrence and effects of flightcrew error and maximize the identification and resolution of errors. [AC 120-76C, 13.o(1)]

Training

- The operator must develop EFB training for all personnel involved with EFB use, database servicing, and maintenance. EFB training must comply with training identified in AC 120-76 and be FAA-approved where applicable. [FAA Order 8900.1, Volume 4, Chapter 15, Section 1, Paragraph 4-1647, F]
- Certificated operators requesting to conduct operations using EFB cockpit applications should use the training guidance in FAA Order 8900.1, Volume 3, Chapter 19, Training Programs and Airman Qualifications. [AC 120-76C, 14.l(2)]
- FAA guidance requires all parts 121 and 135 operators to develop a curriculum segment for the EFB, which may consist of a ground training simulation and, if needed, a flight training segment. The EFB curriculum segment should include an outline of the training, appropriate courseware, and the instructional delivery method.
- Each EFB training module should include the following elements: [AC 120-76C, 14.l(2)]

  (a) A description of the EFB, its capabilities, and the applications for which the operator will use the EFB and its components and peripherals. This should include theory of operation, and the training should ensure that flightcrews understand the dependencies associated with the sources and limitations of the information.
  (b) A description of EFB controls, displays, symbology, and failure modes. EFB failure modes and flightcrew procedures should include a description of the EFB (e.g., EFB processor, switches, and installed databases, such as an airport surface or en route moving map). If color is a significant EFB application feature, then training materials should include color illustrations.
  (c) An AFMS or another form of documentation that provides conditions, limitations, and procedures for the use of the EFB and its associated equipment. Only EFB provisions (mounts, wiring, etc.) for Class 2 EFBs or installation for Class 3 EFBs require an AFMS, unless approved by TSO. Class 1 and Class 2 EFBs and Type A and Type B EFB applications may require an alternative means of documentation that provides conditions, limitations, and procedures for use.
  (d) Descriptions of authorized special flight maneuvers, operations, and procedures that the operator conducts when using an EFB.
  (e) Any special pilot/controller procedures when using EFB-based information.

(f) Geographical areas authorized for specific EFB operations, if applicable.
(g) Authorized methods to defer inoperative EFB equipment.

- Operator training should also provide an opportunity for instruction, demonstration, and practice using the actual or simulated EFB equipment and displays. [AC 120-76C, 14.l(3)]
- Except when under the supervision of an appropriately trained check airman, the [Part 91k, 121 or 135] flightcrew may need to complete an approved training program before being authorized to use the EFB equipment. However, flightcrew members should have satisfactorily completed the ground school portion of the EFB training program, if required. Training as outlined in this AC is only applicable to those flightcrew members that actually operate the equipment. [AC 120-76C, 14.m(1)]
- For air carrier operations, initial qualification with the EFB may require that the flightcrew members demonstrate satisfactory proficiency with the EFB to an FAA inspector or check airman; this may be completed during a line check. [AC 120-76C, 14.m(1)]
- The primary source of operational and training guidance [for Part 91F operators] will be provided through the FITS, which can be obtained through the equipment manufacturer or AFS-800 at Washington HQ. The appropriate FITS program may be used to determine the appropriate best practices for familiarization with and use of the equipment. Each operator's EFB program should identify and document user training in support of the use of an EFB. [AC 120-76C, 14.m(3)]

Workload

- The EFB software design should minimize flightcrew workload and head-down time. The positioning, use, and stowage of the EFB should not result in unacceptable flightcrew workload. [AC 120-76C, 13.l]
- Avoid complex, multi-step data entry tasks during takeoff, landing, and other critical phases of flight. [AC 120-76C, 13.l]
- An evaluation of EFB intended functions should include a qualitative assessment of incremental pilot workload, as well as pilot system interfaces and their safety implications. [AC 120-76C, 13.l]
- If the intended function of an EFB includes use during critical phases of flight, such as during takeoff, landing, or abnormal and emergency operations, its use should be evaluated during simulated or actual aircraft operations under those conditions. [AC 120-76C, 13.l]
- Procedures that mitigate and/or control additional workloads created by using an EFB will need to be addressed. [AC 120-76C, 14.d(3c)]

Other Recommendations

Performance Calculation Data Entry Error Mitigation

- Enable an independent assessment system for weight and balance, and compare the value with crew input and fuel. [BEA, 2008b, 4.3.1]
- Improve the presentation of data, for example, a graphic representation of the runway with indicators for the place where speeds are reached or a graphic representation of the weight data (in the form of superimposed bar graphs, for example, representing the empty weight, the load, the fuel and the MTOW). [BEA, 2008b, 4.3.2]

- Introduce data checking using systematic association of weight – speed data. Joint verification of these three representations should enable detection of errors linked to an insufficient weight being taken into account in calculation of speeds. [BEA, 2008b, 4.3.3]
- Provide a decision support system to detect non-nominal behavior of the aircraft. As for all warning systems, the compromise between efficiency and nuisance can be hard to find. The activation threshold should limit the number of nuisance alerts and aborted takeoffs. [BEA, 2008b, 4.3.4]
- Airlines should examine the ways errors can be introduced into the process and determine if the procedures currently in place prevent these errors from occurring or provide sufficient opportunities for errors to be detected. Procedures need to take into account the entire process and recognize that errors may occur at all stages of pre-flight preparation. Ideally, procedures relating to the calculation and entry of take-off performance parameters should take into account the following: [ATSB, 2011. 6.1.1]

  - An independent calculation or cross-check of the take-off performance data is conducted by another crew member
  - where possible, the data is verified using multiple sources
  - when verifying the data, both the values used to make the calculations and the values that are calculated are checked
  - there are procedures in place in the event the primary aircraft system used to calculate take-off performance parameters is unavailable
  - the roles and responsibilities of all crew members are clearly delineated.
- Where more than one system is available for calculating take-off performance parameters, system manufacturers and airlines should consider provisions for crosschecking the data between both sources. [ATSB, 2011, 6.1.2]
- The Department of Transport, in conjunction with the International Civil Aviation Organization, the Federal Aviation Administration, the European Aviation Safety Agency, and other regulatory organizations, establish a requirement for transport category aircraft to be equipped with a take-off performance monitoring system that would provide flight crews with an accurate and timely indication of inadequate take-off performance. [TSB Action Required (A06-07)]

D.4 Placement/Mounting/Stowage Concerns

D.4.1 Placement/Location

D.4.1.1 Poor View of EFB/PED

FAA Regulatory and Guidance Material

EFB Placement/Location

- [When a Type B application is available on an EFB during certain critical phases of flight (e.g., taxi, takeoff, approach, and landing)] the display must be viewable from an offset angle to preclude difficulty in positioning the EFB on the aircraft flight deck. [FAA Order 8900.1, Volume 4, Chapter 15, Section 1, Paragraph 4-1644, A3]

- Placement for EFB displays must meet the 14 CFR 23.773, 25.773, 27.773, or 29.773 requirements for parts 23, 25, 27, or 29, as applicable. Placement also needs to consider many other factors: accessibility, workload effects, and potential pilot fatigue effects from use, etc. Pilot compartment view considerations include glare, reflection, and visual field. [AC 20-173, 5.d(1)]
- Portable displays should also be evaluated for external vision considerations with the intended EFB. [AC 20-173, 5.d(1)]
- Displays should be located such that the pilot(s) can monitor them with minimal head and eye movement between displays. [AC 23.1311-1C, 14.1]
- Flight information should be legible, accurate, easily interpreted, sufficiently free of visual cutoff (viewing angle), parallax and distortion, for the pilot to correctly interpret it. [AC 23.1311-1C, 14.1]
- If two or more pilots need to view the information, the information elements should also be discernable and interpretable over these viewing distances. The pilots should have a clear, unobstructed, and undistorted view of the displayed information. [AC 25-11A, 31.a(1)]
- Factors to consider when designing and evaluating the viewability and readability of the displayed information include: [AC 25-11A, 31.a(2)]

  - Position of displayed information: Distance from the design eye position (DEP) is generally used. If cross-flight deck viewing of the information is needed, distance from the offside DEP, accounting for normal head movement, should be used. For displays not mounted on the front panel, the distance determination should include any expected movement away from the DEP by the flightcrew…
  - Visual Angles: Account for both the position of the displayed information as well as font height. SAE ARP 4102/7, Electronic Displays, provides additional information on this subject.

- Class 1 EFBs that have Type B software applications for aeronautical charts, approach charts, or electronic checklists (ECL) must be secured to a temporary securing solution or viewable during critical phases of flight, and must not interfere with flight control movement. [FAA Order 8900.1, Volume 4, Chapter 15, Section 1, Paragraph 4-1643A]
- Class 2 EFBs that have Type B software applications for aeronautical charts, approach charts, or ECL must be secured and viewable during critical phases of flight, and must not interfere with flight control movement. [FAA Order 8900.1, Volume 4, Chapter 15, Section 1, Paragraph 4-1643B]
- It is the user's/operator's responsibility to determine that the operation of a portable electronic device (PED) will not interfere, in any way, with the operation of aircraft equipment. [FAA Order 8900.1, Volume 4, Chapter 15, Section 1, Paragraph 4-1644C]
- Yoke-mounted EFBs must be certificated by a design approval by AIR under TC, amended TC, or STC. All the structural and dynamic, as well as wiring protection and security requirements affecting the flight controls (including autopilot, stall warning, stick pusher, crashworthiness, human factors, etc.), must be addressed prior to installation. [FAA Order 8900.1, Volume 4, Chapter 15, Section 1, Paragraph 4-1648C1]
- When attached to its mounting device, the EFB must not interfere with flightcrew duties and must be easily and safely stowed when not in use. [FAA Order 8900.1, Volume 4, Chapter 15, Section 1, Paragraph 4-1644H]

- In addition, the attached EFB must not obstruct flightcrew primary and secondary fields of view, nor impede safe egress. [FAA Order 8900.1, Volume 4, Chapter 15, Section 1, Paragraph 4-1644H]

D.4.2 Stowage

FAA Regulatory and Guidance Material

Stowage

- Class 1 EFBs that have Type B applications for aeronautical charts, approach charts, or electronic checklists (ECL) must be secured and viewable during critical phases of flight and must not interfere with flight control movement. [FAA Order 8900.1, Volume 4, Chapter 15, Section 1, Paragraph 4-1643, A]
- EFB stowage is required for all EFBs not secured in or on a mounting device. If an EFB mounting device is not provided, designate an area to stow the EFB. [AC 120-76C, 12h]
- [Stow the EFB] in a manner that prevents the device from jamming flight controls, damaging flight deck equipment, or injuring flightcrew members should the device move about as a result of turbulence, maneuvering, or other action. The stowage area should not obstruct visual or physical access to controls and/or displays, flightcrew ingress or egress, or external vision. [AC 120-76C, 12h]
- The positioning, use, and stowage of the EFB should not result in unacceptable flightcrew workload. [AC 120-76C, 13.l]

Chart Availability during All Phases of Flight

- Type B aeronautical chart software applications… must be available for use during all phases of flight. [FAA Order 8900.1, Volume 4, Chapter 15, Section 1, Paragraph 4-1645, B1]
- Class 1 EFBs that have Type B applications for aeronautical charts, approach charts, or an electronic checklist must be appropriately secured and viewable during critical phases of flight and must not interfere with flight control movement. [AC 120-76C, 5.c]

D.4.3 Mounting/Securing the EFB/PED

FAA Regulatory and Guidance Material

- Class 1 EFBs that have Type B software applications for aeronautical charts, approach charts, or electronic checklists (ECL) must be secured to a temporary securing solution or viewable during critical phases of flight, and must not interfere with flight control movement. [FAA Order 8900.1, Volume 4, Chapter 15, Section 1, Paragraph 4-1643A]
- Class 2 EFBs that have Type B software applications for aeronautical charts, approach charts, or ECL must be secured and viewable during critical phases of flight, and must not interfere with flight control movement. [FAA Order 8900.1, Volume 4, Chapter 15, Section 1, Paragraph 4-1643B]

- The EFB [Class 2 only], when attached to its appropriately designed mounting device, must be evaluated to ensure operational suitability in all ground and flight operations and conditions. [FAA Order 8900.1, Volume 4, Chapter 15, Section 1, Paragraph 4-1644H]
- When attached to its mounting device, the EFB must not interfere with flightcrew duties and must be easily and safely stowed when not in use. [FAA Order 8900.1, Volume 4, Chapter 15, Section 1, Paragraph 4-1644H]
- In addition, the attached EFB must not obstruct flightcrew primary and secondary fields of view, nor impede safe egress. [FAA Order 8900.1, Volume 4, Chapter 15, Section 1, Paragraph 4-1644H]

D.5 FAA Regulatory and Guidance Material for Part 91 Operations

- EFBs/ECDs can be used during all phases of flight operations in lieu of paper reference material when the information displayed meets the following criteria: [AC 91-78, 6.a]

  (1) The components or systems onboard the aircraft which display precomposed or interactive information are the functional equivalent of the paper reference material.
  (2) The interactive or precomposed information being used for navigation or performance planning is current, up-to-date, and valid.
  NOTE: Supporting reference material such as legends, glossaries, abbreviations, and other information is available to the pilot but is not required in the cockpit during operation.
- The in-flight use of an EFB/ECD in lieu of paper reference material is the decision of the aircraft operator and the pilot in command. Any Type A or Type B EFB application, as defined in AC 120-76A may be substituted for the paper equivalent. It requires no formal operational approval as long as the guidelines of this AC are followed. [AC 91-78, 6.b]
- It is suggested that a secondary or back up source of aeronautical information necessary for the flight be available to the pilot in the aircraft. The secondary or backup information may be either traditional paper-based material or displayed electronically. [AC 91-78, 6.c]
- Training should include preflight checks of the system, the use of each operational function on the EFB, the conditions (including phases of flight) under which the EFB should not be used, and procedures for cross-checking data entry and computed information. [AC 91-78, 9.a(1)]

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