Review of Safety Reports Involving Electronic Flight Bags

DOT/FAA/AR-10/5

DOT-VNTSC-FAA-10-08

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April 2010

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REPORT DOCUMENTATION PAGE	*Form Approved* *OMB No. 0704-0188*

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE April 2010	3. REPORT TYPE AND DATES COVERED

4. TITLE AND SUBTITLE Review of Safety Reports Involving Electronic Flight Bags	5. FUNDING NUMBERS FA6Y DD304 FA6Y ED304 FA6Y FD304 FA6Y HD304 FA6YC2 HT015
6. AUTHOR(S) Divya C. Chandra and Andrew Kendra	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) U.S. Department of Transportation John A. Volpe National Transportation Systems Center Research and Special Programs Administration Cambridge, MA 02142-1093	8. PERFORMING ORGANIZATION REPORT NUMBER DOT-VNTSC-FAA-10-08
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Department of Transportation Federal Aviation Administration Air Traffic Organization Operations Planning (AJP-61) Human Factors Research and Engineering Group 800 Independence Avenue, SW Washington, D.C. 20591 Program Manager: Dr. Tom McCloy	10. SPONSORING/MONITORING AGENCY REPORT NUMBER DOT/FAA/AR-10/5
11. SUPPLEMENTARY NOTES	
12a. DISTRIBUTION/AVAILABILITY STATEMENT This document is available to the public through the National Technical Information Service, Springfield, VA 22161	12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

Safety events in which Electronic Flight Bags (EFBs) were a factor are reviewed. Relevant reports were obtained from the public Aviation Safety Reporting System (ASRS) database and the National Transportation Safety Board (NTSB) accident report database.

Of the 67 relevant ASRS reports identified, 32 pertain to use of chart software and 30 pertain to computation of flight performance. Operational outcomes/anomalies and underlying EFB issues are identified. Charts were often in use on the EFB when deviations in heading, altitude, or speed occurred. Zooming and panning the chart display can induce workload and may cause the pilot to miss important information. With flight performance calculations, anomalies included company policy deviations, incorrect computations, and runway incursions. Finally, some pilots who were new to the EFB mentioned that difficulty using the EFB contributed to the event.

EFB-related findings from two NTSB accident reports are highlighted. Both of these identified use of an EFB for calculating landing distance as a contributing factor. One issue was that assumptions underlying the performance calculations on an EFB must be presented to the crew as clearly as on paper-based performance tables. A second issue was assessment of the adequacy of training and procedures for using EFB performance calculations functions.

14. SUBJECT TERM Electronic flight bag, EFB, charts, electronic charts, flight performance calculations, ASRS, electronic display, flight deck, flight deck procedures, runway incursion	15. NUMBER OF PAGES 35
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	

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Preface

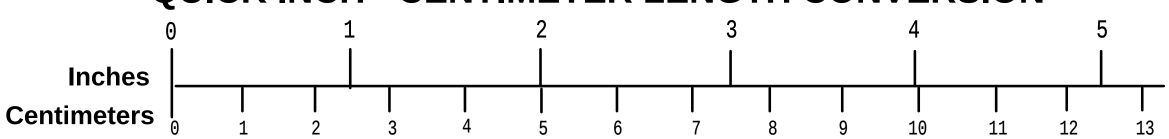
This report was prepared by the Behavioral Safety Research and Demonstration Division at the United States Department of Transportation Volpe National Transportation Systems Center. It was completed with funding from the FAA Human Factors Research and Engineering Group (AJP-61) in support of the Aircraft Certification Service Avionic Systems Branch (AIR-130) and the Technical Programs and Continued Airworthiness Branch (AIR-120). We would like to thank our FAA program manager, Tom McCloy, as well as our FAA technical sponsor Colleen Donovan for their assistance with this project. Thanks to Jason Goodman for support in the data analysis. Thanks also to Michelle Yeh and Stephen Popkin (Volpe Center) for feedback on this document.

Feedback on this document may be sent to Divya Chandra (Divya.Chandra@dot.gov) or Andrew Kendra (Andrew.Kendra@ dot.gov). Further information on this research effort can be found at http://www.volpe.dot.gov/hf/.

METRIC/ENGLISH CONVERSION FACTORS

ENGLISH TO METRIC		METRIC TO ENGLISH	
LENGTH (APPROXIMATE)		**LENGTH (APPROXIMATE)**	
1 inch (in)	= 2.5 centimeters (cm)	1 millimeter (mm)	= 0.04 inch (in)
1 foot (ft)	= 30 centimeters (cm)	1 centimeter (cm)	= 0.4 inch (in)
1 yard (yd)	= 0.9 meter (m)	1 meter (m)	= 3.3 feet (ft)
1 mile (mi)	= 1.6 kilometers (km)	1 meter (m)	= 1.1 yards (yd)
		1 kilometer (km)	= 0.6 mile (mi)
AREA (APPROXIMATE)		**AREA (APPROXIMATE)**	
1 square inch (sq in, in^2)	= 6.5 square centimeters (cm^2)	1 square centimeter (cm^2)	= 0.16 square inch (sq in, in^2)
1 square foot (sq ft, ft^2)	= 0.09 square meter (m^2)	1 square meter (m^2)	= 1.2 square yards (sq yd, yd^2)
1 square yard (sq yd, yd^2)	= 0.8 square meter (m^2)	1 square kilometer (km^2)	= 0.4 square mile (sq mi, mi^2)
1 square mile (sq mi, mi^2)	= 2.6 square kilometers (km^2)	10,000 square meters (m^2)	= 1 hectare (ha] = 2.5 acres
1 acre = 0.4 hectare (he)	= 4,000 square meters (m^2)		
MASS - WEIGHT (APPROXIMATE)		**MASS - WEIGHT (APPROXIMATE)**	
1 ounce (oz)	= 28 grams (gm)	1 gram (gm)	= 0.036 ounce (oz)
1 pound (lb)	= 0.45 kilogram (kg)	1 kilogram (kg)	= 2.2 pounds (lb)
1 short ton = 2,000 pounds (lb)	= 0.9 tonne (t)	1 tonne (t)	= 1,000 kilograms (kg)
			= 1.1 short tons
VOLUME (APPROXIMATE)		**VOLUME (APPROXIMATE)**	
1 teaspoon (tsp)	= 5 milliliters (ml)	1 milliliter (ml)	= 0.03 fluid ounce (fl oz)
1 tablespoon (tbsp)	= 15 milliliters (ml)	1 liter (l)	= 2.1 pints (pt)
1 fluid ounce (fl oz)	= 30 milliliters (ml)	1 liter (l)	= 1.06 quarts (qt)
1 cup (c)	= 0.24 liter (l)	1 liter (l)	= 0.26 gallon (gal)
1 pint (pt)	= 0.47 liter (l)		
1 quart (qt)	= 0.96 liter (l)		
1 gallon (gal)	= 3.8 liters (l)		
1 cubic foot (cu ft, ft^3)	= 0.03 cubic meter (m^3)	1 cubic meter (m^3)	= 36 cubic feet (cu ft, ft^3)
1 cubic yard (cu yd, yd^3)	= 0.76 cubic meter (m^3)	1 cubic meter (m^3)	= 1.3 cubic yards (cu yd, yd^3)
TEMPERATURE (EXACT)		**TEMPERATURE (EXACT)**	
((x-32)(5/9)) °F	= y °C	((9/5) y + 32) °C	= x °F

QUICK INCH - CENTIMETER LENGTH CONVERSION



QUICK FAHRENHEIT - CELSIUS TEMPERATURE CONVERSION

°F	-40°	-22°	-4°	14°	32°	50°	68°	86°	104°	122°	140°	158°	176°	194°	212°
°C	-40°	-30°	-20°	-10°	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°

For more exact and or other conversion factors, see NIST Miscellaneous Publication 286, Units of Weights and Measures. Price [2.50 SD Catalog No. C13 10286 Updated 6/17/98

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Executive Summary

Airlines crews operating under Part 121 of Section 14 the Code of Federal Regulations (CFR) have been using Electronic Flight Bags (EFBs) to compute flight performance for many years. More recently, private and charter operators (14 CFR Part 91 and Part 135) began using EFBs primarily for the charting software. The purpose of this document is to examine what, if any, safety impacts EFBs are having as the industry matures and units are deployed more widely. Two sources of data were accessed: the public online Aviation Safety Reporting System (ASRS) database and the database of accident reports published by the National Transportation Safety Board (NTSB).

Sixty-seven relevant reports were gathered from the ASRS database in August 2009. These reports were submitted by private and professional pilots operating under 14 CFR Parts 91, 135, and 121. The ASRS reports were analyzed and interpreted to determine general trends in the data, flight outcomes and anomalies, and underlying EFB issues.

Thirty-two reports in the ASRS set pertained to use of a chart application on the EFB and 30 pertained to computation of flight performance. The remaining five reports pertain to use of documents or unspecified applications. Of the reports involving EFB charting applications, 24 were from Part 91 operators, five were from Part 135 operators, and three were from Part 121 operators. All reports involving flight performance calculations are from Part 121 operators.

The most common outcome in the ASRS event set was a deviation in heading, altitude, or speed. Charts were typically in use on the EFB when such deviations occurred. Two key underlying issues appear to be that (a) zooming and panning to configure the chart display for readability can induce workload that may impact other tasks and (b) the display could be configured such that important information was out of view and missed when needed.

With flight performance calculations, anomalies include company policy deviations (e.g., takeoff from an unauthorized runway), incorrect computations, and runway incursions. A variety of flight deck procedures issues are implicated in these events. For example, in four runway incursion reports, one crewmember was preoccupied completing calculations during taxi as the other crewmember missed a clearance restriction or hold short line. In two other cases, pilots did not set flaps for takeoff because they forgot to complete necessary checklists while they were preoccupied with the calculations.

Finally, pilots who were new to the EFB mentioned that difficulty using the EFB contributed to the anomaly in 11 ASRS reports. Eight of these cases were from Part 91 operators and three were from Part 121 operators.

Two accident reports from the NTSB that identified the EFB as a contributing factor in aircraft accidents are considered separately in this document. These accident reports are not reinterpreted, but EFB-related findings are excerpted and highlighted here. Both NTSB accident reports identify issues with use of the EFB to determine landing distance. In the older NTSB accident report, from 2000, the key issue is assessment of the adequacy of training and procedures for using EFBs. In the more recent accident report, from 2007, the NTSB recommends that assumptions underlying the performance calculations on an EFB must be presented to the crew as clearly as they are shown on paper-based performance tables.

The results of this activity are intended to provide data that may be considered by regulatory authorities such as the Federal Aviation Administration (FAA) when updating human factors guidance for evaluating, approving, and authorizing the use of EFBs. In addition, this research can be used by operators to anticipate issues that need special consideration. EFB manufacturers and designers may also find this report informative.

Acronyms

AC	Advisory Circular
ASRS	Aviation Safety Reporting System
APLC	Airport Performance Laptop Computer
ATC	Air Traffic Control
CFR	Code of Federal Regulations
EFB	Electronic Flight Bag
FAA	Federal Aviation Administration
IMC	Instrument Meteorological Conditions
NASA	National Aeronautics and Space Administration
NTSB	National Transportation Safety Board
OPC	Onboard Performance Computer
POI	Principal Operations Inspector
SWA	Southwest Airlines
VMC	Visual Meteorological Conditions

1 Introduction

The Electronic Flight Bag (EFB) industry has grown rapidly since the Federal Aviation Administration (FAA) issued Advisory Circular (AC) 120-76A in March of 2003 (FAA, 2003). Airlines crews operating under Part 121 of Section 14 of the Code of Federal Regulations (CFR) have been using EFBs to compute "just-in-time" flight performance for many years, but private and charter operators (14 CFR Parts 91 and 135) operators began equipping with EFBs more recently, primarily for the charting software. Another benefit of EFBs is better access to aircraft operating documents in electronic form. A recent review of EFB products shows the diversity of implementations that are being purchased and deployed by all types of operators (Yeh and Chandra, 2007). For more information on what functions EFBs can support, see Shamo (2000) and Hirschman (2009).

The purpose of this document is to examine what, if any, safety impacts EFBs are having as the industry matures and units are deployed more widely. To accomplish this task, safety-related reports pertaining to EFBs were gathered from two sources: the public online Aviation Safety Reporting System (ASRS) database that is managed by the National Aeronautics and Space Administration (NASA) and the database of accident reports published by the National Transportation Safety Board (NTSB).

In this technical report, we discuss how the EFB-related safety reports were identified from the ASRS online database and then describe the overall set of reports that were obtained. We analyze and interpret the ASRS reports to understand what impact the EFB had in the event and what EFB human factors issues were encountered. Examples of these EFB issues are described and the full set of data is summarized. The two NTSB accident reports that cite EFBs as a contributing factor are addressed separately from the ASRS reports. The findings of the NTSB are not reinterpreted in this report, but points that are relevant to EFBs are excerpted and highlighted. Note that a conference paper on this research was published earlier (Chandra and Kendra, 2009), but that paper is based on only a subset of the ASRS reports covered in this full report.

2 Identifying EFB-Related Safety Reports

All of the safety reports discussed in this report were obtained from the NTSB website and the ASRS website. Other public online data bases were also searched but no further reports were identified (see Appendix A for a list). Other databases that may contain EFB-related safety reports (e.g., those kept by airlines) are not publicly accessible and were not searched for this effort.

The search term *Performance Computer* was used to identify one accident report on the NTSB database. The resulting accident report, from 2007, makes reference to an older accident report, from 2000.[1] Note that there is also a current investigation by the Australian Transport Safety Bureau (ATSB) into a tail strike incident at Melbourne, Victoria in Australia where an EFB was used to compute an incorrect takeoff speed. The ATSB has published an interim report on the case and is seeking more information about these types of events (ATSB, 2009). This case is not discussed in detail here because a final report was not issued prior to the completion of our analysis.

The online ASRS database was searched in August 2009. The ASRS reports are useful for identifying human factors areas of interest. However, there are limitations to the reports in the ASRS database, as noted on the ASRS website. In particular, these are subjective self-reports that have been submitted voluntarily. The reporters are not trained observers and may have difficulty in observing their own situation and performance. Also, ASRS reports cannot be used for describing the frequencies of events

[1] This older report was not retrieved through the NTSB database query form using any of our search terms for some reason, but it can be located by entering the date and aircraft tail number provided in the Reference section of the 2007 NTSB report.

because the FAA or NTSB has not necessarily corroborated them. In addition, there are limits on public accessibility to the full ASRS data set. Not all reports that are submitted to ASRS are posted online because they must be processed manually before they are posted, a labor intensive process. ASRS personnel use a sophisticated system of priorities to determine which reports are processed and posted online. Although all submitted reports are pre-screened within a few days of submission, months may elapse after the date of the event before a full form report is posted online. Over the past several years, approximately 20% of reports submitted to ASRS have been posted in their full form online (E. Taube, personal communication, 1 May 2009).

In order to find EFB-related reports in the ASRS database, a key word search was conducted on the full narrative and synopsis of the report. This task was complicated by the fact that there is no standard terminology in use for EFB systems and applications. The following search terms were used to identify the relevant reports: *EFB*, *Performance Computer*, *Onboard Performance Computer*, *OPC*, *Tablet PC*, *Tablet*, *Paperless*, *Electronic Chart*, *Auxiliary Performance Computer*, *APLC*, *APC*, *LAPC*, *ALPC*, and *Laptop* (and its misspelling, *lap top*). This list contains acronyms that may be used as well as the full terms. For example, *OPC* is an abbreviation for *Onboard Performance Computer*. *LAPC*, *ALPC*, and *APLC* are all potential abbreviations for *Airport Performance Laptop Computer* and *APC* is a potential abbreviation for *Auxiliary Performance Computer*.

Unrelated reports were often returned in the ASRS search and these were manually removed from the search results. In some cases the unrelated reports were easily identified, e.g., references to passenger laptops or medicinal tablets. Some ASRS reports had to be reviewed carefully to identify whether the EFB was actually a factor in the situation. Cases where the EFB was only mentioned in passing or used normally during events that were set in motion by other factors were not considered to be relevant. For example, if the reference stated that the First Officer was using the EFB, then stowed it to listen to Air Traffic Control communications, then no problem with the EFB was documented per se, and the case was dropped from the set. Other cases were excluded for a variety of reasons. For example, in one case, the Part 91 operator’s laptop-based moving map display failed to function at a critical time. This case (ASRS report number 722105) was eventually excluded because it was from a Part 91 operator and Part 91 moving map displays are not addressed under the EFB advisory circular, AC 120-76A (FAA, 2003).

3 Analysis of ASRS Reports

The full ASRS report contains several pieces of information. Table 1 contains a list of all the searchable fields in the full form. The reports that were identified as being relevant to EFB operations were examined carefully, and a separate spreadsheet was constructed summarizing these reports with the information listed in Table 2 below.

Type of Information	Details Provided
Report Information	Report Number [number] Date of Incident between [date] and [date]
Environment	Flight Conditions [conditions] Light Conditions [conditions] Weather Elements [weather]
Aircraft	Operator [organization] Make/Model [aircraft type] Federal Aviation Regulations (FAR)[2] Part [regulation] Flight Plan [type] Flight Phase [phase]
Place	Location [identifier] State [abbreviation]
Person	Reporter Affiliation [organization] Reporter Function [position]
Event Assessment	Event Type [anomaly] Detector [equipment/human] Resolutory Action [action/inaction] Primary Problem [cause] Air Traffic Incident [type]
Narrative / Synopsis	Callback conversations with reporter in some cases

Table 1: Searchable fields in a full form ASRS report.

Information Copied Directly From ASRS Report	Information Extracted or Interpreted from ASRS Report	Interpretations of the Event Constructed by Authors
• Case Number • Year • Operating Regulation (e.g., Part 91) • Operator Type (e.g., Corporate) • Synopsis • Callback Interview • Flight Conditions (e.g., visual or instrument) • Light (e.g., nighttime, daytime) • Other Environmental Conditions • Aircraft Make/Model	• Relevant airport (e.g., origin, destination) • Phase of flight (e.g., arrival, climb) • EFB application in use (e.g., electronic charts) • Outcome/Anomaly (e.g., altitude deviation) • Interesting quotes • Search term(s) used to find the report • Description of EFBs in use (e.g., how many, what type)	• Summarized the EFB issue • Categorized the EFB issue • Determined whether the EFB was a *primary* or *contributing* factor to the outcome/anomaly.

Table 2: Information extracted or constructed for each relevant safety report.

Some information was copied directly from the ASRS report into the spreadsheet for the analysis, but other information was based on the interpretation and judgment of the Volpe Center researchers' subject-matter expertise. For example, the researchers classified the outcome or anomaly that occurred, and judged whether the EFB was *either* a primary or contributing cause for the outcome or anomaly.

In order to identify the outcome or anomaly, the researchers tried to determine why the author of the ASRS report considered the event as being serious enough to warrant filing the report. In general, the answer to this question was the "outcome." Note that the outcomes and anomalies found in the ASRS reports are typically an actual violation or a "near violation" (i.e., a violation that almost occurred) of a requirement (e.g., an altitude clearance, or published heading for a departure or arrival procedure). Filing a voluntary ASRS report grants the reporter a level of immunity for the violation as detailed in AC 00-46D (FAA, 1997). Generally speaking, there is only one such outcome/anomaly in any given report, as it would be rare to have two entirely distinct violations arising from the same set of circumstances.

[2] Note that the term "Federal Aviation Regulation" is no longer used by the FAA, but it is used in the ASRS database. The proper term to use is "Code of Federal Regulations" (CFR).

In order to distinguish between primary and contributing factors for the event, the researchers reviewed the narrative report submitted by the reporter carefully to determine the order of events, and the self-reported actions and difficulties.[3] The distinction between primary and contributing factors is subjective opinion and not a legal finding. In the researchers' opinion, the primary factor was the one without which the event was not likely to have occurred at all. Contributing factors tended to complicate or exacerbate the situation. In some cases, the narrative clearly identifies what the reporter considered to be the primary factor in the event, or there was only one factor in the event (e.g., an expired database on the EFB). In most cases, however, there was more than one factor, and the researchers attempted to prioritize the factors. The use of these terms, "primary" and "contributing" factors, is consistent with language used in NTSB accident reports.

In addition, the description and classification of the EFB issue encountered was based on the researchers' judgment. This was the most subjective part of the analysis. In some cases, there was enough information to judge what the issue was with regard to the EFB (e.g., the reporter mentioned that he/she was unable to read the screen in bright sunlight). In other cases, there was not enough information to identify the exact problem. For example, if there were difficulties accessing information, it may have been because there was a software bug, or because the user training was insufficient, or because the EFB design was problematic. Here the EFB issue was classified more generally, to acknowledge that the underlying issue may not be well understood.

Another subjective aspect of the analysis was in determining the appropriate level of generality of the list of EFB issues. The final list was determined iteratively; where there were enough similar cases, or when the issue was of special interest, the EFB issue was called out on its own, but if the events were relatively unique, they were placed in a "Miscellaneous EFB Operation" category.

4 Results and Discussion

A total of 67 relevant reports were extracted from the online ASRS database,[4] dating from 1995 through 2009. The relevant reports contained information about an EFB that was a contributing or primary factor in the event. In addition to the relevant reports where EFBs were a factor, two reports mentioned EFBs in regard to documents that were *not* available, but could, and perhaps should, have been provided on an EFB (see ASRS reports 767735 and 723218). In a few other cases that were excluded, pilots described issues that they felt were potentially of concern about data and calculation algorithms used in the EFB software. For example, in ASRS reports 747978 and 699668, the reporter complains that the flight performance calculation algorithms make potentially dangerous assumptions. In ASRS report 587196, the reporter complains that it is difficult to interpret the runway length shown on an airport diagram.

Results of the analyses of the 67 relevant reports in the final set are presented below in Section 4.1. Descriptive statistics are presented first for the information taken directly from the ASRS reports. Next is a discussion of the incident outcomes, interpretations, and the EFB issues that were encountered. Findings from the ASRS reports are summarized briefly at the end of Section 4.1. EFB-related highlights from the NTSB accident reports are presented in Section 4.2 below.

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[3] Every event was first reviewed independently by at least two of the Volpe Center researchers. For cases where there was some uncertainty, or a disagreement between the researchers, the event was reviewed jointly to determine the nature of the EFB's impact on the event.

[4] Recall that the online database contains only about 20% of all the reports submitted to ASRS. There may be additional reports related to EFBs in the full database that we could not access.

4.1 ASRS Reports

The ASRS reports were analyzed both in terms of overall descriptive statistics (e.g., weather and lighting conditions at the time of the event) and in terms of the more complex incident interpretations constructed by the researchers. First the descriptive statistics are presented and then the incident outcomes, interpretations, and issues are discussed. The findings are then summarized briefly. Appendix B contains a full list of the ASRS report numbers included in this review.

4.1.1 Descriptive Statistics for ASRS Reports

Reports related to flight performance calculations date back to 1995, as shown in Table 3 below. Chart related reports were first filed in 2002. Reports related to charts peaked in 2006, with 12 cases filed. Of these 12 cases, 11 were from Part 91 or Part 135 operators. The increased number of reports in this timeframe may reflect the wider implementation of EFBs among corporate operators during that time. The number of reports dropped off substantially again in 2008 and 2009. This may reflect a general slowing down in the aviation industry due to economic conditions; fewer new EFBs were probably purchased and deployed in 2008-9.

Year	Charts	Calculations	Documents	Charts and Documents	Unspecified	Total
1995		1				1
1996		1				1
1997			1			1
1999		1				1
2000		2				2
2001		3				3
2002	3	3				6
2003	3	6				9
2004	2	3				5
2005	3	3				6
2006	12	2			1	15
2007	6	5				11
2008	2		2	1		5
2009	1					1
Total	**32**	**30**	**3**	**1**	**1**	**67**

Table 3: Cases by year of report and software application in use.

Overall, 32 pertained to use of the charting application on the EFB, 30 reports pertained to the calculations function, and five others pertained to documents or unspecified applications. Part 91 operations accounted for 25 of the reports, with all but one of those filed pertaining to the chart application (see Table 4 below). Part 121 operators filed 37 reports overall, with 30 reports for the calculations function. Part 135 operators were involved in 5 reports, all for the charting application.

Weather and ambient lighting conditions do not appear to play a part in EFB-related safety reports (see Table 5 and Table 6 below). The bulk of reports were filed for visual flight conditions. Reports were filed for both daytime and nighttime conditions.

Operating Regulation	Charts	Calculations	Documents	Charts and Documents	Unspecified	Total
Part 91	24				1	25
Part 121	3	30	3	1		37
Part 135	5					5
Total	**32**	**30**	**3**	**1**	**1**	**67**

Table 4: Cases by operating regulation and application in use.

Flight Condition	Cases
Visual meteorological conditions	52
Instrument meteorological conditions	4
Marginal visual conditions	1
Mixed visual and instrument conditions	2
Not available	8
Total	**67**

Table 5: Cases by flight condition.

Light	Cases
Dawn	4
Daylight	41
Dusk	3
Night	15
Not available	4
Total	**67**

Table 6: Cases by lighting condition.

Several types of operations are represented in the reports, air carrier, air taxi, charter, corporate, instructional, and personal (see Table 7 below). Air carriers were involved about 54% of the reports (36 of 67).

Operation	Cases
Air Carrier	36
Air Taxi	2
Charter	3
Corporate	19
Instructional	1
Personal	6
Total	**67**

Table 7: Cases by type of operation.

Table 8 below shows the cases by phase of flight and application in use. Events associated with the flight performance calculations were typically discovered on the ground or during takeoff roll, although a few were discovered later in the flight as crews tried to understand earlier events. With the chart application, the majority of anomalies occurred during climb out. A detailed review of the data shows that twelve reports were filed for events that occurred during initial climb out, a very busy time of the flight.

Four of the ASRS reports were filed for events that occurred while flying the same location and procedure, specifically, the TEB 5 departure out of Teterboro, New Jersey (TEB). This procedure provides separation between departures from Teterboro and arrivals into Newark International Airport. Both airports are located in the heart of complex New York and New Jersey airspace. The TEB 5 departure is a complex procedure that imposes a high level of workload, regardless of whether an EFB is used or not, because there is little margin for pilot error (see NASA, 2007 and FAA, 2008b). Because there is insufficient data (just four reports), we cannot determine whether the use of an EFB is an *additional* risk factor under these high workload conditions.

Phase of Flight	Charts	Calculations	Documents	Charts and Documents	Unspecified	Total
Maintenance	1					1
Ground Hold		1				1
Parked		2		1		3
Preflight		6		1		7
Pushback		2				2
Takeoff Roll		7				7
Climb Out	20	2				22
Cruise		1	1			2
Approach	6	3			1	10
Taxi In or Taxi Out	5	6		1		12
Total	**32**	**30**	**1**	**3**	**1**	**67**

Table 8: Cases by phase of flight and software application in use.

4.1.2 ASRS Report Outcomes

Outcomes and anomalies from the ASRS reports are listed in Table 9 below as a function of application in use. The most common outcomes or anomalies described were deviations in heading, altitude, or speed; these occurred in 26 reports. The charting application was in use for 22 of these 26 cases (85%), and just three of the 26 cases involved Part 121 operators (i.e., commercial air lines); 88% of the cases were operating under either Part 91 or Part 135 (i.e., private or charter operations).

A runway incursion occurred in ten reports. However, the EFB was only a contributing factor, not the primary factor in the runway incursion in all of these events. No specific EFB application was implicated in the runway incursions; in four cases, EFB charts were in use and in five cases, the crew was using the EFB to complete calculations. In the typical scenario, one crewmember was preoccupied with the EFB during taxi as the other crewmember missed a taxi clearance restriction or hold short line. For example, in one case, the First Officer’s attention was diverted by stowing the EFB in an awkward location behind his seat; he did not challenge the Captain when the Captain incorrectly read back and then executed the wrong taxi clearance. In another similar case, an inexperienced crew member combined with an awkwardly large and stowed EFB resulted in a runway incursion.

Other observed outcomes listed in Table 9 include company policy deviations, expired databases, incorrect computations, altitude confusion, an aborted takeoff, and a tail strike upon rotation. Some of these outcomes did not result in a violation, but did create confusion and workload.

Outcome	Charts	Calculations	Documents	Charts and Documents	Unspecified	Total
Deviation in heading, altitude, or speed	22	3			1	26
Runway incursion	4	5	1			10
Company policy deviation		7	1			8
Expired database	2	3	1	1		7
Incorrect weight and balance		5				5
Incorrect take-off speed		3				3
Incorrect take-off speed with tail strike		1				1
Erroneous performance data, no adverse effects		2				2
Altitude deviation during declared emergency	1					1
Aborted takeoff		1				1
Altitude confusion	1					1
Almost deviated in altitude	1					1
Taxi route confusion without airport diagram	1					1
Total	**32**	**30**	**3**	**1**	**1**	**67**

Table 9. Outcome by software application in use.

4.1.3 ASRS Report Factors

Table 10 below provides a summary of the outcomes, and information about whether the EFB was a primary or contributing factor in the event. The EFB was judged by the researchers to be the primary factor in the outcome for 43% of the cases (29 of 67), and a contributing cause in the remainder, 57% (38 of 67).

Other factors for the outcomes in these reports included time pressure, fatigue, problems with the Flight Management Computer, and last minute changes to the aircraft clearance. Sometimes when the EFB was found to be a primary factor in the outcome, these other factors were also present as contributing factors. When the EFB was determined to be a contributing factor for the outcome, one of these other factors was usually the primary factor.

EFB Factor	Charts	Calculations	Documents	Charts and Documents	Unspecified	Total
Primary	14	12	1	1	1	29
Contributing	18	18	2			38
Total	**32**	**30**	**3**	**1**	**1**	**67**

Table 10. Whether the EFB was a primary or contributing factor, by software application in use.

4.1.4 Underlying EFB Issues in ASRS Reports

The EFB issues encountered in the ASRS reports are described in Table 11 below. As noted earlier, the list of issue categories was constructed iteratively and is based on researcher interpretations of the underlying issues in the reports.

Issue	Description
Flight Deck Procedures	Related to crew procedures for using the EFB(s) (e.g., sharing/cross-checking information)
Zooming and Panning the Display	Related to crew interactions with the EFB to improve display readability. Information may be missed because it is out of view when needed, or workload may be increased because of the multiple crew inputs required to configure the display
New to EFB	The EFB is new to the crew
Miscellaneous EFB Operation Issues	EFB is difficult to use for a variety of reasons (e.g., stowed away, sluggish response in cold environment, big/heavy for the flight deck)
Data Entry	Difficulty with data entry function
Database Expired	Issue in maintenance or crew verification of database currency
EFB Inoperative	EFB or application is not available for use (e.g., EFB in sleep mode or rebooting)
Screen Legibility	Screen is hard to use under different lighting conditions
Software Bug	Failure of the software to operate as intended
Chart Selection	Difficulty in selecting the required chart at the appropriate time (e.g., due to distraction, or turbulence)
Display Format	Difficulty interpreting information due to inconsistencies between expected and actual format
Battery Issues (EFB Inoperative)	EFB operation is interrupted or prevented due to battery life
Separated Information	Difficulty of accessing related information

Table 11: EFB issue descriptions.

Table 12 below shows how many cases were identified for each of the EFB issues by application in use. Note that the number of issues reported in Table 12 is greater than the total number of reports because more than one EFB issue was encountered in some of the reports. A more detailed mapping of EFB issues to flight anomalies and outcomes is provided in Appendix C. Appendix C also contains a table mapping EFB issues as a function of operating regulation and application in use. Appendix D contains a table that maps the EFB issues to specific ASRS report numbers.

The first row in Table 12 shows that 17 reports had issues related to Flight Deck Procedures. Of these, 14 cases (all Part 121 operators) were associated with computing flight performance. A variety of procedural issues were implicated in these events. For example, in four runway incursion events, one crewmember was preoccupied completing calculations during taxi as the other crewmember missed a taxi clearance restriction or hold short line. In two other cases, pilots neglected to complete necessary checklists as they prepared for the flight, resulting in forgetting to set flaps in preparation for takeoff.

The next most common EFB issue encountered in this set of ASRS reports was related to Zooming and Panning the Display for readability.[5] Eleven of the 14 cases shown in the second row of Table 12 were from Part 91 operators and three were from Part 135 operators; none of these cases were from airline operators (Part 121), most likely because charts are not in heavy use by Part 121 operators to date. In one case, for example, a corporate operator declared an emergency due to electrical smoke in the flight deck from a popped circuit breaker. The pilot had a “small EFB” and no paper charts. The pilot had to manually load an arrival that was not in the flight management system. During the emergency, the pilot

[5] *Panning* produces the same result as *scrolling* within window in that it changes the portion of the document that is in view. The tasks of zooming and panning together could also be referred to as *display configuration*. All of these concepts are combined into this one EFB issue.

had to zoom and pan extensively to read the EFB screen, which created workload, and he/she eventually missed an altitude restriction that was off screen in order to make another portion of the chart readable.

The situation described above occurred in other reports as well. Pilots have to switch between zooming out in order to see the entire procedure and zooming in to read detailed information on the chart. They may have to pan the display screen to move around to the various parts of the chart as needed. The display configuration tasks of zooming and panning create workload, and this workload contributes to pilot errors. A research study has also documented that it takes longer to retrieve information from charts on an EFB when panning and zooming are necessary (Hamblin, 2003). One interesting comment from many of the ASRS reports was that the pilots would have preferred to have paper printouts of the charts for use during approaches and departures, especially when unsecured EFBs must be stowed for safety.

The third row in Table 12 shows 11 cases where the EFB was new to at least one of the crew members, and the reporter noted that this inexperience was a factor that contributed to the outcome or anomaly. Of these 11 cases, eight were from Part 91 operators and just three were from Part 121 operators. The FAA Advisory Circular (AC) 120-76A (FAA, 2003) requires Part 121 operators to be trained on EFBs. However, Part 91 operators are not required to follow this guidance, and it is therefore possible that they receive less training on EFBs than the Part 121 flight crews.

The miscellaneous EFB operation issues in Table 12 include four cases that mentioned the size of the EFB or its stowage as a factor in the report. Two pilots who mentioned size said that their EFBs were large and heavy, making them awkwardly sized for the flight deck. One report mentioned that the stowage location was awkward to reach, and had to be used while the aircraft was taxiing, creating an unsafe situation. The fourth report mentioned that because the EFB had to be stowed according to company policy, the chart could not be reviewed at a later time easily. This pilot added “I have found it takes more time and discipline by [pilots] to obtain all the info they need from an electronic versus paper chart.”

EFB Issue	Calculations	Charts	Documents	Charts and Documents	Unspecified	Total
Flight Deck Procedures	14	3				**17**
Zooming and Panning the Display		14				**14**
New to EFB	2	8			1	**11**
Miscellaneous EFB Operation Issues	2	5	1			**8**
Data Entry	7					**7**
Database Expired	3	2	1	1		**7**
EFB Inoperative	1	3	1			**5**
Screen Legibility		5				**5**
Software Bug	3	2				**5**
Chart Selection		3				**3**
Display Format	2	1				**3**
Battery Issues (EFB Inoperative)	2	1				**3**
Separated Information	1	1				**2**
Total	**37**	**48**	**3**	**1**	**1**	**90**

Table 12: EFB issues encountered by software application in use.

Table 13 below illustrates the correspondence between the EFB issues list used in this report and related sections from Chandra, Yeh, Riley, and Mangold (2003). This mapping could be used to identify sections of that reference document where reports from the current review could be incorporated as examples. In particular, some of the EFB-related incidents from the ASRS reports cut across issues in Chandra et al., and the links between these topics could be highlighted in future guidance as well as in EFB training material and flight deck procedures.

Issue	Related Section(s) from Chandra, et al. (2003)
Flight Deck Procedures	2.3 Training/Procedures Considerations
Zooming and Panning the Display	2.1.1 Workload 6.2.5 Zooming and Panning 6.2.11 De-cluttering and Display Configuration
New to EFB	2.1.1 Workload 2.3 Training/Procedures Considerations
Miscellaneous EFB Operation Issues	2.2.2 Stowage 2.2.3 Use of Unsecured EFB Systems 2.5.3 Display
Data entry	5.1.1 Default Values 5.1.2 Data-entry Screening and Error Messages
Database Expired	2.4.15 Ensuring Integrity of EFB Data 2.4.16 Updating EFB Data
EFB Inoperative	2.4.5 Multitasking 2.4.9 Display of System Status
Screen Legibility	2.1.5 Lighting-Legibility
Software bug	No applicable section
Chart Selection	6.2.6 Chart procedures 6.2.9 Access to Individual Charts
Display format	2.1.3 Compatibility and Consistency with Flight Deck Systems and Other Flight Information 5.1.3 Support Information for Performance Data Entry
Battery Issues (EFB Inoperative)	No applicable section
Separated Information	2.4.18 Links to Related Material

Table 13: EFB issues and related sections of Chandra et al., (2003).

4.1.5 Summary of Findings from ASRS Reports

The 67 ASRS reports involving use of EFBs shed light on the types of issues that pilots are encountering. The data show that private and charter operators (Parts 91 and 135) are the primary reporters for issues related to EFB charts and airline operators (Part 121) are the primary reporters for issues related to flight performance calculations. Use of EFB charts is associated with deviations in heading, altitude, and speed. Anomalies associated with the flight performance calculations include deviations from company policy, incorrect computations, and runway incursions. Underlying EFB issues were categorized subjectively across the ASRS reports based on the researchers' subject-matter expertise. Problem areas noted in Table 12 above appear to include (a) reinforcement of flight deck procedures to ensure that pilots do not become preoccupied with the EFB, in particular, with the flight performance calculations, (b) zooming and panning the display (configuration) of EFB charts, which can create workload and result in the pilot missing off-screen information, and (c) introducing the EFB technology to new users.

4.2 NTSB Accident Reports Involving an EFB as a Contributing Factor

In this section we discuss two NTSB accidents reports in which EFBs were cited as a contributing factor (NTSB, 2000 and NTSB, 2007). First an overview of the events in the accident is provided for context only. Refer to the full NTSB reports for more background information and context than is provided here. These summaries are not reinterpretations of the NTSB findings. There were many factors in the accident that are not addressed in detail here. Following the accident overview, we highlight only the EFB-related issues from each of the accidents.

4.2.1 Accident Overviews

One accident involving an EFB occurred on July 31, 1997 (NTSB, 2000). A Federal Express (FedEx) MD-11 aircraft crashed while landing at night in visual conditions on runway 22R at Newark International Airport in Newark, New Jersey at about 1:30 am local time. The aircraft was inbound from Anchorage, Alaska. Two crew members and three passengers escaped with minor injuries during egress from the flight deck, but the aircraft was a total loss, valued at $112 million.

A more recent accident in which the EFB was cited by the NTSB as a contributing factor occurred on December 8, 2005 (NTSB, 2007). A Southwest Airlines (SWA) flight arriving from Baltimore ran off the departure end of runway 31C at Chicago Midway International Airport in Chicago, Illinois at about 7 pm local time. The Boeing 737-700 aircraft rolled through two fences and onto an adjacent roadway where it struck an automobile before coming to a stop. A child in the automobile was killed, and there were injured passengers both in the automobile and airplane. The flight was conducted in instrument meteorological conditions.

The EFB issues in each of these accidents were related in that they both involved use of the EFB to calculate landing distance. The EFBs had been in use for some time prior to the accident at both SWA and FedEx, and the crews were experienced with their use and related procedures. At SWA, the EFB is referred to as the Onboard Performance Computer (OPC). At FedEx, it is called an Airport Performance Laptop Computer (APLC).

The NTSB determined that the probable cause of the SWA accident was “the pilots’ failure to use available reverse thrust in a timely manner to safely slow or stop the airplane after landing, which resulted in a runway overrun. This failure occurred because the pilots’ first experience and lack of familiarity with the airplane’s autobrake system distracted them from thrust reverser usage during the challenging landing” (NTSB, 2007, p. ix). In the FedEx accident, the NTSB determined that the probable cause was “the captain’s overcontrol of the airplane during the landing and his failure to execute a go-around from a destabilized flare. Contributing to the accident was the captain’s concern with touching down early to ensure adequate stopping distance.” (NTSB, 2000, p. ix). The contributing EFB factors in each of these accidents are highlighted below.

4.2.2 EFB-Related Issues from the FedEx 2000 NTSB Accident Report

In the FedEx accident in 1997, the NTSB determined that there was a safety issue related to the use of on board computers to determine the required runway length for landing (NTSB, 2000). The flight crew used the APLC to determine landing distance, and compared that distance to the after-glideslope touchdown distance provided on the instrument approach plate to determine the stopping margin. Based on this computation, and the fact that the aircraft was dispatched with an inoperative thrust reverser in the left engine, the crew felt a sense of urgency to touch down early and initiate maximum braking immediately. However, the APLC’s landing distance output should have been compared to the APLC runway length, which was longer than the distance provided on the instrument approach plate. The correct comparison would have shown the crew that there was actually an additional 900-ft stopping margin in the calculation.

The Safety Board was concerned that two pilots with significant APLC experience failed to properly interpret the calculated landing distances and felt that other experienced flight crews might also be deficient in their operational knowledge of how the APLC systems function. This lack of proficiency and confusion about calculated landing distances could result in potentially hazardous miscalculations of available runway distances after touchdown.

As a result, the NTSB issued Safety Recommendation A-00-95, which asked the FAA to require principal operations inspectors (POIs) assigned to Part 121 Operators that use "auxiliary performance computers" (i.e., EFBs) to review and ensure adequacy of training and procedures regarding use of the equipment and interpretation of the data generated, including landing distance data. In August 2002, the FAA issued Flight Standards Information Bulletin for Air Transportation 02-03, which has since been updated to the InFO Safety Bulletin 0831 (FAA, 2008a). This safety bulletin calls attention to the importance of operating procedures and pilot training related to OPCs, and asks operators and POIs to review procedures and related training for OPCs. As a result of the original safety bulletin from 2002, the NTSB Safety Recommendation A-00-95 was classified "Closed–Acceptable Action."

4.2.3 EFB-Related Issues from the Southwest Airlines 2007 NTSB Accident Report

The NTSB states that the programming and design of the onboard performance computer (OPC) was a factor in the 2005 SWA accident because it did not present inherent assumptions that were critical to pilot decision-making regarding the decision to land (NTSB, 2007). There were two particular assumptions in the calculations that were not clear to the pilots. The NTSB accident report thoroughly explores these and other related problem areas, such as training on landing calculations for mixed runway conditions.

The first problem with the OPC was that the pilots were not aware that the stopping margins displayed by the OPC for poor runway conditions were in some cases based on a lower tailwind component than that which was presented. More specifically, the pilots entered a tailwind component of 8-knots, but this exceeded the 5-knot limit for poor runway conditions allowed by the software and company policy. The software displayed landing distance calculations based on the 5-knot limit and highlighted the actual tailwind component on the display, without indicating that the stopping margin was not based on the presented tailwind component.

The second problem with the OPC was that the pilots were not aware that, for their model of aircraft, the OPC calculations were designed to incorporate the use of reverse thrust into the calculation, producing more favorable stopping margins. In other words, the pilots of the accident aircraft believed that the stopping margins they were shown were conservative, because they thought that the reverse thrust was not entered into the calculations, when in fact, it was. Southwest Airlines' pilots fly two other models of that aircraft interchangeably, and for those other two aircraft models, the software does *not* assume that reverse thrust is applied in the calculation. The airline's guidance on these differences was inconsistent and may have been misleading to pilots. The guidance has since been clarified.

The NTSB accident report (NTSB 2007) on the SWA accident points out that FAA guidance states only that the output of the performance calculations should be displayed in a manner that is understood easily and accurately and that users of the EFB should be aware of an assumptions upon which the flight performance calculations are based. The accident report states:

> There is no specific guidance suggesting that these assumptions be as clear to pilots as similar information would be on a tabular chart, however. Such clarity is critical because airplane performance data and related OPC assumptions are not consistent across manufacturers, airplane models, or operators and may be based on information other than what the pilots entered. In the case of the accident flight, the SWA OPC did not display OPC assumptions (for example, the thrust reverser credit assumptions) when they were applicable; this information would have been readily available on a tabular chart. (pp. 48-49)

Further, the Safety Board “believes that the FAA should require all 14 CFR Part 121 and Part 135 operators to ensure that all on board electronic computing devices they use automatically and clearly display critical performance calculation assumptions” (p. 49).

5 Summary and Recommendations

Safety events in which Electronic Flight Bags (EFBs) were a factor were reviewed in this report. Relevant reports were obtained from the public online Aviation Safety Reporting System (ASRS) database and the National Transportation Safety Board (NTSB) published accident report database. EFB-related findings from the two NTSB reports were highlighted without reinterpreting the accident.

Of the 67 ASRS accounts identified as relevant, 32 reports pertain to use of a chart application and 30 pertain to computation of flight performance. Descriptive statistics were computed for the ASRS events, and the researchers reviewed the events in order to understand the flight outcomes/anomalies as well as the EFB issues that were encountered.

ASRS reports related to use of the EFB chart software were most often filed by Part 91 and Part 135 operators. Many of these reports concerned events that unfolded during climb out, an intense and short phase of flight. Charting related ASRS reports mentioned outcomes such as deviations in heading, altitude, and speed.

All of the ASRS reports related to flight performance calculations were filed by Part 121 operators. Issues related to flight performance computations were most often identified on the ground (preflight, taxi, or during the takeoff roll), but they were occasionally identified later in the flight. Typical outcomes included company policy deviations (e.g., takeoff from an unauthorized runway) and incorrect take off speeds or incorrect weight and balance data.

Ten ASRS reports of runway incursions were identified with the EFB as a contributing factor. These events were not specific to any one software application; they appear to occur when one member of the flight crew is preoccupied with the EFB.

A list of EFB issues was created iteratively based on the data in the set. Three key EFB issues were identified. First, configuring the EFB display for chart readability can induce workload and may cause the pilot to miss important information. However, larger EFBs are not necessarily a solution, as some reports also mentioned difficulty using the larger EFBs in small flight decks. Second, anomalies associated with flight performance calculations included company policy deviations, incorrect computations, and runway incursions. Computing flight performance can absorb a pilot’s attention fully, distracting him or her from the usual multi-tasking flight duties. Flight deck procedures may need to be emphasized to ensure that pilots continue to monitor other tasks while they do the flight performance calculations. Third, some pilots who were new to the EFB mentioned that difficulty using the EFB contributed to the event. Further initial training may be valuable, particularly for Part 91 and Part 135 operators who filed the majority of these reports mentioning this issue.

Both NTSB accident reports discussed in this report identified use of an EFB for calculating landing distance as a contributing factor in the accident. One issue was that assumptions underlying the performance calculations on an EFB must be presented to the crew as clearly as on paper-based performance tables. A second issue was assessment of the adequacy of training and procedures for using EFB performance calculations functions. These reports emphasize the need for proper user-interface design of the flight performance calculation software for EFBs, and proper assessment of crew training and procedures for the use of the EFB.

The results of this research can be considered by regulatory authorities such as the Federal Aviation Administration (FAA) when updating human factors guidance for evaluating, approving, and authorizing the use of EFBs. In addition, this research can be used by operators to anticipate issues that need special consideration. EFB manufacturers and designers may also find this report informative.

6 References

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Appendix A:
Publicly Available Online Aviation Safety Databases

ASRS Database	http://akama.arc.nasa.gov/ASRSDBOnline/QueryWizard_Begin.aspx
NTSB Database	http://www.ntsb.gov/ntsb/query.asp
FAA Database	http://www.asias.faa.gov This FAA database is supplemental to the NTSB database, and contains full incident reports that were not investigated by the NTSB.
Air Safety Foundation Database	http://www.aopa.org/asf/ntsb/ This database is based on the NTSB database and is only searchable by pre-selected key words and topics. It contains general aviation events.
Helicopter Accident Database	http://rotor.com/Operationsnbspnbsp/Safety/AccidentDatabase/tabid/598/Default.aspx This database is based on the NTSB database and contains only helicopter events.
Aviation Safety Network	http://aviation-safety.net/database This database is not searchable by key word, but does include world-wide data.

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Appendix B:
ASRS Report Numbers

304082	566944	633372	705668	735929
345970	580128	649353	706138	736751
384719	587591	654927	709587	740010
456355	591018	656745	709804	756881
492219	595465	659652	712648	766736
492310	597659	661418	715045	789543
507712	597777	674001	716555	801258
527957	598643	685210	723592	805593
533318	603224	688029	723815	813670
540556	604410	688281	725329	813728
540941	614340	690199	726022	819488
541522	614924	693756	729594	
558392	619651	696563	733615	
564468	625267	697274	735404	

Table 14: ASRS reports included in this review.

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Appendix C:
EFB Issues and Outcomes

Table 15 below shows Outcome/Anomaly in the rows and EFB Issue in the columns to illustrate their association. While Outcomes and EFB Issues may be directly related (e.g., an *Expired database* is the outcome of the *Database Expired* Issue), this is not always the case. For example, *Company policy deviations* were associated with a variety of EFB Issues including, for example, *Flight Deck Procedures* and *Separated Information*. *Deviations in heading, altitude, or speed* were most often associated with *Zooming and Panning the Display,* but also were related to being *New to EFB.* Issues such as *Zooming and Panning the Display* are associated with *Deviations in heading, altitude, or speed,* but they also were associated with *Altitude confusion, an Altitude deviation during a declared emergency,* and with one *Runway incursion.*

Table 16 below provides further details on the relationships between EFB Issues, the application in use, and who filed the ASRS report by type of operator (14 CFR Part 91, 121, or 135). Here one can see that some EFB Issues were more systemic than others. For example, issues that were specific to the EFB chart application include: *Chart Selection*, *Zooming and Panning the Display,* and *Screen Legibility*. More general issues such as *Database Expired* and *EFB Inoperative* affected a variety of EFB applications. Trends related to the fact that Part 121 operators are heavy users of the flight performance calculations and Part 91/135 operators are heavy EFB chart users are also observable in Table 16.

Outcome	EFB Issue: Battery Issues (EFB Inoperative)	Chart Selection	Data Entry	Database Expired	Zooming and Panning the Display	Display Format	EFB Inoperative	New to EFB	Flight Deck Procedures	Miscellaneous EFB Operation Issues	Screen Legibility	Separated Information	Software Bug	**Total**
Aborted takeoff										1				1
Almost deviated in altitude									1	1	1			3
Altitude confusion					1			1						2
Altitude deviation during declared emergency					1									1
Company policy deviation			1			1	1		4	1		1		9
Deviation in heading, altitude, or speed		2			11	1	4	7	3	3	2	1	2	36
Erroneous performance data, no adverse effects			2						2					4
Expired database				7										7
Incorrect take-off speed	2					1			1					4
Incorrect take-off speed with tail strike			1					1						2
Incorrect weight and balance			3					1	1				2	7
Runway incursion		1			1			1	5	2	2		1	13
Taxi route confusion without airport diagram	1													1
Total	**3**	**3**	**7**	**7**	**14**	**3**	**5**	**11**	**17**	**8**	**5**	**2**	**5**	**90**

Table 15: Cases for each combination of outcome and EFB issue.

EFB Issue	Operating Regulation Part 91	Part 121	Part 135	Total
Battery Issues (EFB Inoperative)	**1**	**2**		**3**
Calculations		2		2
Charts	1			1
Chart Selection	**2**	**1**		**3**
Charts	2	1		3
Data Entry		**7**		**7**
Calculations		7		7
Database Expired		**7**		**7**
Calculations		3		3
Charts		2		2
Charts and Documents		1		1
Documents		1		1
Zooming and Panning the Display	**11**		**3**	**14**
Charts	11		3	14
Display Format	**1**	**2**		**3**
Calculations		2		2
Charts	1			1
EFB Inoperative	**3**	**2**		**5**
Calculations		1		1
Charts	3			3
Documents		1		1
New to EFB	**8**	**3**		**11**
Calculations		2		2
Charts	7	1		8
Unspecified	1			1
Flight Deck Procedures	**2**	**15**		**17**
Calculations		14		14
Charts	2	1		3
Miscellaneous EFB Operation Issues	**2**	**3**	**3**	**8**
Calculations		2		2
Charts	2		3	5
Documents		1		1
Screen Legibility	**3**		**2**	**5**
Chart	3		2	5
Separated Information	**1**	**1**		**2**
Calculations		1		1
Charts	1			1
Software Bug	**2**	**3**		**5**
Calculations		3		3
Charts	2			2
Total	**36**	**46**	**8**	**90**

Table 16: Cases for each combination of issue and operating regulation.

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Appendix D:
ASRS Report Numbers Associated with the EFB Issues

Issue	Number of Cases	ASRS ACN Numbers			
Flight Deck Procedures	17	345970 527957 564468 580128 591018	595465 598643 603224 614924 625267	649353 697274 723592 723815 735929	766736 507712
Zooming and Panning the Display	14	540941 558392 587591 604410 633372	685210 688029 688281 690199 706138	709587 709804 725329 766736	
New to EFB	11	456355 540941 633372 654927	661418 709587 712648 729594	735404 735929 756881	
Miscellaneous EFB Operation Issues	8	384719 540556 595465	597659 690199 696563	715045 716555	
Data Entry	7	456355 591018 693756	723592 723815 736751	756881	
Database Expired	7	492219 492310 533318	705668 805593 813670	813728	
EFB Inoperative	5	304082 566944	614340 654927	801258	
Screen Legibility	5	540941 595465	690199 715045	726022	
Software Bug	5	541522 619651	661418 733615	740010	
Chart Selection	3	654927	729594	735929	
Display Format	3	649353	697274	789543	
Battery Issues (EFB Inoperative)	3	656745	674001	819488	
Separated Information	2	597777	659652		