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FACTORS INFLUENCING PILOT TRUST IN ELECTRONIC FLIGHT BAG INFORMATION

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Electronic Flight Bags (EFBs) are widely used by pilots in the commercial aviation industry. EFBs serve as replacements for some traditional sources of information, such as paper charts, manuals, and checklists, augmentation for flight-related information previously unavailable through older cockpit systems such as temporary flight restriction locations, and supplemental information such as a secondary display of traffic). By having access to this information, pilots are able to make more effective decisions in various situations. Related literature has shown that decision makers in situations of uncertainty are influenced by a range of factors such as experience, the level of risk in a situation, and criticality of information. The purpose of this study was to analyze factors that impact pilot trust in information provided by an EFB. Pilot survey and interview data from a simulation study was analyzed and results indicated that an increase in a pilot's total flight hours, experience with specific EFB applications, and the criticality of the information presented on the EFB increased a pilot's trust in information presented by the EFB. Conversely, the more often a pilot used an EFB and the length of time the pilot's company had utilized EFBs on the flight deck, the less trust a pilot had in the information presented by the EFB. The implications of these findings and areas of future research will be discussed.

The U.S. airline industry has been incorporating newer technology into the commercial flight deck, such as Electronic Flight Bags (EFBs). EFBs are capable of providing pilots with supplementary information that was either previously inaccessible or only available through systems built into the aircraft's cockpit. For example, a pilot must be aware of location of their aircraft in proximity to certain restricted airspace and other aircraft to avoid penetrating restricted airspace or colliding with another aircraft in mid-air. EFB applications can support pilots in this task by displaying the location of the pilot's aircraft (ownship) in proximity to restricted airspace and other aircraft on an interactive moving map. EFBs are commonly incorporated onto the flight deck as a tablet computer, but can also be a permanent device installed into a cockpit instrument panel. Certain EFB functionalities are not currently approved by the FAA (2017) for use on the commercial flight deck as an EFB is not intended to replace certified instruments and systems within the cockpit, but to supplement these systems.

Airlines must ensure that pilot trust in their EFBs is properly calibrated and that pilots are able to properly and safely utilize EFBs in conjunction with existing technologies on the flight deck. Trust, as defined by Mayer et al. (1995) is a pilot's willingness to be vulnerable to the

functions of a system based on an expectation that the system will perform its intended action in potentially risky situations. There are a range of different factors which could impact pilot trust in information provided by their EFB (See, for example, Carroll and Sanchez, 2020). The purpose of this paper is to present an analysis of factors that impact a pilot's trust in their EFB during decision making on the flight deck. This research effort analyzed data from a previously published experiment (see Carroll et al., 2020) conducted to study the effects of conflicting information between an EFB and a certifid system in the panel, on a pilot's decision making.

General Experience

Previous research has shown that expertise influences system trust. Mosier et al. (1998) examined the relationship between pilot experience and pilot response to an automated command. A positive correlation was found between numerous experience indicators, including total flight hours and years of experience, with the frequency of omission errors (neglecting to complete a needed action that was not recommended by the automation), suggesting potentially higher levels of trust in the automation. Riley (1994) also examined the relationship between overall aviation experience and trust in automation and found that student pilots are less likely to rely on automation than experienced pilots, even after failure occurs within the automation. As such it was hypothesized that pilot experience would influence pilot trust in the EFB.

Experience with System

Pilot experience with a particular system, such as an EFB, also has an impact on trust in the information. Lee & See (2004) proposed three factors that influence trust: performance, purpose, and process. Performance refers to a pilot's direct observation of system behavior. If an EFB operates as expected over time, the pilot will have greater trust compared to a pilot who experiences unreliable EFB information on a regular basis. Purpose refers to the intended use of the system, and this can be related to whether the EFB is utilized as the users believes it is intended (e.g., for supplemental navigation information). The most relevant factor that is related to the functionality of the EFB is process, and this is defined as a user's understanding of the underlying mechanisms for functionality of the system. A pilot who is familiar with the source and accuracy of the information presented on the EFB will have higher levels of trust in their EFB than someone who is not. Pilots who use their EFB more often are likely to be more familiar with its various functionalities in a variety of situations. Therefore, it is hypothesized that pilot experience with an EFB will impact trust in the EFB's information on the flight deck.

Information Criticality

During the course of a single flight, a pilot can face several situations that vary in the amount of time and effort it takes to reach a decision. Each of these situations can cause a pilot's workload to vary throughout the flight. Campbell and Alexander (2016) found that sources of information that can provide a pilot with the "big picture" of various situations, such as graphical displays of a flight route and traffic, can help a pilot during high workload situations by providing critical information in a quick and dynamic format. The EFB is capable of displaying critical information that can increase situational awareness in time-critical or hazardous situations; potentially resulting in the information being deemed critical to the decision-making

process. The results of Lee (1991) support this concept of novel information affecting a pilot's decision making if the information is considered critical. A between-subjects design compared traditional methods of conveying hazardous weather information to a flight crew against a new display of in-flight weather information. Pilots with the new display were more likely to divert around the critical weather and this decision was reached in a more timely manner, even though this display was novel and had not been used by any of the participants. The display of critical weather information, much like an EFB displaying critical traffic or airspace information, presented the hazard in an easy-to-understand manner that clearly informed the flight crew of the risk to the safety of their flight. As such, it is hypothesized that pilots who deem the EFB information more critical will have higher levels of trust than those who indicate it is less critical.

Methods

Participants

Data associated with 25 commercial airline pilots was analyzed in this study. All participants were type-rated in the B737 as either a Captain (16) or a First Officer (9). Total flight time ranged from 8,000 hours or less (5), 8,001 – 12,000 (4), 12001 – 20,000 (10), or greater than 20,000 (6).

Experimental Design and Procedure

This study analyzed a subset of data from a simulation study that utilized a repeated measures design in which participants performed a series of scenarios in a B737 desktop simulator (See Carroll et al., 2021 for full details of the study). These scenarios introduced situations with the risk of penetrating restricted airspace or traffic collisions to assess how various factors influence a pilot's decision making when presented with conflicting information between the ForeFlight EFB and an approved information source, such as a certified system in the aircraft panel. Before data collection, each participant was given a demographic survey to collect information on aeronautical and EFB experience. Next, each participant watched a short video tutorial on the function of the B737 simulator and EFB. After the video tutorial was completed, each participant was given three practice scenarios in order to familiarize themselves with the flight simulator testbed and EFB. Next, each participant was assigned to one of two groups: airspace or traffic and performed scenarios per their condition with half of the scenarios containing information conflicts between the EFB and an approved source of information on the flight deck. After each participant completed each scenario, they completed a post-trial survey that contained self-report measures rating the criticality of the EFB to the pilot's decision-making and how much the pilot trusted the EFB information for each scenario. For the purpose of this study, a set of 10 predictor variables were selected for use in examining how they related to pilot trust in an EFB, including (1) total flight hours, (2) how often a pilot uses an EFB, (3) how long a pilot's company has used EFB's, (4) how familiar a pilot is with ForeFlight, (5) if a pilot has used ForeFlight before, (6) if a pilot has used EFB apps other than ForeFlight, (7) information type (airspace or traffic), (8) cockpit configuration (whether EFB was mounted external to the panel or integrated), (9) if the data was conflicted between sources, and (10) the self-reported criticality of the EFB on decision making.

Measures

Demographics. A demographic survey collected information on participant age, rank (Captain or First Officer), total flight hours, and flight hours in a B737.

EFB Experience. A pre-study survey collected data associated with experience with an EFB. These measures included how often a pilot uses an EFB (daily, weekly, monthly, yearly, or never), how long a pilot's company has approved the use of EFBs in their operations (less than 6 months, 6 months – 1 year, 1 – 3 years, or over 3 years), how familiar a pilot is with ForeFlight (not at all familiar, slightly familiar, somewhat familiar, moderately familiar, or extremely familiar), if a pilot has used ForeFlight on an EFB before (yes or no), and if the pilot has used any other EFB applications other than ForeFlight (yes or no).

Information Criticality. Participants self-reported how critical the EFB information was to their decision-making after each scenario. EFB criticality was measured on a scale of 1 to 5 (1 = "not critical to decision-making", 5 = "very critical to decision-making."

Trust in the EFB. The criterion variable for this study was pilot trust in the EFB, and this was measured after each scenario using one self-report item of how much a pilot trusted the information displayed on the EFB, ranging from 1 to 5 (1 = "did not trust", 5 = "complete trust".

Analysis and Results

A multiple regression analysis was used to predict a pilot's trust in their EFB from the following predictor variables: (1) total flight hours, (2) how often a pilot uses an EFB, (3) how long a pilot's company has used EFBs, (4) how familiar a pilot is with ForeFlight, (5) if a pilot has used ForeFlight before, (6) if a pilot has used EFB apps other than ForeFlight, (7) information type (airspace or traffic), (8) cockpit configuration (whether EFB was mounted external to the panel or integrated), (9) if the data was conflicted between sources, and (10) the self-reported criticality of the EFB on decision making. The analysis began with data points from 150 scenarios, representing each participant's individual scenario ratings. Sixty-one cases were excluded during a preliminary data screening due to missing or incomplete data in the predictor or criterion variables (e.g., participants who reported that they did not use the EFB in that scenario). Next, a multivariate outlier analysis identified eight cases as "extreme cases" and these excluded from the final analysis. After the outlier analysis, the remaining cases were checked for their compliance with the assumptions of multiple linear regression. The following predictor variables failed the assumption of correct specification of the predictors by having leverage values greater than 0.05: how familiar a participant is with ForeFlight, if a participant has used EFB apps other than ForeFlight, information type, cockpit configuration, and if the data was conflicted between sources. The predictor variables that remained within the final analysis were (a) total flight hours, (b) how often a participant uses their EFB, (c) how long a participant's company has used ForeFlight, (d) if a participant has used ForeFlight before, and (e) how critical the EFB was to a participant's decision making. A simultaneous regression analysis was run using JMP (SAS, 2018), and the model was found to be statistically significant, $F(5, 75) = 2.28$, $p < .01$, $R^2 = 0.60$. The results indicated that an increase in a pilot's total flight hours, experience with the specific EFB application, Foreflight, and the criticality of the

information presented on the EFB increased a pilot's trust in information presented by the EFB. The results also indicated that the more often a pilot used an EFB and the length of time the pilot's company had utilized EFBs on the flight deck, the less trust a pilot had in the information presented by the EFB. See Table 1 for Regression coefficients and standard errors.

Table 1
Multiple regression results for EFB Trust

EFB Trust	*B*	95% CI for *B*		*SE B*	β	R^2
		LL	*UL*			
Model						0.60*
Constant	1.92**	1.08	2.75	0.42	0	
Flight Hours	$2.33e^{-5}$*	$2.57e^{-6}$	$4.40e^{-5}$	$1.04e^{-5}$	0.20	
How Often EFB	-0.59**	-0.96	-0.21	0.19	-0.27	
Company EFB	-0.27	-0.58	0.04	0.16	-0.14	
If a pilot has used ForeFlight before	0.45**	0.19	0.71	0.13	0.27	
How critical EFB was to DM	0.51**	0.35	0.66	0.08	0.5	

*$p < 0.01$, **$p < 0.0001$

Discussion

Several factors appear to influence the trust a pilot has in their EFB. A pilot's overall aviation experience, measured in total flight hours increased with trust in an EFB. This is consistent with Mosier et al. (1998) and Riley (1994) who found a positive relationship between experience and trust. Trust also increased the more often a pilot used their EFB. Pilots who have used the EFB software, ForeFlight, trusted this application more than pilots who were new to ForeFlight. This is consistent with Lee and See's (2004) process factor's relationship with trust. If a pilot is more familiar with the functionality of an EFB or the accuracy of the information presented, they will have greater trust in this system. Lastly, the more critical a pilot believes the information provided on the EFB is to their decision making, the more the pilot will trust the EFB. This is in line with Lee and See's (2004) trust factor of performance. The more experience the pilot has with the system performing as expected and providing effective information, the more critical that information will be to a pilot and the more they will trust it.

These results should be interpreted with caution given the following limitations: (a) small sample size, (b) participants all flew the same make/model aircraft, (c) use of just one EFB software, (d) and the use of a simulator in place of a real aircraft or related systems. However, these preliminary results may provide insight for the airlines regarding factors that influence pilot's developing appropriate levels of trust in EFBs. Airlines can expect pilot trust in EFBs to increase as pilots gain more experience with the EFB application, and in general. Airlines could potentially encourage pilots to use their EFBs as often as possible to gain this experience with the EFB performance and reliability. Airlines could also consider introducing pilots to the EFB software they will use in their operations as early as possible, as trust appears to increase with familiarity with this specific application. It may also be beneficial for airlines to incorporate the usage of EFBs into pilot scenario-based training that involve high-risk situations. This study has revealed that pilots are less likely to trust a source if they do not have experience using it. If pilots gain experience with the EFB through training, they may develop a better understanding of

how their EFB works, resulting in more appropirate levels of trust. These results provide preliminary evidence of the factors that influence pilot trust in the EFB; however, more reseearch is needed to fully understand these factors.

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