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Examining Pilot Decision Making in Information-Rich Cockpits

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Pilots are faced with making decisions based on a range of different information sources. One challenge pilots often face is the presentation of conflicting information between sources. This effort examined pilot decision making with conflicting information by conducting structured interviews with 13 pilots, including seven airline, three corporate, and three GA pilots. Pilots were asked questions regarding their experience with conflicting sources of weather, traffic, and navigation information on the flight deck or cockpit. Further, they were asked to describe how they responded to the information conflict, including which source they trusted, which source they ultimately acted on, and why they acted on that source. This paper describes the methods, results and implications for commercial and military aviation.

Pilots are faced with making decisions based on a range of different information sources. Whether commercial aviation, General Aviation (GA) or military pilots, increases in information sources on the the flight deck or cockpit have resulted in pilots having to determine which pieces of information are accurate and relevant, and integrate the information to create an accurate representation of the environment (Mosier & Fischer, 2010; Mosier, 2002). One challenge pilots often face is the presentation of conflicting information between sources. Conflicting information can significantly hinder decision making by reducing decision accuracy and decision confidence (Mosier et al, 2007; Chen and Li, 2015). Several questions remain regarding pilot decision processes during conflicting information events. Finding answers to these questions is imperative given the growing amount of redundant information available on the flight deck such as via both aircraft-installed avionics and Electronic Flight Bag (EFB) applications. The Federal Aviation Administration is particularly interested in this issue as they work to ensure that NextGen technologies and procedures being integrated on the flight deck are reliable and safe, and promote increased safety, capacity, and efficiency of the National Airspace System.

In order to better understand the decision-making processes that occur when pilots are faced with conflicting information, we conducted a series of studies including (a) a literature review, (b) pilot interviews, and (c) collection of a pilot questionnaire data. This paper describes the methods and results associated with the pilot interviews. Prior to the interviews, we

performed a literature review to examine factors that influence how individuals make decisions when faced with conflicting and uncertain information. Results indicated that pilot decision making under these circumstances is influenced by a) system factors of reliability, transparency, and workload, b) individual factors of experience, system trust, and training, and c) task/environment factors of time pressure, risk, take action tendency, type of conflict, and task difficulty. After the literature review, we conducted pilot interviews to examine, among other things, information conflicts currently being experienced on the flight deck/cockpit and whether the factors identified in the literature review, are indeed the factors that influence aeronatical decision making with conflicting information. Based on results of the interview, a questionnaire was developed and administered to a large sample of pilots to obtain a more comprehensive view of the information conflicts being experienced by airline, corporate and GA pilots. The results of the questionnaire will be covered in a separate paper.

Methods

The research team conducted interviews with 13 pilots, including seven airline, three corporate, and three GA pilots. The goal of interviews was to obtain information from active pilots regarding what type of information conflicts are currently being experienced on the flight deck and what factors influence which source(s) of information pilots trust and ultimately act on. We utilized Florida Institute of Technology (FIT) College of Aeronautics (COA) alumni and faculty network to recruit airline, corporate and GA pilots via email and phone. We attempted to obtain participants who flew a range aircraft with various types of information sources on the flight deck or cockpit. We scheduled the pilots via email for two-hour interview blocks, and provided an electronic informed consent form and a short sample of questions to consider prior to the interview.

Interview Questions and Procedure

The research team prepared a standardized procedure and set of questions prior to the interviews, including a set of questions for airline and corporate pilots, and a slightly different set of questions for GA pilots. The questions targeted pilot demographics, experience with information conflicts, use of EFB applications, and experience with integrated displays on the flight deck. This paper focuses on the portion of the interview in which pilots described their experiences with information conflicts. The interview questions and associated procedures were submitted to, and approved by, FIT's Institutional Review Board (IRB).

Interviews lasted one to two-hour(s) and were conducted either via phone or in-person with each pilot. One or two researchers led the interview and another researcher acted as a scribe. Participants were initially asked to decribe the information sources on their current aircraft and we tailored questions during the interview based on the sources of information available to each pilot on their flight deck or cockpit. With permission from the interviewee, we recorded all interviews and transcribed the interviews for later analysis. The interviews were organized in a semi-structured format including a series of open-ended questions followed by prompts designed to elicit rich contextual responses, while keeping the interviews on track. The interviews commenced with a brief description of project background and ended with a request

to follow up with additional questions in the future, and if the interviewee was interested, a commitment to share results of the research.

Data Analysis

First, the research team transcribed the interviews electronically using the Sonix online transcription services (https://sonix.ai/). Next, we reviewed interview transcripts against researcher notes for accuracy and used the transcripts to fill in any gaps in researcher notes. Then, we extracted question responses from the interview data and input responses into a spreadsheet where responses could be compared across participants. For each question, we analyzed participant responses to extract categorical themes. These themes were compared across different types of information conflicts (e.g., weather, traffic, navigation) for each type of question (e.g., why information was trusted/acted on) and converted into response categories. The research team then re-analyzed participant responses and classified each response within these categories. Finally, we summarized the interview results. Due to the small number of participants, only descriptive statistics were utilized in the analysis.

Results

Participant Demographics

Thirteen pilots were interviewed, including seven Part 121 pilots, three corporate pilots (based on operation of aircraft heavier than 6000 lbs. but not operating under Part 121), and three GA pilots (based on operation of aircraft lighter than 6000 lbs. and not operating under Part 121). Twelve of these thirteen pilots were male; one was female. Demographics are summarized in Table 1. On average, Part 121 and corporate pilots reported flying once a week to daily, while GA pilots reported flying between one to five times per month. Pilots also reported their highest pilot certificates held, which included: ten air transport pilot certificates, two commercial pilot certificates, and one private pilot certificate with an instrument rating. Pilots reported experience flying the following aircraft: Airbus (A320 and A321), Beechcraft Baron, Boeing (737-800/900, 747-400/800, 757-200, 767-300, and 787), Cessna (152 and 172), Challenger 650, Dassault Falcon (DA10 and DA20), Gulfstream G5, Lockheed Jetstar, Mooney, Piper (PA28-161, PA28-181, PA28-201, and PA44), and the Pilatus PC12-NG.

Table 1.

Demographic Data for Interview Participants

	Part 121	Corporate	GA	Overall
Number of Pilots	7	3	3	13
Gender (M/F)	6/1	3/0	3/0	12/1
Average Age, years	36 (SD = 9)	45 (SD = 7.4)	63 (SD = 14)	48 (SD = 3.4)
Average Total Flight Hours	7,800 (SD = 3,554.3)	11,059 (SD = 5,298.3)	6,417 (SD = 8,203.7)	8,233 (SD = 2,383.3)

Information Conflicts

Results indicated that pilots frequently experience conflicting information on the flight deck. When asked whether they had experienced an information conflict specifically associated with either weather, traffic or navigation information, all 13 pilots reported having experienced one type of conflict or another. In fact, pilots often gave answers such as "yes, all the time" or "yes, it is not uncommon".

Table 2 summarizes the number of Part 121, corporate and GA pilots who reported experiencing either a traffic-, navigation- or weather- information conflict on the flight deck. Weather and traffic were the most common types of information in which pilots experienced conflicting information. For weather, the onboard radar was the source most commonly found in conflict with another source such as Air Traffic Control (ATC), Next Generation Weather Radar (NEXRAD) or between the two onboard radars. Onboard radar was most commonly trusted over other sources. For traffic, the most common conflict was between Traffic Collision Avoidance System (TCAS) and ATC, with pilots equally trusting both sources. Navigation conflicts were less frequently reported in the interviews, but typically indicated that certified navigation-information sources in the panel (e.g., the Navigation Display (ND)) were trusted more than other uncertified navigation-information sources on their EFB or mobile devices, such as Jeppesen FliteDeck Pro or ForeFlight.

Table 2.
Number of Conflicts Reported by Part 121, Corporate, and GA Pilots During Pilot Interviews.

	Part 121	**Corporate**	**GA**	**Total**
Total Pilots	**7**	**3**	**3**	**13**
# Weather Conflicts	7	2	1	10
# Traffic Conflicts	6	2	2	10
# Navigation Conflicts	1	1	0	2
Total Conflicts	**14**	**5**	**3**	**22**

Factors Influencing Pilot Response to Information Conflicts

Further, results indicated that there were clear patterns regarding why pilots trusted information sources and ultimately acted on one source or another, and these align with findings from our previously conducted literature review. These patterns are consistent across the different types of conflicts, including conflicts related to weather, traffic and navigation information. The interview results indicated that pilots tended to trust, or distrust, an information source due to: 1) the recency of information on the source, 2) the source's reliability, 3) the pilot's knowledge of the source's strengths and weaknesses and when it is most trustworthy, 4) the source's accuracy, 5) the pilot's past experience with the source, and 6) the pilot's lack of knowledge about how the source's information is obtained. Table 3 summarizes the number of pilots who reported each reason as impacting their trust.

Table 3.
Reasons Pilots Trusted an Information Source and Number of Pilots that Reported Each.

Reasons Trusted	# Pilots
Recency of information on the source	16
Reliability of the source	13
Knowledge of the strengths and weaknesses of each source	11
Accuracy of the source	10
Better experience with this source in the past	5
Lack of knowledge about the sources	5

Note: Pilots typically reported more than one reason.

The interview results indicated that pilots ultimately acted on a source due to: 1) the source indicating a more hazardous situation, 2) their trust in the source, 3) being trained to use the source, 4) their knowledge that the source is certified, 5) the information being presented by the source requiring immediate action, 6) their experience with the source, and 7) being required to use the source. Table 4 summarizes the number of pilots who reported each reason as impacting their ultimate actions.

Table 4.
Reasons Pilots Acted on an Information Source and Number of Pilots that Reported Each.

Reasons Acted On	# Pilots
The source indicated more hazardous situation than the other source	16
I trusted the source the most	8
I am trained to use this source	4
I know that the source is certified	3
The information, as presented on the source, required immediate action	2
I have more experience with this source	1
I am required to use this source	1

Note: Pilots typically reported more than one reason.

Pilot Perception of Information Conflicts.

Results also indicated that pilots may not perceive the presence of conflicting information on the flight deck or cockpit as a problem. Each interview commenced by asking pilots if they had ever experienced conflicting information, in general, on the flight deck. When initially asked this general question, only nine of the 13 pilots (four Part 121 pilots, three corporate pilots and two GA pilots) reported having experienced a conflict. However, later in the interview when queried about specific conflicts such as conflicting weather, traffic or navigation information, all 13 pilots reported having experienced one type of conflict or another. It seems that although these conflicts occur somewhat frequently on the flight deck, pilots do not perceive them as a significant problem. Rather, pilots are accustomed to constantly evaluating and integrating information of varying levels of integrity, in order to hone in on ground truth and therefore

perceive the conflict as a natural characteristic of the information-rich nature of the flight deck. Pilots appear to resolve these conflicts by collecting additional information from other sources, while considering the strengths and weaknesses of each source.

Conclusion

Results of this study indicate that pilots frequently experience conflicting information on the flight deck or cockpit and there are clear patterns as to which source a pilot will trust and ultimately act on. The patterns align with findings from our literature review and suggest that key factors that influence which source a pilot will trust and ultimately act on are influenced by a) system factors such as information recency, reliability and accuracy, b) individual factors such as system knowledge, experience and training, and c) environmental/task factors such as level of hazard.

Although pilots seem comfortable coping with information conflicts, these factors provide opportunities for better supporting pilots in making effective decisions. By optimizing system accuracy, recency and reliability, and by ensuring pilots have the training and experience necessary to understand the strengths and weaknesses of their systems, commercial, military and GA pilots can be better prepared to make decisions when faced with conflicting information.

References

Chen, K., & Li, Z. (2015). How does information congruence influence diagnosis performance?. *Ergonomics, 58*(6), 924-934.

Mosier, K. L. (2002). Automation and cognition: Maintaining coherence in the electronic cockpit. In *Advances in Human Performance and Cognitive Engineering Research* (pp. 93-121). Emerald Group Publishing Limited.

Mosier, K. L., & Fischer, U. M. (2010). Judgment and decision making by individuals and teams: issues, models, and applications. *Reviews of Human Factors and Ergonomics*, *6*(1), 198-256.

Mosier, K. L., Sethi, N., McCauley, S., Khoo, L., & Orasanu, J. M. (2007). What you don't know can hurt you: Factors impacting diagnosis in the automated cockpit. *Human Factors*, *49*(2), 300-310.