Recommended Training Practices to Prepare Pilots to Cope With Information Conflicts

Meredith Carroll

Paige Sanchez

Donna Wilt

RECOMMENDED TRAINING PRACTICES TO PREPARE PILOTS TO COPE WITH INFORMATION CONFLICTS

Meredith Carroll, Paige Sanchez, Donna Wilt
Florida Institute of Technology, College of Aeronautics (Melbourne, FL)

As the next generation of flight deck information systems are being utilized on the flight deck, pilots now have greater amounts of information at their fingertips. Although redundant sources of information allow pilots to crosscheck, they also introduce the potential for information conflicts. There is a need to ensure pilots are trained to effectively evaluate, integrate and make decisions based on information from redundant, and potentially conflicting information. Based on findings from a literature, we present several best practice guidelines for preparing pilots to effectively respond to conflicting information. Based on data collected during a questionnaire study administered to a large sample of pilots, and a simulation-based study with B737 pilots, we transformed these guidelines into training recommendations for the pilot training community and provide use case examples of how these recommendations could be implemented.

Aeronautical decision making on the flight deck requires the integration of information from a range of different technological, environmental and human sources. Traditionally, aeronautical decision making relied on pilots experiencing and interpreting informational cues, such as instrument gauges, to assess the situation and diagnose the state of the aircraft and aircraft systems, in order to decide how to respond. As more technology becomes available on the flight deck, the piloting task is changing. Pilots are no longer purely experiencing cues and utilizing their own internal cognitive processes to transform data into information. Instead, technology is performing many of these cognitive processes and pilots are merely consuming information provided by the technology. The result is a change from a correspondence task (i.e., determining how cues correspond to past experiences) to a coherence task (i.e., assessing if there is coherence and consistency in the information being presented) that requires pilots to determine which pieces of information are accurate and relevant, and integrate the information to form an accurate representation of the situation (Mosier & Fischer, 2010; Mosier, 2002). The resulting coherence task is challenging as there are often multiple sources of redundant information that may have slightly different (a) methods by which the information is obtained and synthesized, (b) accuracy, (c) reliability and (d) security. As a result, these sources could provide conflicting information. Pilots must reconcile, make sense of, and make decisions based on these sources of information, sometimes with limited knowledge of, or access to, how the information is obtained and synthesized, and associated levels of accuracy.

Conflicting information has been shown to have deleterious effects on decision making including reduction in accuracy of decisions, longer decision times and less confidence that the decision was correct (Mosier, Sethi, McCauley, Khoo, & Orasanu, 2007; Chen and Li, 2015). In order to prepare pilots to perform effectively on the flight deck, pilots must be armed with the knowledge and skills to support them in assimilating the information, accurately assessing the situation, and making effective decisions. This effort identified best practices from the literature for preparing individuals to effectively respond to situations with conflicting information, and operationalized these into recommendations for the pilot training community.

Methods

First, we conducted a literature review to examine what empirical research has revealed about how individuals make decisions when faced with conflicting information and what training methods can help mitigate the negative impacts of conflicting information. Throughout the duration of the literature review, we reviewed approximately 300 abstracts to determine if the articles focused on the target areas. Of the initially reviewed abstracts, we selected 98 publications for a more thorough review and performed an analysis of 51 relevant publications. Thirty- six empirical studies and 15 theoretical publications were reviewed in detail and information from each article was extracted and input into an MS Excel database.

Based on the level of corroboration across publications, we quantified, prioritized, and summarized findings from the studies, resulting in two primary outcomes: 1) a framework of factors that influence decision making with conflicting information, and 2) recommended mitigations for supporting effective decision making under these circumstances. Full details of these findings are included in Carroll and Sanchez (2020). Several of these recommended mitigations focused on training, with the literature suggesting that training practitioners should teach: (a) information integration skills, (b) system knowledge, (c) metacognitive skills; as well as (d) increase trainees experience with information conflicts and decision-making biases.

Next, empirical data was collected to examine the types of information conflicts that pilots are experiencing on the flight deck, and therefore need to be trained, as well as how pilots respond to these information conflicts. We administered a questionnaire regarding pilot experiences with conflicting sources of weather, traffic, and navigation information on the flight deck to 108 pilots and conducted a simulation study in which thirty six B737 pilots were exposed to flight deck information conflicts (See Carroll, et al., 2021). The results provided a snapshot of the range of different information conflicts that pilots are experiencing on the flight deck and allowed us to marry findings from the literature review with operational knowledge regarding pilots' experience and response to information conflict. This, along with knowledge of current aviation training practices, allowed us to transform the best practices from the literature into implementable recommendations for aviation training practitioners.

Results and Discussion

This section provides best practices from the literature, recommendations for implementation, and use-case examples for classroom, simulation, and live training.

Functional System Knowledge

In preparing pilots to respond to information conflicts, a key first step is ensuring that they have knowledge of how the systems involved are supposed to work. In order to determine which information source is accurate when faced with an information conflict, performers need to know how their systems work at a functional level, including the ability to distinguish true and false alarms, (Gilson, Deaton, & Mouloua, 1996) and to know source strengths and weaknesses (Richter and Maier 2017). Performers must gain enough system knowledge to facilitate the development of accurate mental models of why systems respond in particular ways across various situations (Gilson, Deaton, & Mouloua, 1996). This knowledge will allow an understanding of times when information from a particular source is more or less trustworthy.

Pilots should be taught enough system knowledge to allow them to: (a) understand causes of false information and how to distinguish a false alarm from a true alarm, (b) understand the systems well enough to recognize when things do not go as expected and how to figure out what is happening from the information provided, and (c) recognize the strengths and weaknesses of information provided by the system. An example, with respect to distinguishing false alarms, is a situation in which the Traffic Information System - Broadcast (TIS-B) suddenly issues a traffic alert for an aircraft 100 feet directly below a pilot's aircraft. No aircraft was anywhere nearby and ATC did not advise of any traffic. Pilots need to understand that this is likely a ghost aircraft, (i.e., an artifact of their own aircraft presented as traffic). An example, with respect to recognizing strengths and weaknesses, is when the NextRad display shows moderate precipitation well left of a pilot's route, but straight ahead is clear on the NextRad display. The pilot is in the clouds and can see that the weather ahead is darker than to the left. Pilots need to understand, and most currently do, that a weakness of NextRad is its slow update rate, and the weather shown on the left may actually be directly ahead.

Techniques to Utilize in Response to Information Conflicts

Pilot should also be trained in techniques for conducting a thorough information search, evaluating conflicting cues, and inductive conflict resolution, such as envisioning missing alerts (Mosier, Sethi, McCauley, Khoo & Orasanu, 2007). Research examining pilot response to information conflicts on the flight deck showed that while exposure to information conflicts led to increased crosschecking behaviour, it often was associated with reduced confidence in their decision (Mosier, Sethi, McCauley, Khoo & Orasanu, 2007). The authors suggest that this may be due to pilots not realizing the risks associated with failing to perform a complete information search and recommend that pilots receive training focused on thorough information search and integration. Further, research has revealed that in a situation in which multiple sources of information are provided and can be in conflict, congruent, or a piece missing, performers' response to missing information was very similar to their response to congruent information, suggesting performers assumed the missing information was consistent with other sources (Chen & Li, 2015). Althought there is currently a heavy focus in aviation training on information search skills, referred to as cross-check; there is an opportunity to bolster this process by systematically training pilots how to determine which piece of information is more accurate using inductive conflict resolution skills. For example, when pilots recognize that a piece of information is missing, they could be encouraged to play devil's advocate, assume the piece of information is in conflict with other sources, and consider how they would respond in this situation. An example scenario is at a non-towered airport, a pilot hears another pilot on the radio call 5 miles west of the airport. The pilot's traffic display shows an aircraft 5 miles east of the airport, and nobody to the west. The pilot should consider both options, including that (a) the other pilot made a mistake and is actually east of the airport, or (b) the pilot really is 5 miles west but not showing on the traffic display and there is another aircraft to the east not talking.

Exposure to Information Conflicts

Once trainees understand the system at a functional level, and learn techniques for responding to information conflicts, trainees could then be exposed to unexpected, but plausible, information conflicts. Past research has shown that exposing performers to systems failures

(e.g., that could result in conflicting information) can result in reduced trust in this information and reduced utilization of the information to make decisions (Dzindolet, Peterson, Pomranky, Pierce, & Beck, 2003). This is beneficial for systems which have rare false alarms, as it allows proper calibration of trust that may result in increased crosschecking behaviours. Research has also shown that exposing performers to rare false alarms resulted in increased cross-checking (Bahner, Huper, & Manzey, 2008). Currently in aviation training, little is done to train interpreting differences between NexRad radar, METARs, ASOS, and onboard weather radar information in the cockpit that could lead to information conflicts. This is because, in part, current training devices do not realistically simulate weather information in the cockpit. However, training could expose trainees to situations that could cause information conflicts via a variety of platforms, including simple low-fidelity training solutions, such as integrating mocks-ups of displays with conflicting information into PowerPoint slides, providing an opportunity to both illustrate how the information conflicts might present themselves and discuss appropriate ways to respond. Simulation-based training can provide an opportunity to present information conflicts to trainees in realistic scenarios and provide them practice in detecting and responding to information conflicts. Simulation can be used in conjunction with a debrief containing what information conflict occurred, why it occurred, and how the trainee should have responded, to help prepare trainees for responding to such occurrences in the future. Although most aviation training simulators are not currently equipped with the capabilities to introduce information conflicts between systems, there are creative ways to accomplish this. For example, the instructor could alter information in a preflight package, such as NOTAMs or preflight weather briefing so they do not agree with products such as weather on ATIS, or ATC could provide information that conflicts with information provided on a traffic or navigation display. Further, editable functions within EFB applications also provide an opportunity to alter Temporary Flight Restriction (TFR) locations and sizes, which can be in conflict with information from ATC.

Decision-Making Biases

Another area in which pilots would benefit from education and training is with respect to decision-making biases. Human decision making can be driven by biases such as our flawed assessment of how likely an event is to occur based on past experiences (availability bias) and potential outcomes based on past experiences we believe are similar (representativeness bias; Mosier et al., 2002). In the literature, biases have been shown to have a significant impact on how performers respond to information conflicts. For example, when presented with conflicting information, performers tend to choose the option that recommends action over inaction (Mosier, Keyes, & Bernhard, 2000; Skitka, 1999). Performers should be educated on these biases and associated mitigation strategies and be given the opportunity to experience how these biases impact their decision making (Parasurman and Riley, 1997). For example, in aviation training pilots learn to anticipate ATC instructions and be ready to execute them. Pilots also need to learn to verify the instructions and not be biased by expectations. Awareness of biases such as (a) take-action tendency bias (the tendency to choose action over inaction), (b) saliency bias (the most prominent piece of information is likely to carry the most weight), (c) anchoring bias (the first piece of information encountered is likely to carry the most weight) and (d) sunken-cost bias (the tendency to persist along an unfavourable course due to the amount of resources already committed) could provide pilots access to knowledge that will assist them in effectively managing conflicting information. Pilots could then be given opportunities to practice

performing in situations in which these biases are likely to emerge. For instance, simulation scenarios could be designed to play into biases, such as suddenly cancelling a landing clearance when the aircraft is below the decision altitude and the pilot is expecting to land.

Self-Reflection

A final skill which could benefit pilots in preparing to respond to information conflicts is the skill of self-reflection. Also known as metacognition, this is the ability to monitor and control ones thought process (Martinez, 2006). This is a skill that can be incredibly important when integrating information from multiple sources with varying levels of integrity and reliability. Self-reflection allows a performer to be aware of what information they have collected, if any information sources are in conflict, whether they have considered why they are in conflict, and the implications for associated decisions. Pilots could be trained to use self-reflection skills such as the use of mental simulation during performance, in which a potential solution is played through in one's head to identify critical risks and relevant situational factors (Martinez 2006; Mosier and Fischer, 2010). With respect to information conflicts, pilots could be taught to mentally simulate how the scenario would play out if they were to trust and act on each of the information sources in conflict, including identifying the potential risks and negative impacts. Instructors could also be trained to use self-reflection in debriefings, specifically to encourage trainees to reflect on the information search and integration steps they performed when experiencing the information conflict, and how they should change performance in the future.

Conclusion

There is an opportunity to leverage best practices derived from the literature to prepare pilots to operate in today's information-rich cockpits, in which there are redundant sources of information. There are several techniques presented herein which can be leveraged to (a) increase pilot knowledge related to information conflicts, why they occur, and strategies to handle them, and (b) provide opportunities for pilots in training to practice responding to information conflicts. Such training practices can be utilized to arm pilots with the knowledge and skills they need to manage information conflicts on the flight deck.

Acknowledgements

This research was sponsored by the Federal Aviation Administration NextGen Human Factors Division (ANG-C1) under Contract # DTFAWA-16-D-00003.

References

Bahner, J. E., A. D. Huper, and D. Manzey. (2008). "Misuse of automated decision aids: Complacency, automation bias and the impact of training experience." *International Journal of Human-Computer Studies 66* (9): 688-699. doi:10.1016/j.ijhcs.2008.06.001

Carroll, M. & Sanchez, P. (2020). Decision making with conflicting information: Influencing factors and best practice guidelines. *Theoretical Issues in Ergonomic Science*. doi.org/10.1080/1463922X.2020.1764660

Meredith Carroll, Summer Rebensky, Donna Wilt, Warren Pittorie, Leonia Hunt, Maria Chaparro & Paige Sanchez (2021) Integrating Uncertified Information from the Electronic Flight Bag into the Aircraft Panel: Impacts on Pilot Response, *International Journal of Human–Computer Interaction, 37*:7, 630-641, DOI: 10.1080/10447318.2020.1854001

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

Dzindolet, M.T., Peterson, S.A., Pomranky, R.A., & Pierce, L.G., Beck, H.P. (2003). The role of trust in automation reliance. *International Journal of Human-Computer Studies 58*(6), 6.

Gilson, R. D., J. E. Deaton, and M. Mouloua. (1996). "Coping with complex alarms: Sophisticated aircraft cockpit alarm systems demand a shift in training strategies." *Ergonomics in Design 4* (4): 12-18. doi: 10.1177/106480469600400404

Martinez, M. E. (2006). "What is metacognition?." *Phi Delta Kappan 87* (9), 696-699. doi:10.1177/003172170608700916

Mosier, K. L., Keyes, J., & Bernhard, R. (2000). Dealing with conflicting information: Will crews rely on automation? In G. Edkins & P. Pfister (Eds.), Innovation and consolidation in aviation: Selected contributions to the Australian Aviation Psychology Symposium 2000 (pp. 243–254). Aldershot, Hampshire, UK: Ashgate Publishing Ltd.

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.

Parasuraman, R., & Riley, V. (1997). Humans and automation: Use, misuse, disuse, abuse. *Human Factors, 39*, 230–253.

Richter, T., and J. Maier. (2017). "Comprehension of multiple documents with conflicting information: A two-step model of validation." *Educational Psychologist, 52* (3): 148-166. doi:10.1080/00461520.2017.1322968

Skitka, L. J. (1999). Automation: Decision aid or decision maker? (No. NASA/CR-1998-207767.). Retrieved from NASA Technical Reports Server: https://ntrs.nasa.gov/search.jsp?R=19980048379