

A Review of Pilot Attention Needs and Issues During Flight

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Abstract: Automation has been a norm for commercial air travel for many decades, including the first automatic landing by Pan Am in the 1960s. Unfortunately, with automation comes less manual operation, or hand-flying, by pilots. Although this development appears beneficial to both pilots and aviation safety, it has sometimes led to overtrust of the systems, resulting in preventable accidents. It also means pilots may become bored with their jobs and stop using their skills. This loss of skill may result in either unsafe activities or loss of attention. The literature review indicates that automation can lead to less attention, unrelated thoughts, and increased errors. When automation is used, more direct interaction between pilots and the plane, such as occasional manual operation, is recommended to assist with task focus. This inquiry serves as a cautionary example of how automation, while beneficial, can lead to unintended consequences such as skill degradation, over-reliance on technology, disengagement, and error-prone environments. In business, fostering a balance between automation and human involvement is crucial for maintaining performance, attention, and engagement, ensuring employees and systems operate optimally.

Keywords: Automation, Attention, Attention Pull, Complacency, Mind-Wandering

1. Introduction

This literature review focuses on unsafe flight practices emerging from pilot boredom and I explore known and suspected issues and factors pilots have in maintaining attention during flight (Antonovich, 2008; Baird et al., 2011; Bhana, 2010; Casner et al., 2014; Casner & Schooler, 2014; Chen et al., 2021; Dismukes et al., 1998; Lu et al., 2021; Martinussen & Hunter, 2010; NTSB, n.d.; Parasuraman et al., 1993; Parasuraman & Manzey, 2010; Prinzl & Pope, 2000; Valecha, 2020; Young & Stanton, 2002). As a result of distractions pulling attention, more errors and incidents/accidents can and have occurred (Antonovich, 2008; Baird et al., 2011; Bhana, 2010; Casner et al., 2014; Casner & Schooler, 2014; Dismukes et al., 1998; Martinussen & Hunter, 2010; NTSB, n.d.; Parasuraman et al., 1993; Parasuraman & Manzey, 2010; Prinzl & Pope, 2000; Valecha, 2020; Young & Stanton, 2002). However, existing literature has suggested that attention issues are more than just a pilot having a lack of desire to pay attention (Baird et al., 2011; Casner et al., 2014; Casner & Schooler, 2014; Chen et al., 2021; Lu et al., 2021; Valecha, 2020). Instead, since the adoption of flight deck automation, less attention is necessary to operate the aircraft, meaning that a pilot's attention can easily be elsewhere. Therefore, the issue is ensuring a proper and immediate response can occur when something goes wrong, such as malfunctions or changes in conditions. Given the need for an appropriate and immediate response, it is evident that successful responses depend on the distraction type or type of

thoughts (Antonovich, 2008; Bhana, 2010; Casner et al., 2014; Casner & Schooler, 2014; Chen et al., 2021; Lu et al., 2021; Malik et al., 2020; Parasuraman et al., 1993; Valecha, 2020; Yang et al., 2023). Unfortunately, more reasons than automation exist for increased attention pulls. With time in the role and with better systems, pilots become complacent and trust the systems, allowing them to focus on other expectations and stressors, and thereby allowing their minds to wander (Dismukes et al., 1998; NTSB, n.d.; Valecha, 2020). While researchers have continued to review automation impacts, such as complacency, newer aviation research on it continues to be essential, as well as incorporating the boredom relationship with response. Until its retirement in 2023, the NTSB Most Wanted List included pilot attention as a leading area of concern and causes of incidents and accidents (NTSB, n.d.). The appearance follows earlier concerns dating back to the 1970s and 1990s (Dismukes et al., 1998).

2. Research Questions

RQ 1: How does cockpit automation create an environment that may enable unsafe practices among bored pilots?

RQ 2: What types of attention pulls or distractions are most prevalent among pilots?

RQ 3: What has or continues to occur relating to safety due to pilot attention issues?

RQ 4: What strategies will help pilots maintain better attention during flight operations?

RQ 5: What strategies can pilots use to regain attention to flight operations?

This review will cover how automation has changed flying for pilots, reduced focused attention on flying due to less effort needed, and other factors that increase the chance of unsafe activities due to the increased boredom pilots may experience.

3. Problem Statement

Pilots' attention during flight operations has long been critical for safe operations. Existing literature has long included this, although comprehensive solutions have been minimal. While the Federal Aviation Administration (FAA) and the National Transportation Safety Board (NTSB) have long identified pilot attention and similar issues as significant concerns, however, these issues have yet to be resolved (Dismukes et al., 1998; NTSB, n.d.; Valecha, 2020). I analyzed existing literature to determine if attention focus changes impact safe operations. If so, to what extent? From there, I will explore the solutions presented and the challenges of the solutions, offering a comprehensive plan for further study and use.

As aircraft technology has changed and updated, pilot attention requirements have shifted. While aircraft and operations are safer and more effortless in many cases, the need for constant attention has decreased. While this change allows pilots to focus better while on task, it also means less time is needed to operate the aircraft overall. Given the situation, the attention pulled away from the task at hand may have a more significant impact when pilot attention redirects to flight operations. Attention pull can be from personal conversations between pilots, mind wandering, personal matters, phone usage, or other operation-unrelated activities. Tasks may include redirection from Air Traffic Control (ATC), changes in weather conditions, or items such as turbulence, malfunction alarms, and proximity alerts. Weather changes generally allow pilots several minutes to respond.

In contrast, an alarm for an engine malfunction, or worse, an aircraft proximity alert may require a high-precision response within seconds. Therefore, researchers and members of the aviation industry need to explore types of attention pull and their impact on pilot response time for emergent issues, especially when events occur suddenly and without warning. Furthermore, it is essential to explore solutions that help pilots maintain better focus or train them to rapidly regain focused attention (Malik et al., 2020).

4. Significance of the Study

Increased aviation safety represents the significance of this study. Specifically, existing research has identified pilot-attention issues and suggested solutions either through experimental research or future research requests, therefore, furthering this subject area can identify additional options (Chen et al., 2021; Lu et al., 2021; Malik et al., 2020; Valecha, 2020). Additionally, given that the NTSB and the FAA have repeatedly listed pilot attention as an area of concern, it is evident that it still needs to be adequately addressed (Dismukes et al., 1998; NTSB, n.d.). Potential information to be examined includes reports of attention issues, error rates related to attention issues, and proposed solutions to reduce or avoid errors. In particular, some solutions may either already have been tested or are awaiting additional research.

While attention pull is a focus, researchers and members of the aviation industry need to understand that nonactive attention is not itself an issue. Instead, solutions to nonactive attention may simply be how to regain focus when something occurs. The significance of an approach to regaining attention, rather than eliminating nonactive attention, is that it is more functional for real-world applications. Solutions for regaining attention acknowledge that full attention is not always possible. The approach to practical application would build on previous studies with either singular approaches or the occurrence of issues without suggested corrections. Equally important, I will delve more deeply into the solution options identified in previous studies. Given the nature of attention issues and safety risks, ensuring a fully addressed solution is paramount.

Accident data from the NTSB reveals over 140 reports between 2017 and 2023, which mention attention in the factual analysis for accident investigations (CAROL, n.d.). Trends have shown that this has been a consistent issue and concern for several decades (Chen et al., 2021; Dismukes et al., 1998; Lu et al., 2021; Malik et al., 2020; NTSB, n.d.; Valecha, 2020).

This review will provide insights to help researchers focus experimental studies on proposed solutions and strategies to help reduce errors that may lead to accidents. Accident reduction benefits everyone, both within and beyond the aviation field. Additionally, while internal findings within aviation companies do not appear in official reports, since they do not typically lead to formal accident or incident investigations, the knowledge gained can help the industry develop strategies to reduce internally identified risks. Due to the fragmented nature of existing research and current findings, this review aims to provide a more cohesive review for researchers and industry seeking to implement strategies and address the topic further, hopefully leading to safer flight operations.

5. Methodology

Two approaches can be used to address pilot attention issues and the impact of pilot inattention on aviation safety. The first approach is identifying and testing a single solution through a quantitative experimental design, determining if it would either improve pilot attention or the ability to regain focused attention when needed. The experimental approach could also compare two proposed solutions against each other. The second method is to analyze existing literature and research. This will better uncover the findings over the years, trends, and changes as technology has changed, as well as the general ebbs and flows of this topic. Such an analysis enables future researchers to analyze the topic effectively and create and study more comprehensive solutions and industry-attempting solutions that may have already been identified in prior research.

Given these two options, this article presents a review of the existing literature, combining all known and suspected areas related to pilot attention and associated matters. Instead of a data review or analysis, I will focus on the primary drivers and provide an in-

depth review of each area, concluding with suggested further research based on the literature review and possible solutions identified during the review. Literature reviews are particularly effective when topics need more research yet are widely discussed and present issues that quantitative research may only partially address (Maggio et al., 2016; Pickering & Byrne, 2013). Additionally, literature reviews help inform future research methodologies (Maggio et al., 2016). This article's literature review concludes with suggestions for further study and presents known tools for pilots supported by prior research.

I will conduct a scoping review of the literature. I selected this method due to its focus on identifying key concepts and gaps, as well as the breadth of the topic (Munn et al., 2018; Peterson et al., 2017; Pham et al., 2014). This approach is preferable when the topic lacks depth or has limited studies available (Munn et al., 2018; Peterson et al., 2017; Pham et al., 2014). While it poses the challenge of less depth and analysis, a scoping literature review typically offers a more comprehensive inclusion criterion and provides a clearer opportunity to identify gaps and the need for further research on the topic. The inclusion criteria were peer-reviewed or sourced from governmental agencies relevant to pilot attention or mental workload. Exclusion criteria were non-peer-reviewed or governmental agency sources and non-English language articles. Given the small research sample size, the source publication dates include 2024, without a specific start date, to allow for full inclusion of existing literature. Additionally, given the use of the term "pilot" in the search phase, I excluded any study that was not about aviation pilots. Again, no specific study designs were included or excluded, given the type of literature review and the narrower amount of existing research on the topic. While the topic relates specifically to pilots, I included non-aviation journals given the psychological aspect of attention focus. My search strategy used academic journal search engines, including ProQuest and EBSCOhost. The following search terms were used: pilot boredom; pilot attention; pilot attention issues; pilot attention span; pilot concentration; concentration issues during flight; attention issues during flight.

6. Theoretical Framework

The theoretical frameworks guiding this literature review include systems theory and technology-organization-environment (TOE) theory. Systems theory is a framework for how systems interact with their environments, while TOE theory is about the relationship between technology, people or organizations, and the environment (Nach & Lejeune, 2010; Sinnott & Rabin, 2012). The plane and the pilot are interdependent systems in aviation, and external factors such as attention pulls are always involved. This review explores the constant relationship between these components, particularly in pilot processes during flight operations. With pilot attention needs and operational issues changing suddenly, it is crucial to understand and expand upon how these interactions occur.

Along with systems and TOE theories, Kahneman's Attentional Resource Theory and Reason's Swiss Cheese Model further guide my review and understanding of the underlying issues. Kahneman's Attentional Resource Theory posits that attention is a finite resource and must be allocated across tasks (Bruya & Tang, 2018; Kahneman, 1973; Young & Stanton, 2002). Therefore, automation reduces task demand, resulting in the potential for attention misallocation. With the increase in automation, there is less need to check instruments frequently. Pilots may lose focus, and become bored and distracted, leading to unrelated thoughts, causing a reduction in vigilance. Put another way, low cognitive demands lead to attention drift, increasing the likelihood of errors. This situation is especially likely during routine phases of flight. Reason's Swiss Cheese Model suggests that human errors emerge from a combination of generally smaller errors that slip through or add up (Reason, 1990; Reason et al., 2006). These errors can be active failures or latent

conditions, or a combination of the two. An active failure may be a pilot over-trusting the automation, therefore becoming less vigilant, resulting in errors when manual control is needed (Antonovich, 2008; Baird et al., 2011; Bhana, 2010; Casner et al., 2014; Casner & Schooler, 2014; Dismukes et al., 1998; Martinussen & Hunter, 2010; NTSB, n.d.; Parasuraman et al., 1993; Parasuraman & Manzey, 2010; Prinzel & Pope, 2000; Reason, 1990; Reason et al., 2006; Valecha, 2020; Young & Stanton, 2002). Latent conditions, such as loss of skill, generally occur over time (Antonovich, 2008; Baird et al., 2011; Bhana, 2010; Casner et al., 2014; Casner & Schooler, 2014; Martinussen & Hunter, 2010; Parasuraman et al., 1993; Parasuraman & Manzey, 2010; Prinzel & Pope, 2000; Reason, 1990; Reason et al., 2006; Young & Stanton, 2002). An example is over-reliance on automation, which can contribute to a loss or reduction in manual flying skills, leading to an accident when combined with a moment of system failure and the inability to properly respond. This is the Catch-22 in aviation. Automation can provide many safety improvements and decrease pilot workload during times when overload may occur, but it also poses a system design flaw of over-reliance on automation, which, when combined with human error, boredom, and distraction, can lead to accidents.

7. Cockpit Automation and Pilot Boredom

Although all pilots start with essential stick and rudder skills, and many pilots continue to focus heavily on this for hundreds, if not thousands of hours, once pilots join airlines, the amount of technology available to assist them expands. Self-landing planes have existed since the 1960s (“Automatic Landing Survey,” 1968). Given that the necessary skill and attention required for landing is not needed as often, it is no wonder that pilots can become bored (Antonovich, 2008; Baird et al., 2011; Bhana, 2010; Casner et al., 2014; Casner & Schooler, 2014; Chen et al., 2021; Dismukes et al., 1998; Lu et al., 2021; Martinussen & Hunter, 2010; NTSB, n.d.; Parasuraman et al., 1993; Parasuraman & Manzey, 2010; Prinzel & Pope, 2000; Valecha, 2020; Young & Stanton, 2002). Although pilot attention is still supposed to be on controlling the aircraft, even when automated, the reduced operational demand often leads to distracting activities or unsafe actions (Antonovich, 2008; Baird et al., 2011; Bhana, 2010; Casner et al., 2014; Casner & Schooler, 2014; Chen et al., 2021; Dismukes et al., 1998; Lu et al., 2021; Martinussen & Hunter, 2010; Parasuraman et al., 1993; Parasuraman & Manzey, 2010; Prinzel & Pope, 2000; Valecha, 2020; Young & Stanton, 2002). In short, automation pushes the pilot to be a systems manager.

Research on topics such as pilot boredom, complacency, automation, human factors relating to human-computer interactions, and the combination of these topics continues (Antonovich, 2008; Baird et al., 2011; Bhana, 2010; Casner et al., 2014; Casner & Schooler, 2014; Chen et al., 2021; Lu et al., 2021; Martinussen & Hunter, 2010; Parasuraman et al., 1993; Parasuraman & Manzey, 2010; Prinzel & Pope, 2000; Valecha, 2020; Young & Stanton, 2002). Previous researchers included boredom in many of their studies. However, most previous aviation research has focused on mind-wandering and skill loss due to automation, as well as other impacts of automation (Antonovich, 2008; Baird et al., 2011; Bhana, 2010; Casner et al., 2014; Casner & Schooler, 2014; Chen et al., 2021; Lu et al., 2021; Martinussen & Hunter, 2010; Parasuraman et al., 1993; Parasuraman & Manzey, 2010; Prinzel & Pope, 2000; Valecha, 2020; Young & Stanton, 2002).

8. Mental Workload

Mental workload varies during flight with the workload typically seen as highest during approach and landings. However, even cruise-level flight operations tax the sustained focus of pilots who do not use automated systems. Since a high cognitive workload can be challenging and stressful, automation reduces this drain (Martinussen & Hunter, 2010;

Young & Stanton, 2002). However, this solution can also be negative; thus, “mental underload” can also harm pilot performance (Young & Stanton, 2002).

During mental underload, thoughts that do not relate to the task at hand capture the pilot’s attention (Baird et al., 2011; Casner et al., 2014; Casner & Schooler, 2014; Chen et al., 2021; Lu et al., 2021; Valecha, 2020). These unrelated thoughts emerge from boredom and divert attention that could become necessary for aircraft operational safety (Baird et al., 2011; Bhana, 2010; Casner et al., 2014). This distraction can result in slower responses or even missing “automation failures,” as Prinzel and Pope (2000, p. 107) put it, among other researchers (Antonovich, 2008; Baird et al., 2011; Parasuraman et al., 1993; Parasuraman & Manzey, 2010).

Over-trusting automated systems offer another chance for error. Although the system’s purpose is to relieve the mental workload, it can also result in pilots assuming the system will always be right (Parasuraman et al., 1993; Young & Stanton, 2002). On the other hand, distrusting the systems can also increase mental workload to a greater level than previously existed. This increased mental workload is largely due to additional options and confusion with modes (Young & Stanton, 2002). The issue ultimately becomes balancing automation and manual control. After the unfortunate Air Inter Airbus A320 accident in France in January 1993 (Parasuraman et al., 1993), investigators suggested balancing automation and manual control. The Airbus A320 represented the most automated aircraft available at the time. Given this accident, it appeared that the pilots did not take enough control believing the system to be correct (Parasuraman et al., 1993). Other research supports the conclusion that pilots trust and rely strongly on the system, thereby reducing physical monitoring (Bhana, 2010). Monitoring reduction and active participation also result in less manual flying. The loss of manual flying may negatively affect pilot skills, although prior researchers have not fully agreed upon this point (Antonovich, 2008; Bhana, 2010; Casner et al., 2014; Parasuraman et al., 1993).

Automation changes parallel trusting the systems as an error source. In this context, if the automation stays stable and requires little interaction, pilots pay less attention and become even more complacent (Parasuraman et al., 1993; Parasuraman & Manzey, 2010). A balance is necessary between mental underload and overload. Workload management is critical to success, especially in aviation. Doing enough keeps the pilot’s attention on the task. Doing too little means the pilot’s thoughts wander, and too much leads to pilot stress and errors (Baird et al., 2011; Casner & Schooler, 2014; Chen et al., 2021; Lu et al., 2021; Parasuraman et al., 1993; Valecha, 2020).

9. Safety and Culture

Safety issues can and do occur as a result of pilots trusting automated systems and losing attention, wandering minds, and boredom (Antonovich, 2008; Bhana, 2010; Casner et al., 2014; Casner & Schooler, 2014; Chen et al., 2021; Lu et al., 2021; Malik et al., 2020; Parasuraman et al., 1993; Valecha, 2020; Yang et al., 2023). Reason’s Swiss-cheese model of accident analysis considers automation to be a safety layer with a hole in it (Bergeon & Hensley, 2009; Martinussen & Hunter, 2010; Reason, 1990; Reason et al., 2006). While automation can provide higher levels of safety, an apparent hole appears in the case of an attention lapse due to boredom (Bergeon & Hensley, 2009; Martinussen & Hunter, 2010; Parasuraman et al., 1993; Parasuraman & Manzey, 2010).

Although attention lapse is one crucial aspect, an organization’s safety culture provides another view. The Federal Aviation Administration in the United States requires airlines to have a sterile cockpit below 10,000 feet, meaning that only essential and related discussion and action occur, conversely, other activities or discussions are open the rest of the time (ECFR, 2025a; 2025b; Sumwalt, 1993). Depending on organizational policies and

practices, there could be a weak safety culture (Freiwald et al., 2013; Martinussen & Hunter, 2010). Moreover, the safety culture, or rather its lack, can encourage pilot boredom and lead to attention lapses or other unsafe behaviors (Freiwald et al., 2013; Martinussen & Hunter, 2010). Safety and its culture are critical to any organization. Finding ways to manage it can be challenging.

10. Skills

Automation ultimately results in fewer manual control activities (Antonovich, 2008; Bhana, 2010; Casner et al., 2014; Martinussen & Hunter, 2010; Parasuraman et al., 1993; Valecha, 2020). Previous research findings suggest a mixed effect on pilot skills (Antonovich, 2008; Bhana, 2010; Casner et al., 2014; Parasuraman et al., 1993). Casner et al. (2014) assessed instrument scanning and manual control skills, such as stick and rudder, during automated events and simulated changes. The study also measured unrelated thoughts. The researchers ultimately found that the manual skill and instrument scans remained of sound quality. Further, pilots doing these tasks tended to maintain focus on the task at hand. However, it was found that the pilot's thoughts would wander in an automated system, and this mind-wandering would occur relatively quickly (Casner et al., 2014). Another study supported the faster mind-wandering due to automation, demonstrating that only 20 minutes of automation resulted in unrelated thoughts and complacency (Parasuraman et al., 1993). Indeed, while the entire automation of all phases and aspects of flight does not occur, even the skills that are retained better and longer, such as stick and rudder, would decrease if entire automation were the case (Casner et al., 2014).

Feedback is tied to skills. For pilots, the most common form of feedback, though often forgotten, is manual feedback. This feedback occurs when the pilot does something to the plane, and the pilot experiences physical sensations. Unfortunately, with automation, the pilot does not experience immediate feedback from their actions (Antonovich, 2008). This lack of feedback also ties into reduced situational awareness, which can result in too much trust in the system and less effective control during necessary events, such as automation failure (Antonovich, 2008; Prinzel & Pope, 2000; Wang et al., 2021).

Pilots tend to enjoy flying planes, a skilled activity. Whether or not the skill itself is reduced through automated systems, it would make sense that pilots become bored in the short term. In the long term, boredom can lead to job dissatisfaction and higher attention lapses.

11. Unrelated Thoughts

First, some researchers have pointed out that mental underload can be more harmful to pilots predisposed to stress or fatigue, resulting in decreased performance, especially when a demand is placed on them requiring manual action (Young & Stanton, 2002). Pilots who state they are bored show a higher likelihood of attention lapses (Bhana, 2010). The attention lapse covers a broader range than many assume. In the case of pilots, attention lapse can range from nonessential flight operation thoughts to unrelated thoughts, such as situations at home. The unrelated thoughts are highest during autopilot and lowest during manual control combined with raw data (Casner et al., 2014). Researchers observed more errors and roughly a 30% variability in performance, meaning that pilots had the wrong altitudes, headings, or other setup issues (Casner et al., 2014). As expected, Baird et al. (2011) pointed out that "lapse of executive control of task-relevant information" is highly possible from untimely mind wandering (p. 1610).

This issue of mind-wandering is also addressed with self-efficacy, or belief in self-on-task performance (Prinzel & Pope, 2000). Pilots with higher self-efficacy seem less complacent than their counterparts, resulting in better overall performance (Prinzel & Pope,

2000). In other words, automation doesn't cause them to lose task focus. It would make sense that those who believe in their skills more are less likely to lose focus due to automation and, therefore, get less bored.

The more automation that occurs, the more likely unrelated thoughts occur (Casner & Schooler, 2014). Expanding on automation and unrelated thoughts, Casner and Schooler (2014) point out that "higher-level flight-related thinking" (p. 440) or future planning and complex processing is decreased when automation is used. This shift means that pilots are not planning and considering possible alternatives for an emergency. Pilots will think about something unrelated when things seem under control (Casner & Schooler, 2014). Again, the aircraft or systems not needing attention does not have to be accurate, only perceived, meaning that the system is trusted, likely to be unchanging, requiring little to no interaction (Parasuraman et al., 1993; Young & Stanton, 2002).

Finally, situational awareness—a necessity for pilots to know what is going on, and predict and plan for alternatives—is greatly and negatively affected as more automation occurs (Antonovich, 2008; Wang et al, 2021). Meaning that should an emergency arise, not only are the pilots' thoughts not on flying, but they may also not be able to recover well enough to respond appropriately if they or the automated system detects the emergency (Antonovich, 2008).

12. Boredom

Automation that remains stable and requires little pilot attention seems to result in more pilot complacency and reduced situational awareness (Antonovich, 2008; Bhana, 2010; Parasuraman et al., 1993; Parasuraman & Manzey, 2010; Prinzel & Pope, 2000; Wang et al, 2021). This complacency increases for boredom-prone pilots (Bhana, 2010). Some research findings have suggested that even high workloads, coupled with automation, will still result in complacency (Parasuraman et al., 1993). Thus, pilots will get bored with any automation, especially when it is not variable. The result is an adverse effect on attention span (Bhana, 2010).

One theory suggests that there are two critical parts of pilot boredom. First, if there is insufficient arousal, someone will seek it out in other ways (Bhana, 2010). Second, boredom can only occur when someone does not enjoy what they are doing at that moment (Bhana, 2010). These findings, especially the first, certainly seem to be supported, given the wandering and unrelated thoughts other studies have shown and the general desire to fly by nearly every pilot (Antonovich, 2008; Baird et al., 2011; Bhana, 2010; Casner et al., 2014; Casner & Schooler, 2014; Parasuraman et al., 1993; Parasuraman & Manzey, 2010; Prinzel & Pope, 2000; Young & Stanton, 2002). Although individual differences, such as self-efficacy, have been noted above, it also appears that pilots who find stimulation from internal sources are less likely to fall into complacency (Bhana, 2010). The internal source stimuli would essentially be a thought on flying, although other similar thoughts may be related to future parts of the trip. The pilots with adverse emotional reactions to boredom are the ones who are likely to become complacent (Bhana, 2010). Subsequently, the latter part of Bhana's (2010) theory may hold true, although it is due to a dislike for the automation and systems manager role, not the entire act of flying. Bhana's (2010) theory needs additional exploration to be defined in the manner mentioned above.

Boredom is rarely a good thing, and unfortunately, in the case of aviation, it can lead to unsafe behavior. Pilots often enjoy flying, and the less active they are operationally the less they enjoy it. The cause of boredom, the automation itself, should ensure safety. However, it also means that the role of the pilot, the system manager, is now compromised by a distracted or uninterested individual. A simple solution would be to have more interaction with the plane, such as more manual flying operations (Antonovich, 2008;

Parasuraman et al., 1993). In contrast, other researchers argue that adding intermittent steps to the automation to increase interaction is not enough and can result in either mental overload or more boredom (Casner & Schooler, 2014; Parasuraman et al., 1993; Young & Stanton, 2002). Wang et al. (2021) point out though that inadequacy in safety training reduces the situational awareness and emotional intelligence link. This furthers the need to address situational awareness in multiple ways.

13. Recommendations

The primary recommendation is to repeat existing studies. Depending on the time frame, this approach may show a change with new developments in automation, as well as known errors since the original studies. Further studies are also necessary and should expand on the existing topics and others. This should include systems interaction, boredom, regaining attention, loss of pilot skills such as hand-flying/manual control, self-efficacy, and the intersection of these. In the case of pilot boredom, not all studies need to focus on the particular type of automation and distraction. Instead, the sum of all related existing and further research, ideally through a subsequent meta-analysis, will provide a strong indicator of the risks and solutions. However, more research from academia and industry would be necessary for an effective meta-analysis.

Monitoring pilots during flight and measuring response times and accuracy would provide the most real-world data as a potential study. While this has been done by comparing types of distractions at different times and for different lengths of flight, it would help researchers and the aviation industry develop better solutions for maintaining pilot focus during flight operations. Using an experimental design approach would also be possible, with the utilization of flight simulation. This design would allow researchers to input various flight tasks and vary timing and severity, and likely allow for more accurate measurements, such as through biofeedback measurement. The challenge to obtaining actionable data lies in the pilot knowing the exercise is a simulation, although utilizing known biofeedback measurements from the psychology field will provide quality data and pose no additional safety hazards. Finally, other industries that rely on automation should also be further measured and compared. This comparison may include manufacturing and medical interventions.

14. Summary

This literature review focused on unsafe flight practices due to pilots' boredom. According to the reviewed literature, cockpit automation creates an environment that allows unsafe practices by bored pilots. However, researchers also found that this is a more ongoing and ever-changing dynamic. The type and level of automation directly affect the level of boredom. If the automation changes and requires more attention, less boredom occurs, and the pilots' thoughts stay on the task. If the automation is high and requires little action from the pilot, they are more likely to become bored and unaware.

I surmise that it is the level of interaction with the plane, not automation itself, that keeps the pilots engaged. Future research is also encouraged to investigate further the levels of boredom and levels of automation, as well as how each unrelated thought may impact boredom or recovery differently. Finding ways to keep workload levels reasonable, although the greatest challenge, solves many of the problems associated with unrelated thoughts and boredom. Let the pilots fly the plane.

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