

Article Citation Format

Uhuegho K.O, Na'Allah, A, Akaaba I.I, & Fadele A.A. (2026):
A Systematic Review of the Literature on the Relationship of Pilot
Flight Experience, Stress, Automation Dependency, and
Complacency. Journal of Digital Innovations & Contemporary
Research in Science, Engineering & Technology. Vol. 14, No. 1.
Pp 71-80. www.isteams.net/digitaljournal.
dx.doi.org/10.22624/AIMS/DIGITAL/V14N1P5x

Article Progress Time Stamps

Article Type: Research Article
Manuscript Received: 17th January, 2026
Review Type: Blind Peer
Final Acceptance: 23rd March, 2026

A Systematic Review of the Literature on the Relationship of Pilot Flight Experience, Stress, Automation Dependency, and Complacency

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ABSTRACT

Human error remains a significant contributor to aviation accidents despite continuous technological advancements in aircraft systems. This study presents a systematic review and quantitative synthesis of the literature examining the relationship between pilot flight experience, stress, automation dependence, and complacency. Using a structured systematic review approach, relevant studies published between 1990 and 2025 were identified and analysed from major academic databases and aviation regulatory sources. The findings reveal a complex and interdependent relationship among the variables. While pilot experience enhances situational awareness and decision-making, it may also lead to overconfidence and reduced vigilance over time. Stress demonstrates a dual effect, where moderate levels improve performance, but excessive stress impairs cognitive functioning and increases reliance on automation. Automation dependence, although beneficial in reducing workload, is strongly associated with decreased situational awareness, skill degradation, and increased complacency. Quantitative synthesis indicates a strong positive relationship between automation dependence and complacency, alongside moderate relationships involving stress and experience. The study highlights critical research gaps, particularly the lack of integrated models and limited context-specific studies in developing aviation environments. It concludes by recommending enhanced training, improved human-centred automation design, and stronger safety culture initiatives to mitigate complacency and improve overall aviation safety.

Keywords: Aviation Safety; Human Factors; Pilot Experience; Stress; Automation Dependence; Complacency; Situational Awareness; Flight Operations; Safety Culture; Meta-Analysis.

1. INTRODUCTION

The term "complacency" in aviation lacks a precise definition, complicating its identification and management, as experts advocate for focusing on specific behaviors rather than the broad concept itself.

Complacency, characterized by overconfidence in safety protocols, poses significant risks within the aviation industry, potentially leading to reduced vigilance and adherence to safety measures. Factors contributing to complacency include overconfidence, dependency on automation, fatigue, and inadequate training, all of which may degrade situational awareness and decision-making. The cognitive and behavioral aspects of complacency manifest through pilots' behaviors, such as fixation on routine tasks and a belief that "it won't happen to me," which can cloud judgment and lead to dangerous outcomes.

Research by various experts' highlights that while pilot experience generally enhances proficiency, it can paradoxically promote complacency, especially when pilots become too accustomed to routine and overestimate their capabilities. To combat complacency, a multifaceted approach is recommended, focusing on continuous learning, fostering a strong safety culture, enhancing communication, and employing advanced technologies for risk assessment. Organizations should also emphasize resilience training and maintain open channels for reporting risks without repercussion, thereby encouraging proactive management of safety concerns. Recognition of the complex relationship between experience and complacency is crucial in developing effective strategies to ensure safety within the aviation sector.

This article presents a summary, interpretation, and evaluation of the existing literature on pilot experiments, complacency, stress, compliance, and automation dependence, and complacency. Information for this purpose was collected from a review of associated literature to include findings, model and theories all gathered from textbooks, journal articles, and other relevant sources brief introduction of the importance of aviation safety, the role of human factors, the conceptual framework, theoretical perspectives, empirical evidence of pilot experiments, complacency stress, compliance, automation dependences, and complacency in the airline industry.

2. LITERATURE REVIEW

Concept of complacency Merritt et al. (2019) define complacency as "a state of self-satisfaction with one's own performance coupled with an unawareness of danger, trouble, or controversy." It further stated that it is a state of self-satisfaction and reduced vigilance due to a perception of low risk, often despite existing hazards. This definition highlights the subjective element of complacency, emphasizing the individual's perception of their own abilities and the potential for overconfidence. The research discusses the dual impact of experience on pilot safety, highlighting both positive and negative effects, as well as the concept of stress in aviation. It begins by outlining the positive effects of experience, such as enhanced situational awareness, improved decision-making, and refined airmanship, which contribute to safer flight operations. However, it also warns of the negative effects, notably overconfidence bias, automation dependency, and the normalization of deviance, which can lead to increased risks if pilots become complacent.

To mitigate these risks, the research suggests a proactive approach, emphasizing continuous learning, cultivating humility, and active risk management. This is crucial as experience alone does not prevent complacency; rather, pilots must be vigilant and adaptable to ensure safety in aviation. The discussion of stress begins with defining it as the body's response to challenging situations in aviation, identified as stressors that can detrimentally affect pilot performance and decision-making.

Key sources of stress, such as workload, fatigue, environmental factors, and psychological influences, are outlined along with their potential consequences, including reduced situational awareness and impaired communication. The concept of the Yerkes-Dodson Law is introduced, illustrating the relationship between stress and performance with an inverted U-shaped curve. The law indicates that while optimal stress can enhance performance, excessive stress can severely hinder it, suggesting that pilots must find a balance. Recognizing individual differences in managing stress is vital, as is implementing effective stress management techniques.

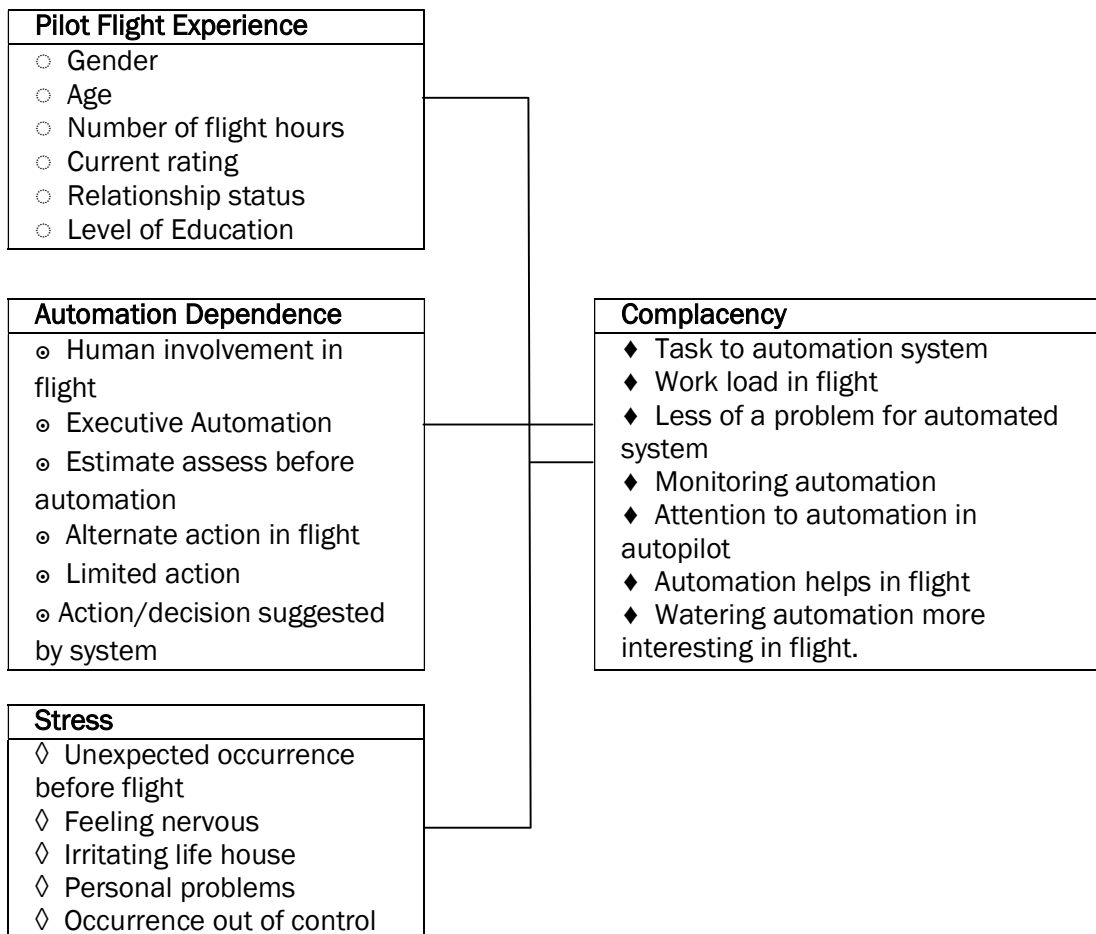


Figure 1: Conceptual Model of Study
(Source: Fieldwork 2025)

The study also emphasizes the hidden connection between stress and complacency, explaining how elevated stress can paradoxically lead to complacency through mechanisms like attention tunneling, cognitive overload, and stress-induced habit formation. It suggests that chronic stress can reduce motivation for vigilance and proactive safety behaviors. To break the stress-complacency cycle, strategies such as stress management training, workload management, and promoting a just culture in aviation workplaces are recommended.

Ultimately, a comprehensive understanding of the dynamics of experience, stress, and complacency is essential for enhancing safety and performance in aviation. By addressing these interconnected issues, the aviation industry can foster a culture that prioritizes vigilance and safety, optimizing both pilot performance and flight safety.

2.1 Automation Dependence in Modern Aviation

Automation dependence in aviation refers to pilots' overreliance on automated systems, leading to a decline in their manual flying skills and situational awareness. The prevalence of this phenomenon has surged due to sophisticated automation technology, a generational shift in pilot training, and an industry focus on efficiency. Signs of automation dependence include reduced situational awareness, difficulties in manual flight, and overconfidence in automation capabilities. Addressing this problem involves enhanced training that balances automation management with manual flying skills, encourages active monitoring of automated systems, and promotes a questioning attitude towards automation.

The danger of complacency is highlighted, wherein pilots may exhibit passive observation, skill degradation, and a false sense of security, which can obscure recognition of system failures. Counteracting complacency entails scholarly approaches such as pilot engagement, scenario-based training, and the encouragement of vigilance. The concept of "out-of-the-loop syndrome," where pilots become disconnected from active system management, underscores the importance of maintaining situational awareness and responsiveness. The significance of human factors in aviation safety is paramount, as human error accounts for a high percentage of aviation incidents, signaling the necessity for human factors integration in aviation training and operations. This comprehensive perspective aims to enhance safety culture among aviation professionals and mitigate risks associated with automation dependence.

2.2 Theoretical Framework

The research discusses various Human Factors Theories relevant to aviation, with a significant focus on Reason's Swiss Cheese Model and Rasmussen's Skill-Rule-Knowledge (SRK) Model. Reason's Swiss Cheese Model illustrates accident causation in complex systems, such as aviation, through the analogy of Swiss cheese slices representing defense layers (technological, organizational, procedural, and human vigilance). Accidents occur when gaps in these layers align, presenting a pathway for hazards. Key factors contributing to these vulnerabilities include organizational pressures for efficiency leading to hastened maintenance and inadequate training in automation limitations, and increasing automation dependence, which results in skill degradation and complacency among pilots. These factors can create scenarios where critical signs of issues are overlooked, resulting in delayed responses and errors.

To mitigate risks, the research emphasizes strengthening defenses, addressing latent conditions, and reducing active failures through enhanced training and a proactive safety culture. Furthermore, Rasmussen's SRK Framework categorizes human performance into skill-based, rule-based, and knowledge-based behaviors, highlighting how automation and complacency erode pilots' skills, ultimately impacting decision-making and situational awareness. The research also explores cognitive theories, including Attentional Control Theory, demonstrating how stress affects attention and cognitive performance, potentially leading to errors if pilots become overly reliant on automation and complacent. Suggestions for countering complacency include equipping pilots with stress management techniques, encouraging active engagement in flight, and promoting a culture of vigilance and open communication.

Pilot experience is crucial in ensuring safety, as experienced pilots often mitigate operational errors and enhance decision-making, although stress can impede their performance. Therefore, comprehensive stress management programs and continuous professional development are recommended to maintain high safety standards and operational effectiveness in aviation. The relationship between experience, stress, and safety is complex, necessitating targeted interventions to support pilots' well-being and enhance overall aviation safety.



Fig 1: Typical Flight Control Cockpit

Source: <https://e3aviationassociation.com/aviation-articles/exploring-the-psychology-of-pilots/>

2.3 Pilot Automation Dependence

The increasing reliance on automation in aviation has led to enhanced flight operations and safety, as noted by various researchers, including Singh et al. (1993) and Cahill et al. (2018). Nevertheless, this dependence raises concerns about pilot complacency and the erosion of manual flying skills. Singh et al. (1995) identify "automation-induced complacency," where pilots risk over-relying on automated systems, resulting in less vigilance and situational awareness. Sarter emphasizes that excessive automation reliance can impair pilots' manual operation proficiency and their capacity to react to unexpected scenarios, a point echoed by Cahill et al. (2018). Further studies, like that of Kihe and Ucler (2019), highlight that this overdependence, particularly during routine phases of flight, hampers pilots' monitoring abilities and responses to non-normal situations, contributing to accidents as detailed in the NTSB report (2019).

To counteract risks from pilot automation dependence, comprehensive training focusing on both technical and non-technical skills is essential. Research by Parasuraman et al. (1993) indicates that variations in the reliability of automated systems can affect operators' failure-detection performance. Meanwhile, Milner et al. (2020) and Stanton (2003) suggest that adaptive automation system designs must consider the trade-offs of automation for specific tasks, recognizing that "automation is neither inherently good nor bad" but alters work dynamics by solving some issues while creating others. According to ICAO (2019), pilots who succumb to complacency due to automation may show slower responses in critical situations, necessitating an understanding of complacency's roots and training strategies to maintain pilot vigilance and proficiency in automated contexts.

The literature collectively underscores that while integrating automation in aviation has significantly bolstered safety and efficiency, it simultaneously introduces challenges like complacency and diminished manual skills. Key strategies include emphasizing the right use of automation alongside maintaining pilot skills and awareness, supported by points made by Sengupta et al. (2016) and Waldron et al. (2013). Further, a 2019 study by Kihe and Ucler surveyed airline pilots regarding 'Automation Surprise,' where systems behave unexpectedly, occurring on average once a month but typically without severe consequences. This suggests a complex interrelation between automation and pilot performance. Complacency, ranked among the top five automation safety concerns (Funk et al., 1999), occurs when pilots become excessively reliant on systems, leading to poor monitoring and awareness, per Sengupta et al. (2016).

Endsley and Kiris found that excessive automation use correlates with lower situational awareness, which can delay responses to failures. Nonetheless, Sarter and Woods propose that automation could enhance situational awareness by reducing workload. As pilots gain experience, complacency and reduced vigilance can paradoxically increase the risk of accidents. Attempts to decrease complacency through better automation task visibility were deemed ineffective by Singh et al. (1997). Research shows that complacency can lead to poor adherence to safety protocols and diminished awareness, as noted by Canhan et al. and Casner et al. (2014).

In summary, while automation can improve safety and efficiency, without careful management, it can also induce complacency and a decline in manual skill, necessitating a balanced approach that upholds pilot proficiency and readiness to intervene. Research findings delineate the multifaceted relationship between pilot experience and complacency. Key factors influencing this relationship include the type and regency of experience, individual personality traits, and organizational culture—each playing a role in how complacency manifests and can be managed through effective training and a strong safety culture that encourages vigilance and accountability.

3. METHODOLOGY OF THE REVIEW

This study adopts a systematic literature review (SLR) approach to examine the relationship between pilot flight experience, stress, automation dependence, and complacency in aviation. A structured search strategy was employed to ensure comprehensive coverage of relevant studies. Academic databases such as Scopus, Web of Science, Google Scholar, and aviation regulatory sources, including ICAO and NTSB reports, were utilised. Keywords used in the search included *pilot experience*, *stress in aviation*, *automation dependence*, *complacency*, and *human factors in aviation safety*. The search process was iterative, allowing refinement of results to ensure relevance and quality. To ensure rigor and transparency, explicit inclusion and exclusion criteria were applied as presented in Tables 1 and 2.

Table 1: Inclusion Criteria

Criterion	Description
Study Type	Peer-reviewed journal articles, conference papers, and official aviation reports
Time Frame	Publications between 1990 and 2025
Language	English language publications
Subject Focus	Studies addressing pilot experience, stress, automation, or complacency
Context	Aviation or closely related high-risk industries
Relevance	Direct relevance to human factors and flight safety

Table 2: Exclusion Criteria

Criterion	Description
Study Type	Non-peer-reviewed articles, blogs, opinion pieces
Language	Non-English publications
Irrelevant Scope	Studies unrelated to aviation or human factors
Duplicates	Repeated studies across databases
Outdated Sources	Studies lacking relevance to modern aviation systems
Insufficient Data	Studies without empirical or theoretical contribution

3.1 Data Extraction and Analysis

Data from selected studies were systematically extracted and categorized into key variables: pilot experience, stress factors, automation dependence, and complacency indicators. A thematic analysis approach was employed to identify recurring patterns, relationships, and contradictions across the literature.

Table 3: Summary of Key Themes from Literature

Variable	Key Indicators	Reported Effects
Pilot Experience	Flight hours, age, training level	Improved decision-making, but risk of overconfidence
Stress	Workload, fatigue, personal issues	Reduced situational awareness and cognitive performance
Automation Dependence	Autopilot usage, system reliance	Skill degradation, reduced monitoring
Complacency	Reduced vigilance, overconfidence	Increased likelihood of human error

3.2 Synthesis Approach

The synthesis followed a narrative and thematic structure, integrating findings across studies to explain the interrelationship between variables. The approach allowed identification of patterns such as:

1. Experience contributing to both safety and complacency
2. Stress influencing reliance on automation
3. Automation dependence leading to reduced situational awareness

4. FINDINGS AND SYNTHESIS OF LITERATURE

The review reveals a complex and interdependent relationship between pilot experience, stress, automation dependence, and complacency. While pilot experience generally enhances situational awareness and decision-making, it can also lead to overconfidence and routine-based complacency, particularly in highly automated environments. Experienced pilots may rely on past success, leading to reduced vigilance and an underestimation of emerging risks. Stress is identified as both a mitigating and exacerbating factor. Moderate levels of stress can enhance alertness and performance, as explained by the Yerkes-Dodson Law. However, excessive or chronic stress impairs cognitive functioning, reduces situational awareness, and increases the likelihood of errors.

Notably, stress can indirectly contribute to complacency by encouraging reliance on automated systems as a coping mechanism for workload and cognitive demands. Automation dependence is a critical factor influencing pilot behaviour. While automation improves efficiency and reduces workload, excessive reliance can result in skill degradation, reduced manual flying proficiency, and the “out-of-the-loop” phenomenon. This condition limits pilots’ ability to effectively intervene during system failures. The literature consistently shows that automation-induced complacency leads to decreased monitoring, slower reaction times, and increased safety risks. Furthermore, the synthesis highlights that organizational culture, training quality, and system design significantly influence how these factors interact. A strong safety culture and continuous training can mitigate the negative effects of automation dependence and complacency.

4.1 Discussion of Key Relationships

The relationship between pilot experience and complacency is paradoxical. While experience enhances competence, it can also foster overconfidence and habitual behaviour, reducing the pilot’s sensitivity to potential risks. This aligns with the concept of normalization of deviance, where repeated exposure to non-critical deviations leads to their acceptance as normal practice. Stress interacts with both experience and automation dependence. High workload and environmental stressors may push pilots to rely more heavily on automation, increasing the risk of complacency. Conversely, well-managed stress can enhance vigilance and performance.

This highlights the importance of stress management strategies in aviation operations. Automation dependence further amplifies the risk of complacency by reducing active engagement in flight operations. When pilots rely excessively on automated systems, their role shifts from active controllers to passive monitors, increasing the likelihood of missed anomalies. The interplay between these variables demonstrates that complacency is not a standalone issue but a product of multiple interacting factors within the aviation system.

4.2 Research Gaps

Despite extensive research on human factors in aviation, several gaps remain. First, there is limited empirical research that simultaneously examines the combined effects of pilot experience, stress, and automation dependence on complacency. Most studies focus on these variables in isolation, limiting a holistic understanding of their interactions. Second, there is a lack of context-specific studies in developing aviation environments, particularly in Africa, where infrastructural, training, and regulatory conditions may differ significantly from developed regions. Third, insufficient attention has been given to emerging technologies such as artificial intelligence and adaptive automation, and their potential impact on pilot behaviour and complacency. Finally, there is a need for more longitudinal studies that examine how pilot behaviour evolves over time with increasing experience and exposure to automation.

5. CONCLUSION AND FUTURE RESEARCH DIRECTION

This systematic review highlights the intricate relationship between pilot flight experience, stress, automation dependence, and complacency in aviation. While experience and automation contribute significantly to operational efficiency and safety, they also introduce risks when associated with overconfidence and reduced vigilance. Stress further complicates this relationship by influencing cognitive performance and decision-making. The findings underscore the importance of adopting a balanced approach that integrates technical proficiency with continuous training, stress management, and active monitoring of automation systems. Aviation organizations must prioritise human factors, foster a strong safety culture, and implement adaptive training programmes to mitigate the risks associated with complacency. Future research should adopt integrated models that examine the combined effects of experience, stress, and automation dependence on pilot performance. Additionally, there is a need to explore the role of emerging technologies, such as AI-driven decision support systems, in shaping pilot behaviour.

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