The Aeronautical Journal (2025), 1–9
doi:10.1017/aer.2025.10088

SURVEY PAPER

Failure to switch tasks due to cognitive lockup in airline pilots: a review of mechanisms, influences and mitigation strategies

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Received: 3 November 2024; **Revised:** 27 September 2025; **Accepted:** 30 September 2025

Keywords: aviation safety; cognitive lockup; crew resource management (CRM); framing effect; go-around decision-making; human factors; mindfulness in aviation; pilot decision-making; sunk cost fallacy; task completion bias; task switching; time pressure; unstable approach

Abstract
Unstable approaches contribute significantly to accidents during the critical approach and landing phases of flight, many of which could have been prevented by executing a go-around. This review investigates cognitive lockup, a tendency to adhere to task completion despite shifting priorities, and its role in aviation incidents. Specifically, we explore the psychological underpinnings of cognitive lockup, the influence on pilot decision-making and potential mitigation strategies. We examine factors such as task completion bias, framing effects and the perceived cost of task switching, and provide recommendations for training and policy modifications to reduce cognitive lockup. Aviation safety in critical flight phases can be improved through enhanced pilot training, mindfulness techniques, positive policy framing and AI-based alert systems.

Nomenclature

AI	Artificial Intelligence
CRM	Crew Resource Management
EASA	European Union Aviation Safety Agency
EPM	Error Producing Mechanism
HRV	Heart Rate Variability
ICAO	International Civil Aviation Organisation
NASA	The National Aeronautics and Space Administration
SOP	Standard Operating Procedure
TEM	Threat and Error Management
TNO	TNO is the Netherlands Organisation for Applied Scientific Research
TSC	Task-Switch Cost

1.0 Introduction

The approach and landing phases represent 49% of all fatal accidents in commercial aviation [1]. According to the Flight Safety Foundation's Go-Around Decision-Making study [2], many of these accidents were preceded by unstable approaches that did not result in go-arounds. An unstable approach, in which an aircraft's speed, descent rate, position, or configuration deviates from prescribed safety parameters and may lead to landing risks, often requires the pilot to initiate a go-around—a procedure that discontinues the approach and climbs the aircraft back to a safe altitude for another landing attempt.

Cognitive lockup, a state where pilots persist with a plan of action despite changing circumstances, may contribute to these outcomes. This review explores the mechanisms, evidence and proposed mitigation strategies for cognitive lockup in aviation, drawing upon behavioural theory, experimental studies and domain-specific data.

2.0 Methodology

A structured literature review was conducted using Scopus, Web of Science and PubMed databases. Keywords such as 'cognitive lockup', 'task-switching aviation', 'attentional fixation' and 'decision inertia' were used. Only English-language studies published between 1980 and 2024 were included. Preference was given to empirical and simulation studies involving flight crew or analogous high-stress decision-making environments. This review excludes anecdotal reports, non-peer-reviewed sources and studies unrelated to aviation or high-risk operational domains.

3.0 Understanding cognitive lockup

First defined by Moray and Rotenberg [3], cognitive lockup is the tendency to complete tasks sequentially, without switching to more critical tasks as needed. This phenomenon poses significant risks in aviation, where quick task prioritisation can mean the difference between a safe landing and an accident. Human beings are naturally limited in their ability to perform multiple tasks simultaneously, requiring prioritisation and task-switching, which cognitive lockup inhibits [4].

3.1 Psychological mechanisms of cognitive lockup

Several cognitive biases contribute to cognitive lockup, particularly in high-stakes environments like aviation:

1. **Task Completion Bias**: The need to complete a task can dominate pilots' decision-making, even if the current task is no longer optimal for safety. This bias has been extensively studied, with findings indicating that individuals feel compelled to continue tasks in which they have invested time and effort [5].
2. **Sunk Cost Fallacy**: The sunk cost fallacy reinforces task completion bias, where pilots may persist with landing rather than performing a go-around due to the time and resources already invested in the approach [6].
3. **Time Pressure**: Time constraints often exacerbate cognitive lockup, as shown by Beevis [7], who noted that when time is scarce, individuals may prioritise immediate task completion over shifting to a more critical task.
4. **Perceived Cost of Task Switching**: Task switching often involves an inherent cognitive 'cost'—the mental energy required to reorient to a new task. This perceived cost can reinforce cognitive lockup, as pilots weigh the psychological and physical effort of switching tasks.
5. **Zeigarnik Effect:** The psychological tendency for people to remember uncompleted or interrupted tasks better than completed ones. Discovered by psychologist Bluma Zeigarnik, this effect suggests that incomplete tasks create cognitive tension, which in turn drives people to mentally return to the task until it is completed. This effect highlights our brain's natural inclination to resolve unfinished business, often creating a 'cognitive pitch' that motivates individuals to finish what they start [8]. In day-to-day scenarios, the Zeigarnik Effect can be beneficial, helping people remember incomplete tasks, follow through on projects and stay organised. However, in situations requiring rapid task-switching or the prioritisation of more urgent issues, this effect can become problematic.

4.0 Cognitive lockup during critical phases of flight: Review of key studies and evidence

Cognitive lockup in aviation is frequently observed during the approach and landing phases, where task-switching is critical. For a landing to be safe, the aircraft's vertical and lateral positioning, speed and descent rate must stabilise by approximately 1,000 feet above ground level. When these parameters are not met, a go-around should be initiated to allow for a more stable approach. However, due to cognitive lockup, pilots often persist with the landing, overlooking unstable conditions and increasing accident risk [2].

4.1 Review of key studies and evidence

1. **Eastern Airlines Flight 401**: The 1972 crash of Eastern Airlines Flight 401 has often been cited as a case of cognitive lockup. However, as reviewed in the study by Johnston [9], this incident may better illustrate distraction and failure to detect critical issues than cognitive lockup. In this case, the focus of the crew on a malfunctioning landing gear indicator distracted them from monitoring altitude, leading to a crash. This incident highlights the importance of task switching, but does not entirely capture cognitive lock-up.
2. **HUMAN project**: The HUMAN project [4] modelled cognitive lockup in high-stress aviation tasks, revealing that pilots often struggle to prioritise high-risk over low-risk tasks due to cognitive lockup. The project demonstrated that pilots tend to focus on low-risk tasks, such as maintaining a landing approach even when unstable, due to inherent task biases.
3. **Schreuder and Mioch's study on task completion**: Schreuder and Mioch [10] conducted an experiment that simulated firefighting under time pressure. The results showed a significant increase in cognitive lockup under high time constraints, and participants frequently adhered to a current task despite the emergence of higher-priority issues. This reinforces the need for aviation training focused on task switching.

5.0 Experimental findings on cognitive lockup

In addition to the HUMAN project and studies by the Netherlands Organisation for Applied Scientific Research (TNO), recent research highlights the interaction between automation reliance and reduced task-switch readiness [11]. For instance, in simulator studies conducted by the National Aeronautics and Space Administration (NASA) (2021), pilots exhibited delayed decision-making when engaged with automated flight systems under time stress, indicating that automation may reinforce cognitive lockup by creating an illusion of situational stability. This aligns with findings by Dorobantu et al. [12], who advocate structured scenario-driven simulation training for improving crew adaptability in rapidly evolving conditions.

5.1 Study 1: HUMAN model-based analysis

The HUMAN project, initiated in 2008, aimed to analyse human errors during aircraft cockpit system design. They developed a methodology based on a cognitive model of the crew behaviour. This supported the prediction of human errors in ways that are usable and practical for human-centred design of systems operating in a complex cockpit environments [4]. The study identified cognitive lockup as a serious error-causing mechanism for airline pilots. Scenarios from a human factor perspective with operational relevance were developed, wherein the combination of contextual factors would induce cognitive lockup. The simulated cognitive model was based on Rasmussen's three behaviour levels [13] in which cognitive processing takes place, that of skill-based, knowledge-based and behaviour-based. The decision-making module, also called the goal management, determines which goal is executed. In the decision-making process, cognitive lockup was found to be a relevant error-producing mechanism (EPM). EPM has been modelled in the decision-making process as task switch cost (TSC), representing the difference in goal priorities that must be met before switching goals.

https://doi.org/10.1017/aer.2025.10088 Published online by Cambridge University Press

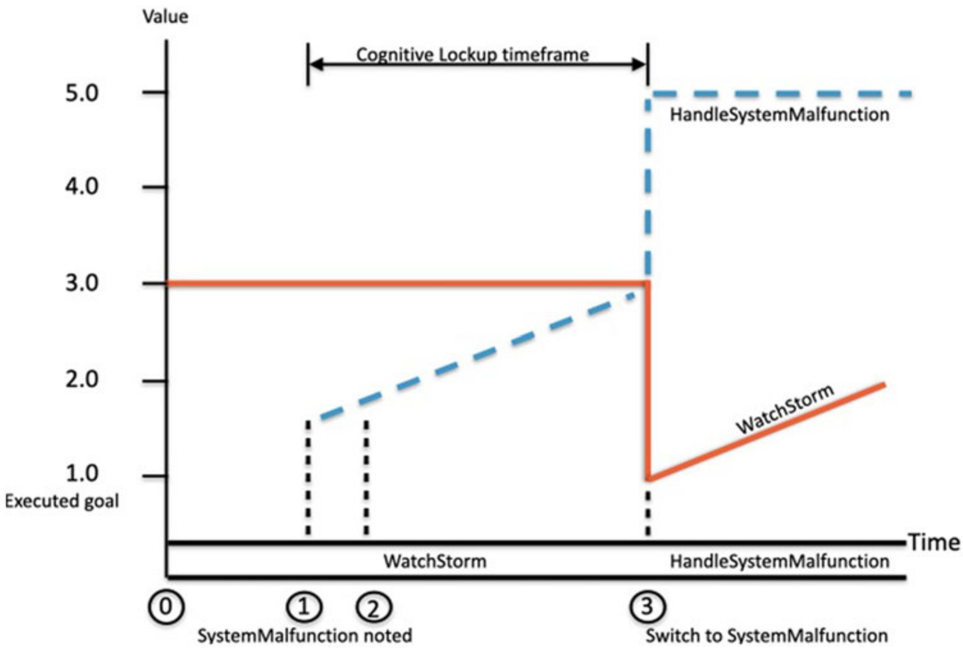

Figure 1. *Goal priorities during thunderstorm avoidance [4]. The crew begins by focusing on the goal 'Watch Storm' (orange line). At point 1, a system malfunction is noticed, but instead of switching immediately, the operator continues monitoring the storm. This period between recognition of the malfunction and actually shifting to the goal 'Handle System Malfunction' (point 3) is the cognitive lockup timeframe. During this delay, attention remains fixated on a lower-priority task, even though greater value and safety gains would be achieved by promptly addressing the malfunction (blue dashed line). The graph highlights how fixation, attentional tunnelling and stress can cause dangerous delays in goal reallocation, with direct consequences in aviation, shipping or any high-risk environment.*

1. **Scenario:** The aircraft is in cruise phase in the scenario, and a thunderstorm is presented very close to the destination. This attracts the pilot's attention, as it is not clear if there is a need to divert to the alternate. The pilot keeps monitoring the movement and intensity of the thunderstorm. During this monitoring phase, a failure is introduced in one of the aircraft engines. The pilot recognises the failure but does not react and continues to monitor the thunderstorm. After a while, the urgency to handle the engine malfunction is realised and the pilot begins to solve the engine malfunction task. The cognitive lockup prevents the pilot from immediately switching tasks, from that of monitoring the thunderstorm to handling the engine malfunction. Figure 1 [4] shows the goal priorities of each goal over time during thunderstorm avoidance.

5.2 Study 2: Time pressure and task completion

Schreuder and Mioch [10] examined the influence of time pressure and task completion on cognitive lockup. Conducted at the TNO Human Factors Research Institute, this study placed participants in a simulated task environment where they had to respond to two types of fires—normal and urgent—requiring different extinguishing techniques. Time constraints varied between trials, and participants needed to decide whether to continue with the current task or switch to address the more pressing one.

The results indicated that while time pressure alone did not significantly increase cognitive lockup, the task completion effect had a pronounced impact. Participants were more likely to finish their current task before switching, even when an urgent task emerged. This effect demonstrates that nearing task

https://doi.org/10.1017/aer.2025.10088 Published online by Cambridge University Press

completion amplifies cognitive lockup, as individuals are reluctant to abandon tasks they are close to finishing.

These studies highlight the complexities of task prioritisation under cognitive load and the substantial impact of cognitive lockup on decision-making. They also reinforce the importance of training pilots to manage task-switching more effectively, especially under high-stress conditions common in the aviation environment.

6.0 Factors influencing cognitive lockup in aviation

1. **Sunk Cost Fallacy:** The sunk cost fallacy describes a tendency to continue an endeavour due to prior investments of time, money or effort, rather than based on current utility or risk. Pilots may continue with an unstable approach instead of executing a go-around due to the commitment already invested in completing the approach. Arkes and Blumer [6] discuss how sunk costs create a bias, closely related to the status quo bias, where commitment to an ongoing task leads to cognitive lockup, despite safer alternatives.
2. **Task Completion:** The project completion hypothesis suggests that individuals near task completion allocate more resources to finish, often prioritising completion over other goals [5]. Garland and Conlon [14] noted that completion gains precedence near the end of a project, even if other objectives become more critical. This is relevant in aviation, where pilots may experience cognitive lockup if another urgent task arises during a near-complete approach. Pilots who have completed 90% or more of a task are statistically more likely to continue with it, even if a safer course of action is available [5, 14].
3. **Time and Task Pressure:** Pilots face time and task pressure due to constraints such as fuel limitations and a high workload in critical flight phases. As aircraft approach the destination, remaining fuel allows limited time for approach, landing and potential diversion. Near the final approach, fuel usage reaches about 85% of the total needed for approach and landing, leaving minimal resources for holding patterns or diversions if issues arise. According to Beevis [7], time pressure becomes critical when the time needed for a task exceeds 70% of the available time, creating a perception of scarcity. This urgency can intensify cognitive lockup, limiting task-switching flexibility under time constraints.
4. **Study on Time Pressure and Task Completion:** A study at the TNO Human Factors Research Institute [10] simulated task-switching scenarios with two fire types—normal and urgent—requiring different responses under variable time pressures. While time pressure alone didn't strongly impact cognitive lockup, high task completion did. Participants nearing task completion were significantly more likely to stick with their current task rather than switch to address the more urgent fire. The results confirmed that cognitive lockup is more probable with high task completion, although it lessened on subsequent attempts as individuals adapted to prioritising urgent tasks.
5. **Risk Perception and Framing Effect:** The framing effect is a cognitive bias that shifts decision-making based on how information is presented [15]. Pilots may view diversion as a 'failure' if their primary task is framed as landing at the destination, thus imposing additional pressure to complete the landing. A reframed policy, where diversion is considered a primary objective if landing is unsafe, could reduce task pressure, encouraging pilots to execute go-arounds without negative connotations. Framing shifts pilots' decisions from risk-averse to risk-taking, affecting their flexibility in adapting to unforeseen circumstances.
6. **Zeigarnik Effect:** The Zeigarnik Effect can contribute to cognitive lockup in situations where an incomplete task creates a strong, lingering sense of urgency. If an individual has started a task but then encounters a higher-priority demand, the mental 'tension' created by the uncompleted

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task can make it harder for them to disengage and shift focus. This residual mental focus on the uncompleted task can, in turn, intensify cognitive lockup, as individuals feel compelled to complete the initial task before moving on.

7.0 Mitigating cognitive lockup: training and policy recommendations

A novel approach involves AI-powered decision-support tools that track aircraft energy state, a deviation from stabilised approach parameters and real-time pilot interaction. For example, a time-to-land algorithm could dynamically calculate whether approach stabilisation is achievable given the current aircraft configuration and trajectory. With voice-based AI agents monitoring crew speech and pitch patterns for signs of cognitive tunnelling, such systems could issue contextual advisories, consider go-around, before thresholds are breached.

1. **Enhanced Scenario-Based Training:** Training emphasising cognitive flexibility and task-switching can reduce cognitive lockup. Regular go-around simulations are recommended, aligning pilots' real-life experience with procedures for task prioritisation (European Aviation Safety Agency, 2017).
2. **Positive Framing in Policies:** Policy framing goes around as a routine rather than failures can reduce the stigma associated with task-switching. For instance, regulatory guidelines could reframe diversion and go-arounds as safe practices rather than deviations.
3. **Technological Support Systems:** Artificial intelligence-based alert systems that detect unstable approaches and prompt task-switching can support pilots under high-stress conditions. Such systems help mitigate cognitive biases by highlighting risks and guiding pilots toward high-priority actions.
4. **Human Factors Training:** Human factors training should focus on cognitive biases, workload management and resilience. Emphasising situational awareness and decision-making under pressure can enhance pilots' mental flexibility and reduce cognitive lockup.
5. **Instructor's role:** Besides pilot-focused training, the instructors' role in shaping behavioural responses during high-stress phases must not be overlooked. Limited standardisation in instructor training specific to decision-making during unstable approaches remains. Future efforts should address this gap through crew resource management (CRM) updates, standardised go-around coaching protocols and simulator scenario debriefing frameworks.

8.0 Mindfulness as a strategy to prevent cognitive lockup

Mindfulness, defined as nonjudgemental awareness of present-moment experiences, has been shown to enhance cognitive flexibility, reduce stress-induced tunnel vision and improve decision-making in high-stakes domains, including aviation, healthcare and the military [16–18]. While still emerging in aviation training protocols, mindfulness has proven useful in domains requiring sustained attention and rapid task-switching under pressure, which are central to mitigating cognitive lockup.

In aviation, cognitive lockup often results from fixation on a routine task despite emerging higher-priority cues. Mindfulness interventions train pilots to notice when attention becomes narrowly focused, enabling earlier recognition of deteriorating safety margins and facilitating adaptive task reprioritisation. Neurocognitive studies suggest mindfulness training strengthens functional connectivity in brain regions responsible for metacognition and executive control—key faculties disrupted during lockup [19, 20].

Several aviation-adjacent studies have shown that even brief mindfulness sessions reduce cognitive rigidity and improve performance on high-load multitasking simulations [21]. Notably, the U.S. military has implemented Mindfulness-Based Mind Fitness Training (MMFT) to enhance situational awareness and stress regulation in soldiers and aircrew [16].

1. **Key Benefits in the Aviation Context:**
   (a) **Enhanced Situational Awareness:**
   Mindfulness fosters open monitoring of internal and external cues, enabling pilots to detect emerging threats earlier and shift from lower-priority tasks [17].
   (b) **Reduced Task-Completion Bias:**
   Mindfulness encourages non-attachment to outcomes, allowing pilots to release fixation on completing one task when more urgent needs arise [21].
   (c) **Stress Buffering:**
   High stress narrows cognitive bandwidth. Mindfulness reduces sympathetic arousal and supports calmer, more adaptive decision-making [20].
   (d) **Improved Cognitive Flexibility:**
   Regular practice strengthens the dorsolateral prefrontal cortex and anterior cingulate cortex, which govern task-switching and conflict monitoring [19].

8.1 Practical mindfulness techniques to prevent cognitive lockup

1. To be effective, mindfulness should be integrated into CRM and human factors training, not treated as an isolated wellness module. Techniques may include:
   - **Focused Breathing:**
   A three-breath cycle before a go-around decision point helps re-anchor attention, interrupting fixation loops.
   - **Pre-Flight Body Scan (2 minutes):**
   Increases awareness of stress-induced muscle tension, especially before approach phases.
   - **Post-Landing Reflective Journaling:**
   Helps develop meta-awareness and pattern recognition over time (e.g. repeated fixations on visual acquisition).

These techniques are brief, portable and evidence-based. They have been successfully implemented in simulator studies [21] and can be adapted for line-oriented flight training (LOFT) debriefs.

9.0 Future directions and research recommendations

Future work should focus on empirically validating cognitive lockup indicators through full-flight simulator trials, wearable biosensors (e.g. HRV, pupillometry) and AI-driven cockpit monitoring. A multi-pronged research framework is proposed:

1. **Basic Research:** Conduct controlled studies to define and distinguish cognitive lockup from related constructs such as attentional fixation or task shedding.
2. **Simulator Validation:** Implement and test real-time detection algorithms during high-workload, time-critical scenarios in advanced training environments.
3. **Applied System Development:** Integrate AI agents into training simulators to assess crew behavioural adaptation, decision switching, and go-around initiation dynamics.
4. **Cultural Considerations:** Recognise task-switching behaviours and cognitive biases may vary across cultures. Future studies should examine how cultural dimensions (e.g. power distance, collectivism) influence susceptibility to cognitive lockup and responsiveness to mitigation strategies such as mindfulness or AI advisories.
5. **Experience-Level Effects:** Investigate how cognitive lockup manifests across varying pilot experience levels. Differences in cognitive resilience, automation trust and decision thresholds should inform customised training modules.

https://doi.org/10.1017/aer.2025.10088 Published online by Cambridge University Press

6. **Policy and Regulatory Translation:** Collaborate with aviation authorities (e.g. ICAO, EASA) to incorporate validated cognitive flexibility metrics into SOPs, training curricula and CRM standards.

10.0 Conclusion

Cognitive lockup represents a critical vulnerability in pilot decision-making, particularly during the high-stakes approach and landing phases. This review synthesised psychological mechanisms such as task-completion bias, sunk cost fallacy and framing effects, all contributing to persistence on suboptimal courses of action. Empirical and simulation-based studies confirm that cognitive lockup impairs task-switching under pressure, increasing the risk of unstable approaches and missed go-arounds.

Importantly, this work identifies multiple avenues for mitigation. Scenario-based training, cognitive reframing of go-arounds, human factors education and the integration of AI-based alerting systems offer structured interventions to promote cognitive flexibility. Furthermore, mindfulness training emerges as a promising adjunct strategy, grounded in neuroscience and validated in other high-stress professions.

Future research should focus on empirically validating these mitigation strategies in operational settings, developing predictive cognitive lockup models and evaluating their integration into flight training and SOPs. By proactively addressing cognitive lockup, the aviation industry can better align pilot behaviour with safe outcomes, reducing accident risks and improving resilience during critical flight phases.

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Cite this article: Singh A. Failure to switch tasks due to cognitive lockup in airline pilots: a review of mechanisms, influences and mitigation strategies. *The Aeronautical Journal*, https://doi.org/10.1017/aer.2025.10088