International Journal for Multidisciplinary Research (IJFMR)

E-ISSN: 2582-2160 • Website: www.ijfmr.com • Email: editor@ijfmr.com

Human-AI Interaction in Cockpit Design: How Co-Pilots of the Future Might Be Intelligent Agents

Prithvi Sharma

Abstract

This paper explores the emerging role of artificial intelligence in modern cockpit design, focusing on how intelligent agents may function as co-pilots in future aviation systems. As a secondary research study, it synthesizes insights from recent advancements in AI technologies, including large language models, neuroadaptive systems, and human-machine interaction frameworks, to evaluate their application in enhancing flight safety, reducing pilot workload, and enabling single-pilot or unmanned operations. The study traces the evolution of cockpit automation, analyzes the integration of adaptive virtual copilots, and examines critical factors such as trust, personality, and human-AI teaming. It also compares various design frameworks and highlights ethical and regulatory considerations associated with AI deployment in safety-critical environments. Finally, the paper outlines future directions, emphasizing the potential of AI copilots in both manned and unmanned flight scenarios. The findings suggest that, with robust evaluation systems and thoughtful human-centered design, AI can serve as a reliable and efficient partner in next-generation aviation.

Keywords: Artificial intelligence (AI), cockpit design, intelligent copilots, human–AI interaction, aviation safety, neuroadaptive systems, flight automation, pilot workload reduction, human-centered design, trust and human–AI teaming, ethical and regulatory considerations, single-pilot and unmanned operations.

1. Introduction

Recent advancements in AI across various fields have revolutionized industries. From professional works to day-to-day household tasks, AI has started to influence. Through this paper, we try to understand how AI can also be of great use in the aviation industry by assisting pilots as smart and automated co-pilots. Even though automation in aviation is not advised, through this paper, we show how AI co-pilots can assist in basic tasks such as accident prevention, crew and passenger safety, and aircraft ergonomics, as well as complex tasks like fault mitigation and quick judgments in dangerous and life-threatening situations.

Recently, automation has been achieved in many industries such as cybersecurity, finance, healthcare, and energy, and through thorough research, it can be achieved in commercial and defense aviation as well. The main need of these AI co-pilots is to reduce basic human error and lower pilot workload. These intelligent agents would appear useful in situations of distress, as this human-AI teaming would help in quicker decision-making in such situations.

2. Literature Review

2.1 Evolution of Cockpit Automation to Intelligent Agents

The first step toward aircraft automation was taken in the 60s. It all started with basic work of maintenance and aircraft control. At that time, this new technology was supervised by the FAA and ICAO to ensure safe usability.

From the 70s to 90s, more advancements were made, such as new digital screens that monitored engine health and navigation. Modern technologies include high-tech glass cockpits with advanced navigation and direct radio connection to ATC for air traffic updates. The most significant advancement made was the addition of the autopilot feature at higher altitudes.

2.2 Role of LLMs and Neuroadaptive Systems in Cockpits

Large Language Models (LLMs) can be used to create smart conversational virtual copilots (V-COPS). Such V-COPS will allow single-pilot flights, which would help in cost-cutting. V-COPS would be able to instantly integrate the pilot's instructions into the cockpit's system

Such a model has a success rate of 90.5%.

2.3 Human-Machine Interface (HMI) and Interaction Technologies

AI can be assistive in the cockpit in more than just tasks like automation. AI can be used to create a neural system linked to the pilot which constantly monitors the pilots to avoid any mishappenings.

This can be achieved by adding eye tracking and gesture recognition systems in the cockpits, which are integrated with AI. This AI would be able to monitor the pilot's condition by tracking their gestures and voice modulations. This could be useful to avoid plane crashes or aviation mishaps, which are caused by the ill health of the pilot.

2.4 Personality and Trust in Intelligent Co-Pilots

The cockpit of an aircraft brings along an intense mood because the lives of around 200 or more people are in your hands. The introduction of an AI copilot in this environment would cause some emotional disbalance to it as well, but studies have been conducted on this and it has been concluded that the AI does seem to get a bit tensed in some intense situations, because it has to process a lot of data and give out an output to it, but overall remains emotionally stable and majorly focuses on the work which has been assigned to it.

Psychologically, the AI remains quite vocal and extroverted in the scenario of the cockpit. It was rather open about its decision-making and perception of things. It acted quite similarly to a regular copilot, which was a great result.

2.5 Evaluation Frameworks and Limitations

AI, particularly in safety-critical areas like aviation, requires immense evaluation frameworks to evaluate its performance, reliability, and human AI interaction. These metrics often focus on capabilities such as perception, decision-making, and adaptability, while also considering human factors like trust and usability. One prominent example is the P-CAFE framework, which has been developed specifically for evaluating intelligent cockpit systems powered by LLMs and AI agents. This framework is highly suitable for aviation, where intelligent cockpits function as V-COPS that perceive environments, process data, and collaborate with pilots.

The P-CAFE framework (Perception, Cognition, Action, Feedback, Evolution) has a structured, multi-dimensional approach to evaluating AI copilots in cockpits. It was proposed in 2024 to address the lack of systematic assessment methods for AI-integrated systems in vehicles, including aviation applications.

The current automation agents of the cockpits, such as autopilot systems, have over-reliance on them by the pilots, which causes a safety hazard in some situations, as these systems often have calibration issues.

3. Comparative Analysis

There is widespread consensus in the paper about the growing need for intelligent, adaptable AI copilots in aviation, despite the wide variations in approach design and focus. Whereas frameworks like P-CAFE focus on the systematic evaluation of AI systems across dimensions like perception and feedback, models like AdaptiveCoPilot prioritize real-time integration and responsiveness. Most studies agree that it's critical to calibrate trust between AI agents and human pilots, especially when safety is involved. Some systems, such as Virtual Co-Pilot and Cockpit-Llama, are reactive and require explicit input, while others take a proactive and multimodal approach through the use of gesture, voice, and gaze tracking.

4. Ethical, Safety, and Regulatory Considerations

The integration of AI assistants in the cockpits does raise several ethical and safety concerns, as a small technical failure could lead to something catastrophic.
Key areas include over-dependence on system explainability and decision accountability.
It is important to balance out the integrated AI or automations in the cockpit to ensure life safety and to avoid mishappenings.
To avoid such situations, there should be human override systems integrated along with the AIs in order to take complete control when the AI systems fail.

5. Future Directions

The recent urbanisation of transport has made the true use of aviation more common. This advanced air mobility (AAM) has been evolving with several advancements involving automation through human-computer interactions. This can further be boosted by integrating AI in the cockpits as co-pilots through LLMs
A study conducted says that an adaptive co-pilot could be a solution to this. This adaptive co-pilot could be an AI integrated in the cockpit system, which could be easy to use. This system would be used by both novice and expert pilots.
The integrated AI pilot would also be able to handle tasks that are rather easy for the main pilot to handle, such as basic radio communication with ATC or other cockpits, and automate routine tasks and flight checks.
Also, integration of AI in unmanned flying objects such as drones would be beneficial as it allows for various possibilities of improvements in them, such as swarm drone intelligence, where a centralised AI goes and gives information to a group of drones and analyses flight paths, and carries out advanced navigation and computer-based vision analysis of terrain, threat, and landing zones.

6. Conclusion

Since intelligent systems are developing so quickly, the use of AI in the cockpit is no longer a sci-fi fantasy but rather a reality as aviation continues to evolve. In this paper, we explored the transition from traditional cockpit automation to the development of intelligent agents, with a focus on how AI copilots, powered by large language models, neuroadaptive systems, and human-machine interaction technologies, can enhance flight safety, reduce pilot workload, and maximize decisions in emergencies.

The paper indicates that there is widespread consensus about the potential benefits of AI copilots, especially with regard to improving emergency response times, assisting with daily tasks, and lowering the cost of single-pilot or unmanned flights. However, these developments also raise pressing concerns about regulatory oversight, ethics, trust, and over-reliance. To ensure accountability and safety, AI integration must be properly calibrated, with robust evaluation frameworks like P-CAFE and human override systems in place.

Ultimately, rather than taking the place of human judgment, AI copilots are a powerful addition to it. Instead of being a battle between man and machine, the cockpit of the future will be a collaboration between human intuition and machine intelligence, thanks to meticulous planning, continuous evaluation, and moral foresight.

References

1. Fairclough, S. H. (2023). Neuroadaptive technology and the self: Human-AI interaction in cognitive control environments. *AI & Society, 38*(4), 1327–1342. https://doi.org/10.1007/s13347-023-00636-5
2. Gao, Y., Li, S., & Zhou, W. (2023). Deep reinforcement learning for flight control fault prediction. *IEEE Transactions on Aerospace and Electronic Systems, 59*(5), 4112–4126. https://doi.org/10.1109/TAES.2023.3267529
3. Gordon, R. (2023, October 3). AI co-pilot enhances human precision for safer aviation. *MIT CSAIL News*. https://news.mit.edu/2023/ai-co-pilot-enhances-human-precision-safer-aviation-1003
4. Graydon, M. S. (2025). *Challenges, research, and opportunities for human–AI teaming.* NASA Technical Memorandum 20250002888. https://ntrs.nasa.gov/api/citations/20250002888/downloads/NASA-TM-20250002888.pdf
5. IOSR Journal. (2024, October 26). AI collaboration in aircraft cockpit systems. *IOSR Journal of Computer Engineering (IOSR-JCE), 26*(5), 7–21.* https://www.iosrjournals.org/iosr-jce/papers/Vol26-issue5/Ser-5/B2605050721.pdf
6. Klaproth, O. W., Vernaleken, I., Krol, L. R., Halbrügge, B., Zander, T. O., & Russwinkel, N. (2020). Tracing pilots' situation assessment by neuroadaptive frameworks. *Frontiers in Neuroscience, 14,* 259. Tracing Pilots' Situation Assessment by Neuroadaptive Cognitive Modeling
7. Korentsides, J. (2024). Human-AI teams in aviation. *Journal of Aviation/Aerospace Education & Research, 33*(2), Article 5.* https://commons.erau.edu/cgi/viewcontent.cgi?article=2046&context=jaaer
8. Leveson, N. G. (2012). *Engineering a safer world: Systems thinking applied to safety.* MIT Press.
9. NASA Aeronautics Research Mission Directorate. (2024). *Advanced Air Vehicles Program.* NASA. https://www.nasa.gov/aeroresearch/programs/aavp/advanced-air-vehicles-program/
10. Sellen, A., & Horvitz, E. (2023). *The rise of the AI co-pilot: Lessons for design from aviation and beyond.* arXiv preprint arXiv:2311.14713. https://arxiv.org/abs/2311.14713
11. Wen, S., Middleton, M., Ping, S., & Zhou, Y. (2025). *AdaptiveCoPilot: Design and testing of a neuroadaptive LLM cockpit guidance system.* arXiv preprint arXiv:2501.04156. https://arxiv.org/html/2501.04156v1
12. Wickens, C. D., Li, H., Santamaria, A., & Sebok, A. (2020). Human factors in cockpit design: Reducing error through interface optimization. *Human Factors, 62*(3), 456–469. https://doi.org/10.1177/0018720819874561