



Enhancing Pilot Situational Awareness through an Eye-Tracking Assisted Adaptive interface

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Abstract: Modern flight decks are increasingly characterized by advanced automation, sensor integration, and data-driven systems that enhance aircraft performance and safety (D. Minas, 2024). However, this complexity also imposes elevated cognitive demands on pilots, particularly in high stress, time-constrained scenarios (C. M. Muehlethaler, 2016). Human factors research has shown that as automation increases, maintaining situational awareness becomes more challenging, especially during dynamic flight operations, revealing a need for tools that will support pilots during them (V. Peysakhovich, 2018). To address this gap, we are presenting an adaptive, eye-tracking-assisted interface designed to enhance situational awareness by guiding pilot attention to relevant but potentially overlooked visual information during flight.

The proposed system utilizes real-time eye-tracking data to monitor where pilots direct their gaze. It was built using the Tobii Pro SDK integrated into a PyQt6-based user interface. This setup captures continuous gaze data to infer whether an object of interest has been adequately processed. To assess that, if an object of interest reaches the center of the screen and has not been fixated upon by the user for a minimum threshold duration of 0.1 seconds (Woo, 2020), the system automatically highlights it with a white circular outline to redirect attention. Once fixated upon, the marker is removed, indicating successful acknowledgment.

We conducted a controlled usability study with 40 participants to evaluate our adaptive interface in cognitively demanding multitasking conditions, closely resembling a real-world cockpit environment. The experimental setup, illustrated in Figure 1, was specifically designed to simulate realistic operational scenarios by combining flight control tasks with concurrent monitoring of adaptive map-based updates, effectively replicating the attentional demands pilots face during actual flight operations (Beckman, 2013). This approach allowed us to accurately assess the interface's effectiveness in enhancing situational awareness under realistic cognitive loads, providing robust evidence for its practical application.

Based on whether there was need for the interface to adapt (in case the participant did not see the object) or not, as well as the response of the system to this need, we have clustered the possible outcomes as shown in Table 1. A key result was the absence of any true negatives, as in all cases, the system reliably detected when a participant failed to observe a target and subsequently highlighted the missed item. In aviation, where missed cues can result in operational failures, this result is highly promising. The system also produced many false positives, where it falsely highlighted objects that had already been seen by the participant. While not safety-critical, these false positives indicate room for improvement in fixation validation logic, for which we examine the ideal size the white circle needs to be for the eye tracker to catch it through the participants' peripheral vision. Participant feedback revealed general approval of the interface's utility, particularly in low to moderate workload phases. However, during high-stress flight maneuvers, some users reported missing subtle cues. Suggested improvements included enhancing visual salience through flashing cues or integrating auditory signals.

Our research demonstrates the feasibility of real-time adaptive cueing systems in aviation interfaces. Through the integration of eye-tracking and symbolic overlays, our system successfully supports attentional management in cognitively demanding conditions. By eliminating overlooked objects, it offers a promising avenue toward safer and more intelligent cockpit environments. Future work will focus on reducing false positives by refining fixation detection thresholds, incorporating peripheral vision modeling, and leveraging saccadic patterns to better infer attentional intent.



Additionally, expanding cue modalities like auditory or haptic feedback may enhance adaptability across varying workload conditions and pilot preferences.

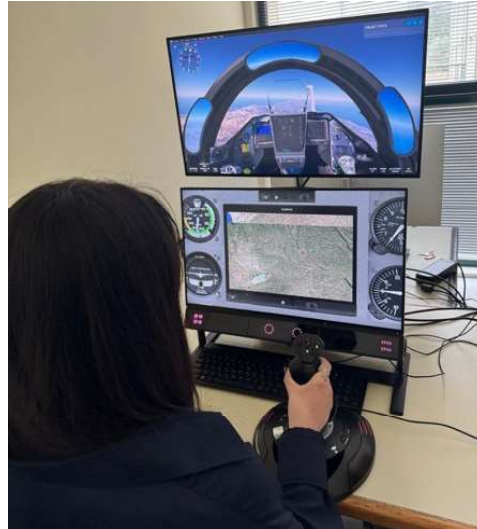


Figure 1: The experiment setup used to simulate an actual flight (top screen) while using the adaptive interface (bottom screen)

System / Participant	Did not see the object	Saw the object
Adapted	True Positive	False Positive
Did not adapt	True Negative	False Negative

Table 1: Possible outcomes based on participant and system behavior

Satellite Front-End Electronics

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GaN Solid-State amplifier developments for multi-orbit broadband active-antenna front-ends

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Abstract: In recent years, secure satellite communications have been evolving from traditional military satellite communication systems based on geostationary satellites to multi-orbit satellite constellations, where satellites in the three traditional orbits —GEO, MEO, and LEO— coexist and operate within the same communication system. An example of this will be the IRIS2 system. These multi-orbit systems require higher bandwidth to cover the needs of higher throughput and low latency, which are required for military applications and demanding services. This has led to secure