The eyes have it

Captain Matt Gray explains how eye tracking technology could help enhance the learning and development of commercial pilots

Flying an aircraft is a visual task, with up to 90% of the necessary information being gathered through the pilot's eyes.

In order to make sense of an increasingly dense visual environment in a modern aircraft, a pilot must learn and perfect the skill of an instrument scan using modern flight equipment.

According to the Federal Aviation Administration's (FAA) Instrument Flying Handbook, the first fundamental skill of instrument flying is developing a scan, which is defined as the 'continuous and logical observation of instruments for attitude and performance information'. Many pilots will recall their initial instrument flight training where they were arranged in a radial pattern with the attitude indicator at the hub and performance instruments placed around this central area. This was the result of work by researchers just after World War Two, who determined that this configuration was the best design.

The scan pattern pilots were taught in order to use this arrangement was referred to as the 'selected radial scan'. This required pilots to focus on the attitude indicator and then visually select the appropriate information from the other instruments before returning to the attitude indicator.

Keeping pace

Flight instruments have evolved from the previous display of individual radial examples, fusing into more complex presentations. Aircraft such as the Boeing 787-9 have a primary flight display (PFD) that combines an enormous amount of information into one instrument.

These new tools are referred to as "glass instruments" and are now the standard display.

In addition to the glass presentation, many new airliners such as the Dreamliner and Airbus A350 are fitted with a head-up display (HUD). The HUD is an instrument that was developed from the military and has the advantage of presenting critical information to the pilot in his or her line of sight.

The pilot can then scan the vital instrumentation and still view the outside world, making the transition to landing after an instrument approach easier – particularly in poor weather. The result of this modern approach suggests scan modification from the traditional radial scan pattern.

A pilot requires extensive training to fly a complex modern airliner and an effective scan is essential. Novice pilots transitioning to their first large aircraft take time to develop a scan and often need guidance from the instructor about refining a pattern to improve their performance.

After training, the pilot spends years further improving their scan through line-flying experience and in the simulator during recurrent exercises.

If pilot scan behaviour is regarded as critical and new information-rich and diverse instruments require modified scan techniques, then a number of questions arise about exactly how pilots scan and what training methods might be used to enhance learning.

To what extent does the scan behaviour of a pilot influence »

ABOVE • ***Captain Matt Gray has experience flying most of the current generation of Boeing widebodies*** VIA AUTHOR
MAIN IMAGE • ***Qantas has installed a Seeing Machines eye tracker as part of its new 787-9 full flight simulator*** AIRTEAMIMAGES.COM/DIPANKAR BHAKTA
BELOW • ***Technology has come a long way since this cadet trained in a Boeing 727 simulator in the mid-1960s*** DENVER POST VIA GETTY IMAGES

Wider context

Head-up displays (HUDs) and head-up guidance systems (HGS) introduce value beyond real-time gaze tracking. When integrated with eye tracking solutions during training, guided by instructor and pilot input and supported by visual and instructional learning tools, these systems can build up additional safety, organisational and operational capability drivers for aircrews, especially amid rising demands.

HUD/HGS are becoming more prevalent in single and multi-crew cockpits and they have been recognised as a powerful tool for accident prevention by substantially reducing crew error and improving aircrew situational awareness.

However, they do present a training challenge. It is difficult for an instructor or examiner to confirm the exact nature of a pilot's scan, or even that the HUD is being used at all.

Precision eye tracking helps overcome a gap in traditional flight simulator training: understanding aircrew behaviour, decision-making and attention levels.

By making pilots' scan patterns observable and within the normal training footprint, for the first time, instructors can confirm the degree of attention being given to flight path monitoring.

their performance? What similarities or differences exist between expert and non-expert pilots? Do differences in eye scan exist between the HUD and the PFD and if they do, what does this mean for training? What value can eye trackers bring and how can they be used in flight training? Can eye trackers accelerate learning?

Aussie ambition

Prior to the pandemic, Australia's Qantas Airways invested in a Seeing Machines eye tracker as part of its new 787-9 Full Flight Simulator (FFS) making it the first purpose-built eye tracker/simulator combination. The equipment was fitted to explore the complexities of pilot eye scan versus performance with the aim of improving training and seeking answers to scan questions.

Eye tracking research has been of interest for more than 100 years in a number of industries, such as medicine, as well as aviation.

In the last two decades, relevant technology has improved to permit eye trackers to be fitted to a simulator that are unobtrusive to the pilot and allow the eye positions to be accurately displayed on the instructor's panel as an additional diagnostic and remediation tool.

The eye tracking/simulator research is ongoing at Qantas and is planned to be conducted in a number of phases, firstly to gather data to examine scan patterns during a range of manoeuvres flown by experts versus novices and, in particular, examining scan patterns on the HUD. This is an excellent tool, but has some human factor considerations such as the width of the presentation and differences in the symbology between the HUD and the PFD. Understanding these limitations may allow more targeted and effective training for learners and provide more guided input from the instructor.

The opportunities for further research continue to evolve with COVID-19 providing a unique opportunity, despite the devastating effect on the global aviation industry. Large numbers of pilots worldwide have been stood down for extended periods and changes in scan behaviour for this group remain unknown.

Interest in the potential of eye tracking for aviation remains high and the research presently being undertaken at Qantas is aimed at finding answers that may help flight training worldwide. AW

ABOVE • ***Eye tracking can offer trainees and assessors valuable additional insights*** SEEING MACHINES

BELOW • ***Researchers are considering the extent to which the scan behaviour of a pilot influences their performance*** NICOLAS ECONOMOU/NURPHOTO VIA GETTY IMAGES

About the author

Captain Matt Gray trained as a pilot and instructor in the RAAF and spent 32 years at Qantas flying the Boeing 747, and flying and examining on the 767, 737 and 787. He was a management pilot for 20 years, finishing as the head of training and checking, where he introduced an eye tracker on the Dreamliner simulator. He holds a Master's in Aviation and is currently undertaking a PhD in pilot eye scan behaviour.