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Previous simulation studies have shown that, without the assistance of automation, controllers have difficulty in timely detection and resolution of aircraft-to-aircraft conflicts under future air traffic management concepts such as Free Flight (Galster et al., 2001; Metzger & Parasuraman, in press). However, how automated information on potential conflicts should be displayed to the controller is not well understood. In the present study, we reasoned that automation that was integrated with the primary radar display would be effective in enhancing conflict detetction. We also manipulated display modality so that the automation provided information to the controller using simple visual, enhanced visual, or visual+auditory (multi-modal) displays. It was expected that under high traffic load, the associated requirement for communication by datalink could divert visual attention from the radar, thus potentially impairing conflict detection performance and necessitating automated assistance. We hypothesized that multi-modal feedback could lead to earlier conflict detection than purely visual feedback by better guiding visual attention. A performance benefit was also expected for the enhanced visual aid by providing more transparency regarding conflict prediction and reducing the requirement for visual search.

Eight experienced, full-performance level controllers were tested on an ATC simulator displaying a generic airspace and consisting of a radar display, a datalink display, and electronic flight strips, presented on two different 21-inch monitors. Traffic density was manipulated to be either moderate (on average about 10 aircraft in a 50-mile radius sector) or high (about 16 aircraft). In addition, the feedback type of the conflict detection aid was varied. In the simple condition, two red filled circles predicted which aircraft pair would be in conflict. In the enhanced visual condition, the circles were supplemented with two red heading lines indicating why and where the aircraft were predicted to be in conflict. Finally, in the multi-modal condition, the enhanced visual aid was supplemented by an auditory alert presented on loudspeakers on either side of the monitors. In addition to performance and subjective measures, ocular activity (i.e. fixations and dwells) was recorded with an ASL Model 5000 head-mounted eye tracker at a sampling rate of 60 Hz as a measure of visual attention.

Of the several results of interest, a few are reported here. First, the present experiment provided additional evidence that controller performance under Free Flight can be improved with the help of effective automated decision aids. Conflict detection performance was substantially improved—to near perfect performance—by the automated aids. However, the prediction that multi-modal feedback would result in better conflict detection performance (especially earlier detection) than simple visual feedback was not supported. The expected differential benefit of the visually enhanced feedback was also not found. Controllers fixated over 60% of the time on the radar display, which may explain why no differential effects of the automated aids were found: when attention is allocated to the radar most of the time it is unlikely that a salient visual aid is missed, and enhancing the visual aid or adding redundant auditory information provides no additional benefit. Finally, the sizeable benefits provided by the automated aids may largely due to the automation being integrated into the primary radar display, which was the major focus of controller attention.