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An Interoperability Concept for Detect and Avoid and Collision Avoidance Systems: Results from a Human-In-The-Loop Simulation

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Abstract : The integration of Unmanned Aircraft Systems (UAS) into the National Airspace System (NAS) poses a variety of technical challenges to UAS developers and aviation regulators. In response to growing demand for access to civil airspace in the United States, the Federal Aviation Administration (FAA) has produced a roadmap identifying key areas requiring further research and development. One such technical challenge is the development of a 'detect and avoid' system (DAA; previously referred to as 'sense and avoid') to replace the 'see and avoid' requirement in manned aviation. The purpose of the DAA system is to support the pilot, situated at a ground control station (GCS) rather than in the cockpit of the aircraft, in maintaining 'well clear' of nearby aircraft through the use of GCS displays and alerts. In addition to its primary function of aiding the pilot in maintaining well clear, the DAA system must also safely interoperate with existing NAS systems and operations, such as the airspace management procedures of air traffic controllers (ATC) and collision avoidance (CA) systems currently in use by manned aircraft, namely the Traffic alert and Collision Avoidance System (TCAS) II. It is anticipated that many UAS architectures will integrate both a DAA system and a TCAS II. It is therefore necessary to explicitly study the integration of DAA and TCAS II alerting structures and maneuver guidance formats to ensure that pilots understand the appropriate type and urgency of their response to the various alerts. This paper presents a concept of interoperability for the two systems. The concept was developed with the goal of avoiding any negative impact on the performance level of TCAS II (understanding that TCAS II must largely be left as-is) while retaining a DAA system that still effectively enables pilots to maintain well clear, and, as a result, successfully reduces the frequency of collision hazards. The interoperability concept described in the paper focuses primarily on facilitating the transition from a late-stage DAA encounter (where a loss of well clear is imminent) to a TCAS II corrective Resolution Advisory (RA), which requires pilot compliance with the directive RA guidance (e.g., climb, descend) within five seconds of its issuance. The interoperability concept was presented to 10 participants (6 active UAS pilots and 4 active commercial pilots) in a medium-fidelity, human-in-the-loop simulation designed to stress different aspects of the DAA and TCAS II systems. Pilot response times, compliance rates and subjective assessments were recorded. Results indicated that pilots exhibited comprehension of, and appropriate prioritization within, the DAA-TCAS II combined alert structure. Pilots demonstrated a high rate of compliance with TCAS II RAs and were also seen to respond to corrective RAs within the five second requirement established for manned aircraft. The DAA system presented under test was also shown to be effective in supporting pilots' ability to maintain well clear in the overwhelming majority of cases in which pilots had sufficient time to respond. The paper ends with a discussion of next steps for research on integrating UAS into civil airspace.

Keywords : detect and avoid, interoperability, traffic alert and collision avoidance system (TCAS II), unmanned aircraft systems
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