Fielding a Sense and Avoid Capability for Unmanned Aircraft Systems: Policy, Standards, Technology, and Safety Modeling

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Unrestricted access to civil airspace requires the ability to see-and-avoid other aircraft. While an on-board pilot normally provides this capability, unmanned aircraft systems must develop an alternate means of compliance with the see-and-avoid regulations, that is a sense and avoid capability is required to gain flexible airspace access. This article outlines an analytical methodology for the rigorous definition of sense and avoid standards, development of requirements for technology components, assessment of system architectures, and demonstration of system safety. The methodology described is applied to a ground-based sense and avoid testbed being developed for the US Army. This testbed validates requirements derived from analysis and demonstrates an end-to-end capability to be used in the national airspace.

Modeling and Simulation of a Ground Based Sense and Avoid Architecture for Unmanned Aircraft System Operations

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The safe operation of Unmanned Aircraft Systems (UAS) in the National Airspace System necessitates a capability to sense and avoid other airborne objects. One solution is a Ground Based Sense and Avoid (GBSAA) concept, where data from ground-based radars are fused in a specially tuned tracking system that can provide traffic information to manual (flight crews) or automatic collision avoidance systems. In this paper, we will present a modeling and simulation approach to assess site-specific radar detection and tracking performance. High fidelity primary surveillance radar and tracking system models enable simulation studies to determine target probability of detection and distributions of expected track initiation times across the surveillance volume. Atmospheric and environmental conditions, terrain, and land coverage type affect radar wave propagation. Models take into account these sources of degradation, as well as target characteristics, site-specific radar performance, tracking system filtering, and initiation logic. This information will help in developing a GBSAA concept of operation, mission planning, and will ultimately define where UAS can operate with sufficient surveillance performance to meet sense and avoid requirements.
Radio Spectrum Requirements of Control and Non-Payload Communications Links for Future Unmanned Aircraft Systems

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The planned introduction of unmanned aircraft (UA) systems (UAS) into non-segregated civil airspace will require highly reliable radio links to enable remote pilots to maintain operational control and ensure safe operation. The safety-critical functions of those control and non-payload communications (CNPC) links distinguishes them from “payload” links (e.g., area-surveillance data downlinks) that, although essential to UAS missions, are not needed for piloting. Enough spectrum must be allocated to meet the individual and aggregate bandwidth requirements of the CNPC links. Obtaining all the spectrum needed is a major challenge, since competing uses already exist for every usable frequency band of significant size. In this paper we describe our work in preparing for the 2012 World Radiocommunication Conference (WRC-12) to support the quest for protected UAS CNPC spectrum. We analyze the bandwidth requirements of the CNPC system, identify suitable frequency bands, describe a potential system architecture, and demonstrate that such a system can coexist with other radio systems using the same bands.

MQ-9 Unmanned Aircraft Responsiveness to Air Traffic Controller Commanded Maneuvers: Implications for Integration into the National Airspace System

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Unmanned Aircraft Systems (UAS) integration into the National Airspace System (NAS) will require overcoming numerous challenges, including evaluating the responsiveness of Unmanned Aircraft (UA) to Air Traffic Control (ATC) commands. Since developing a complete understanding requires a series of investigations, the purpose herein is to provide a foundation for future studies. An MQ-9 UAS simulator was connected to a UFA ATC radar simulator and scripts were flown by Certified Flight Instructor (Instrument) (CFI(I)) rated pilots to measure response and maneuver completion times. The MQ-9 was flown in stick-and-rudder mode to emulate manned aircraft (MA) and provides a baseline for future studies.

Response and heading-change-maneuver-completion times for the simulated MQ-9 UAS were comparable to those estimated for MA. Use of strict maneuver-completion requirements, however, resulted in a high bias in heading-change-maneuver-completion times. Suggestions for future work are provided.
Effects of UAS Performance Characteristics, Altitude, and Mitigation Concepts on Aircraft Encounters and Delays

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Introduction of Unmanned Aircraft Systems (UAS) into positively controlled airspace may cause greater per-aircraft impact on the National Airspace System than existing traffic because UAS aerodynamic performance and mission types are often different from aircraft that typically fly in positively controller airspace (i.e. commercial passenger traffic). This paper examines the impact new UAS operations will have on existing aircraft and measures that impact by the number of predicted conflicts and associated conflict resolution delays that occurred in fast-time simulation. The two conflict metrics are quantified as a function of the UAS altitude and cruise speed. Two mitigation approaches are also investigated: increasing horizontal separation requirements for UAS and “burdening” UAS with the responsibility to execute all resolution maneuvers when possible. Results indicate that en route conflict maneuver delay for existing traffic because of new UAS operations can be nearly eliminated by burdening UAS with the responsibility to execute conflict resolution maneuvers and maintaining the current en route horizontal separation requirement of five nautical miles from other aircraft.