

Identifying and Addressing Human Factors Issues of ADS-B and Cockpit Displays of Traffic Information

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Introduction

Automatic Dependent Surveillance – Broadcast (ADS-B) is a key element in the Next Generation Air Transportation System (NextGen). ADS-B integrates information derived from GPS units broadcast from aircraft with information from ground-based radar facilities to provide flight crews with unprecedented access to precise information about the position and intentions of nearby aircraft. ADS-B also can be augmented with weather information to provide crews with a rich near-real time picture of the operational environment. However, simply providing this information to pilots does not guarantee that it will be used effectively. Indeed, under some conditions ADS-B could increase the risks to safe flight.

For example, for the foreseeable future, aircraft equipped with ADS-B will share the airspace with aircraft that are not ADS-B equipped. Furthermore, ADS-B aircraft will need to operate in areas with and without radar coverage with varying degrees of air traffic control (ATC) supervision. Thus, on a single flight an aircraft could fly from an area where ATC has primary responsibility for the separation of aircraft but all aircraft are visible to the flight crew on the ADS-B display to airspace in which ADS-B aircraft continue to be displayed while non-ADS-B equipped aircraft disappear due to gaps in radar coverage. To ensure safe and efficient flight, different monitoring, communication, and avoidance procedures for different conditions must be developed and pilots must be trained in these procedures. Furthermore, displays will need to be built that will alert the pilot to the conditions in which they are operating. This will be especially important if NextGen plans which call for the ability to dynamically shift airspace depending on weather and traffic demands are implemented.

On-going research and analysis has identified these and other human factors issues related to pilots' use of ADS-B and to Cockpit Displays of Traffic Information (CDTIs) that must be addressed to ensure effective NextGen system operation. The objectives of this research program are to:

1. Compile a comprehensive list of human factors issues related to pilots' use of ADS-B and CDTIs.
2. Determine which issues represent significant system effectiveness and safety problems and prioritize them with respect to potential impact.
3. Develop and evaluate prototype solutions to selected problems.

Method and Preliminary Results

The research program encompasses issue identification, problem identification and prioritization, and prototype solution development and evaluation. It takes advantage of the ongoing statewide deployment of ADS-B in Oregon and all components involve a panel of Subject Matter Experts (SMEs): pilots, flight instructors, flight school faculty, avionics engineers, and government regulators.

Issue Identification. A comprehensive review of literature related to pilots' use of ADS-B and CDTIs is in progress. Reports from the Capstone program (e.g., Williams et al 2002) and SafeFlight 21 (e.g., Operational Evaluation Coordination Group, 2001) have yielded specific ADS-B issues. Sources on cockpit design (e.g., General Aviation Manufacturers Association, 2000; Federal Aviation Administration, 2002) cite relevant general equipment issues. ADS-B/CDTIs also share important features with other forms of information automation, and relevant issues are being gleaned from this literature (e.g., Funk et al, 1999).

An adaptation of Failure Modes and Effects Analysis is being used to identify system vulnerabilities to pilot error in the use of ADS-B equipment. A functional model of a generic general aviation flight mission has been developed and detailed modeling of traffic identification and conflict resolution is underway. A prototype database of human fallibilities and potential human errors has been created and a new version, focusing on human fallibilities and how they interact with tasks and equipment is being developed. The database will be applied to the functional model to identify potential difficulties and errors in the use of ADS-B. Those difficulties and errors will be rated with respect to their likelihood of occurrence, detectability, and consequences.

A flight simulator is being used to identify issues by means of simulated flight scenarios. The simulator is built around a Precision Flight Controls PCATD running X-Plane 9.0 software and includes a CDTI. Traffic modeled in X-plane is controlled by LUA scripts. Flight scenarios have been developed for situations in Oregon airspace that will challenge pilot participants to use ADS-B effectively and safely. Analyses of simulator data will reveal additional issues.

Pilot reports from ADS-B-equipped Lane Aviation Academy aircraft, interviews of SMEs, and broader surveys of Oregon pilots using ADS-B will be used to identify additional issues that may be encountered in operational settings.

Preliminary work has yielded about 100 cockpit issues related to ADS-B, including those mentioned above, plus the following:

1. Procedures using different sources of traffic information (visual, ADS-B, TCAS-II, ATC) may lead to unsafe situations.
2. Pilots using CDTIs may be more likely to unsafely deviate from ATC clearances.
3. Excessive use of CDTIs may reduce visual traffic scan skills.
4. ADS-B equipment may increase workload and distractions.

5. Pilots may become overconfident in and over-reliant on ADS-B.
6. Pilots may not adequately understanding ADS-B capabilities and limitations.
7. Lack of standardization of ADS-B cockpit equipment may lead to errors.
8. CDTI placement may make displays difficult to read.
9. CDTI display clutter may exacerbate conflicts.
10. ADS-B pilot training may be inadequate.

Problem Identification and Prioritization. Based on the literature review, simulator and flight studies, SME surveys and interviews, and formal analyses, the potential risk posed by the identified issues will be assessed. All issues will be prioritized for further work based on the evidence that each issue represents a real problem, its potential impact on performance and safety, the feasibility of developing solutions for it, and its relationship to other issues. The prioritized issue/problem list will be published.

Prototype Solution Development and Evaluation Several of the highest priority issues determined to represent real performance and safety problems will be chosen for interventions. Prototype cockpit procedures, pilot training modules, and equipment modifications will be designed with the assistance of SMEs. These prototype interventions will be tested in flight simulator studies and in the Lane Aviation Academy fleet. Based on these evaluations, final procedures and training modules will be developed and design recommendations will be published.

References

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