PEGASUS—Performance Experiments in Germany on ADS-B Using Mode S Extended Squitter

Roland Mallwitz

Future surveillance systems have to be capable of operating worldwide and to co-exist with other systems in the same frequency band. Extended Squitter is an ADS-B system which uses the same frequencies as current SSR (Secondary Surveillance Radar) systems (also called ATCRBS = Air Traffic Control Radar Beacon System). The German CAA, Deutsche Flugsicherung GmbH (DFS), and the U.S. Department of Transportation/Federal Aviation Administration (FAA) agreed to collaborate on a measurement activity in 2000 using Extended Squitter as the ADS-B medium. The Extended Squitter frequency 1090 MHz is actively being used for replies to secondary surveillance radars and for TCAS air-to-air surveillance. Frankfurt was chosen to perform the measurements under high interference conditions.

The primary objective of the tests was the Extended Squitter performance measurement in the dense interference environment of Frankfurt. Both air-to-air and air-to-ground receptions were to be tested. For a good understanding of the results and to allow estimates for future environments, measuring the interference environment, the aircraft density and distribution was another objective. Results of these background measurements as well as of Extended Squitter performance in this specific environment are presented below.

Effect of Automatic Dependent Surveillance Broadcast (ADS-B) Transmission Quality on the Ability of Aircraft to Maintain Spacing in a Sequence

Eric Hoffman, Dan Ivanescu, Chris Shaw, and Karim Zeghal

The effect of ADS-B update rate, latency and accuracy on the airborne spacing performance of a sequence of six aircraft in descent was investigated using fast time simulation. Two different spacing criteria based on constant distance (7 nmi) and constant time delay (60 s) were evaluated using a spacing guidance law between aircraft. The performance of three different compensation terms for ADS-B update rate, latency and accuracy was also assessed. Spacing performance indicators used were distance or time between aircraft, speed variation and throttle behaviour. Results show that constant time delay spacing remained more stable than constant distance spacing for degradations in ADS-B update rate, latency and accuracy. Constant distance spacing was sensitive to the quality of ADS-B aircraft position information whereas constant time delay spacing was sensitive to the quality of ADS-B aircraft position and speed information (particularly speed accuracy). Transmission loss compensation terms for update rate, latency and accuracy produced significant improvements in spacing guidance stability.
Safety Analysis of an Approach Spacing For Instrument Approaches (ASIA) Application Using ADS-B

Jonathan Hammer

This paper illustrates new techniques being adopted by some members of industry for analysis of the safety of aircraft surveillance applications. The techniques are illustrated using the example flight deck application of Approach Spacing for Instrument Approaches (ASIA). The techniques include analysis of the operational procedures, conducting a hazard analysis, and treating identified hazards in a fault-tree analysis. The fault-tree analysis in turn results in system requirements on various subsystems that support the operational application.

The specific analysis of the approach spacing application results in a requirement that the probability of presenting hazardingly misleading information be held to less than $10^{-5}$ per operation. The $10^{-5}$ value represents “major” system criticality, and is a criticality that is considered by avionics vendors to be achievable within reasonable cost constraints. If the benefits of reduced spacing that are offered by the approach spacing concept are significant enough to justify the cost, users may find that it is worthwhile to equip their aircraft with such a capability.

ADS-B Surveillance Quality Indicators: Their Relationship to System Operational Capability and Aircraft Separation Standards

Stanley R. Jones

Use of Automatic Dependent Surveillance-Broadcast (ADS-B) data for support of aircraft separation is examined on the basis of a Close Approach Probability (CAP) model previously used for determination of radar based minimum separation standards. A central concern in this treatment relates to the integrity of the GPS derived position estimates reported by ADS-B, and how undetected failures in GPS integrity monitoring affect safe separation requirements. A review of the GPS integrity monitoring concept shows the relationship between the probability of missed detection of an error and the false detection rate, and how the resulting factors influence overall system performance. Comparisons of ADS-B based and radar based surveillance are then made. These comparisons indicate the adequacy of ADS-B for separation maintenance. During the transition to full ADS-B equipage, ground based radar estimates on unequipped targets will be uplinked to ADS-B equipped aircraft in a concept termed Traffic Information Service-Broadcast (TIS-B). Application of the model to TIS-B again shows ADS-B supports separation services under very conservative assumptions.

Development of an Information Structure for Reliable Communication of Airborne Intent and Aircraft Trajectory Prediction

Richard Barhydt and Anthony Warren

Airborne intent information refers to an aircraft’s intended future trajectory and is expected to offer significant benefits to many current and future Air Traffic Management (ATM) applications. Potential uses for intent include separation assurance, traffic flow management, and conformance monitoring. In response to operational needs, an information structure for broadcasting airborne intent was developed. This intent structure is applicable to Automatic Dependent Surveillance-Broadcast (ADS-B) and other datalink systems. Airborne intent information is separated into two major categories, target state and trajectory intent, based on the control states of typical commercial aircraft. Primary target state elements are target altitude and target heading or target track angle. Trajectory intent information includes four-dimensional waypoints and their connecting flight segments. The intent structure establishes a standardized format for exchanging intent elements. Standardization is deemed essential for ensuring accurate and unambiguous trajectory synthesis. The intent elements in this structure are designed to reflect the capabilities of current avionics systems and data buses, while allowing for future growth as avionics are developed and as needed to support evolving ATM applications. Future work will focus on obtaining standardized intent parameters from avionics systems and further validation of intent requirements.