Protocol-Based Conflict Resolution for Air Traffic Control

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This paper proposes a simple geometric method for collaborative multiple-aircraft conflict avoidance. We assume that aircraft cruise at constant altitude with varying velocities and thus consider conflict resolution on planar airspace. The multiple-aircraft conflict resolution methodology is presented in two steps; first, we consider an unrealistic but geometrically simple exact conflict, in which the original trajectories of all aircraft intersect at a point, in order to derive a closed-form analytic solution for the required heading change, and then we consider a realistic general conflict, in which conflict points of multiple aircraft do not coincide. Heading change is the main control input for conflict resolution, yet velocity change is also used for a general conflict. The proposed algorithm is based on a protocol, a simple rule for multiple-aircraft conflict resolution, which is easily understandable and implementable by all aircraft involved in the conflict, and provides guarantees of safety within the limits of the model used. We show that this solution is robust to uncertainties in the aircraft’s position, heading, and velocity, as well as to path smoothing, and asynchronous maneuvers. We present simulation results using a dynamic aircraft model for various multiple-aircraft conflict scenarios based on Enhanced Traffic Management System (ETMS) data.

Concept and Laboratory Analysis of Trajectory-Based Automation for Separation Assurance

David McNally and Chester Gong

An operating concept and a laboratory analysis methodology were developed and tested to examine how four-dimensional trajectory analysis methods could support higher levels of automation for separation assurance in the National Airspace System. Real-time simulations were conducted in which a human controller generated conflict resolution trajectories using an automated trial plan trajectory generation and analysis function, but only in response to conflicts detected and displayed by an automatic conflict detection function. Objective metrics were developed to compare aircraft separation characteristics and flying time efficiency under automated operations with that of today’s operations using common airspace and common traffic scenarios. Simulations were based on recorded air traffic data from the Fort Worth Air Route Traffic Control Center and were conducted using today’s and nearly two-times today’s traffic levels. The results suggest that a single controller using trajectory-based automation and data link communication of control clearances to aircraft could manage substantially more traffic than under today’s conditions, and with improved route efficiency while maintaining separation. The simulation and analysis capability provides a basis for further analysis of semi-automated, or fully automated, separation assurance concepts.

Evaluation of Airspace Complexity and Dynamic Density Metrics Derived from Operational Data

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Mental workload experienced by air traffic controllers cannot be measured directly but may be inferred from observable performance or task load imposed on them by volume and complexity of traffic. This research evaluated several measures used to quantify the aforementioned variables. Data were obtained from Indianapolis (ZID) and Kansas City (ZKC) centers and processed by a modified objective activity and task load assessment program, POWER. We compared sectors with different characteristics to measures of pilot-controller communications and to sector complexity metrics, derived from the POWER output. Results from ZKC data were evaluated against subjective workload ratings. The ZID results were consistent with the different characteristics of the selected sectors. Dynamic density correlated with subjective workload estimates and controller transmission durations, known to be a workload indicator. This research demonstrated the viability of extracting metrics relevant to controller task load from operational data and the practicability of implementing additional algorithms to the POWER program for derivation of new metrics.