Optimizing Flight Departure Delay and Route Selection Under En Route Convective Weather

Avijit Mukherjee, Banavar Sridhar, and Shon Grabbe

This paper presents an optimization model and a priority-based scheduling algorithm for managing air traffic flow in the United States. The models assign departure delays and pre-departure reroutes to aircraft whose trajectories are predicted to cross weather-impacted regions of the National Airspace System. It is ensured that the 4-dimensional trajectories of flights remain free of conflict with weather when the forecasts are deterministic. The optimization model and the scheduling algorithm are applied to solve a large-scale traffic flow management problem with realistic weather data and flight schedules. Experimental results indicate that allowing rerouting can reduce departure delays by nearly 67%, but it is associated with an increase in total airborne time due to longer routes flown by aircraft. The performances of the optimization model and the priority-based scheduling algorithm were compared. Delays obtained from the optimization model were 5% lower than those from the scheduling algorithm. However, the priority-based scheduling algorithm was about 5-times faster in generating solutions than the optimization model. This paper also discusses how airline rerouting preferences and some of the latest concepts in Collaborative Decision Making can be incorporated into the proposed models.

Monitoring and Alerting Congestion at Airports and Sectors under Uncertainty in Traffic Demand Predictions

Eugene Gilbo and Scott Smith

Important functions of the Traffic Flow Management System (TFMS) include predicting air traffic demand for National Air Space (NAS) elements (airports, fixes and en route sectors) for several hours into the future, and using these predictions to alert traffic flow management (TFM) specialists to potential congestion when predicted demand exceeds available capacity. The current TFMS Monitor/Alert functionality uses deterministic predictions, neglecting their stochastic nature. This paper focuses on improving the accuracy and stability of traffic demand predictions for airports and sectors by considering the uncertainty in aggregate demand count predictions. The emphasis is on uncertainty caused by errors inherent in TFMS during processing flight data not affected by future air traffic control. We propose a constructive approach for improving aggregate demand predictions under uncertainty based on linear regression that includes TFMS demand counts for several adjacent time intervals within a sliding time window. Numerical examples based on TFMS data showed that the regression models produce more accurate (up to 22% reduction in the standard deviation of errors in demand predictions) and more stable (fewer crossings of the Monitor/Alert threshold) predictions than current TFMS predictions. For airports, regression significantly reduced the total number of missed alerts (21%) with a small increase in the total number of false alerts (3%). For sectors, the reduction in missed alerts was 22%, with an increase in false alerts of 8%.
A Systematic Analysis of Surface Trajectory Models

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This paper presents a systematic analysis of different mathematical models of the surface trajectory process for use in planning and prediction. Components of the surface trajectory process are first discussed. Five models of different fidelity levels for aircraft dynamics are then derived that include rigid-body, point-mass, and kinematic models, and their differences explicitly stated. Models of motion intents and guidance strategies are studied next, followed by the modeling of pilot trajectory tracking actions. Numerical simulations are used to evaluate different model combinations of the pilot-aircraft system in terms of accuracy, computational speed, and feasibility constraint satisfaction. In general, a suitable model depends on the characteristics of the speed profiles it seeks to describe. Results of this paper lay a foundation to appropriate model selections for the surface trajectory process to support automated airport surface operations.

Analysis of Clear-Air Turbulence Avoidance Maneuvers

Jimmy Krozel, Victor Klimenko, and Robert Sharman

In order to better understand how turbulence impacts the National Airspace System (NAS), an analysis is provided for how pilots tactically respond when encountering Clear-Air Turbulence (CAT). Given estimations of CAT and aircraft trajectory data describing potential turbulence encounters in the NAS, models are developed to estimate the relationships between the type and magnitude of the maneuver versus the existence of turbulence in the upcoming sector of airspace or the existence of turbulence along the upcoming flight trajectory. Given that the existence of turbulence throughout the NAS can only be estimated through limited observations and Numerical Weather Prediction (NWP)-based models, these models must necessarily be probabilistic. Results based on historical data indicate that pilot responses to CAT depend on several factors, including user class, weight class, physical class, aircraft type, as well as airline policies. This information can be used within the Next Generation Air Transportation System (NextGen) to increase the capacity of the NAS while maintaining aviation safety.