Ground Delay Programs: Optimizing over the Included Flight Set Based on Distance

Michael O. Ball and Guglielmo Lulli

The Ground Delay Program (GDP) is an air traffic flow management mechanism used to decrease the rate of in-coming flights into an airport when it is projected that arrival demand will exceed capacity. Under a GDP, a set of flights destined for a single airport is assigned ground delays. In this paper we investigate how the set of flights to which delays are applied is defined. Specifically, we define a “distance-based” GDP as one that only applies to flights whose origin airports are less than a prescribed distance, $d$, from the destination airport. This approach is different from the current approach which groups origin airports by air route traffic control center jurisdiction and restricts flight based on a center-based tier system.

We also investigate methods for setting the parameter $d$. We describe the two measures currently used to evaluate GDP options, i.e. unrecoverable delay and average delay, and show how to optimize $d$ based on an objective function defined in terms of these parameters. A new GDP measure, unnecessary delay, which represents the expected cost of ground delay that was unnecessarily assigned is defined. It is shown that this measure provides an improvement over unrecoverable delay.

Analysis of Coast Times Upon Loss of GPS Signals for Integrated GPS/Inertial Systems

Young C. Lee and Swen D. Ericson

For aircraft navigation, integrating the Global Positioning System (GPS) with an inertial reference system provides a synergistic benefit because of their complementary error characteristics. GPS has good long-term accuracy while an inertial system has almost no high frequency noise. These complementary characteristics can be exploited to allow the aircraft to coast even if GPS signals are lost because of intentional or unintentional interference. In case of an interference-caused GPS outage affecting multiple aircraft, such a coasting capability would provide improved availability of Required Navigation Performance (RNP) operations, bringing significant operational benefits. For this purpose, the FAA Satellite Operational Implementation Team RNP Working Group asked the GPS/Inertial Working Group of RTCA Special Committee-159 to determine the characteristics of coasting capability for aircraft equipped with a tightly-coupled GPS/Inertial Reference System (IRS).

This paper analyzes coast times for both a tightly-coupled GPS/IRS and a loosely-coupled GPS/IRS to determine if they can meet the FAA’s requirements for three coasting scenarios which were considered to provide potentially significant operational benefits. The analysis is performed for a variety of conditions in terms of flight profile and user-to-satellite geometry along with a set of assumptions that the GPS/Inertial Working Group The contents of this material reflect the views of the author and The MITRE Corporation. Neither the Federal Aviation Administration nor the Department of Transportation makes any warranty or guarantee, or promise, expressed or implied, concerning established. The results show that the tightly-coupled integration can meet the requirements for two of the FAA’s three coasting scenarios, but the loosely-coupled integration cannot meet them for any of the three scenarios.
A Genetic Algorithm Approach for Ground Delay Program Management: The Airlines’ Side of the Problem

Ahmed Abdelghany, Khaled Abdelghany, and Goutham Ekollu

In this paper, we present a model for slot allocation for flight landings during Ground Delay Programs (GDPs). The model efficiently assigns inbound flights affected by GDP to available landing slots such that the overall downline impact resulting from delaying these inbound flights is minimized. In this model, a Genetic Algorithm (GA) is integrated with a flight simulation model. The GA searches for the optimal landing-slot allocation pattern. The flight simulation model guides the search by evaluating the overall airline performance for each generated slot-allocation pattern. It captures the schedule interaction of the different resources (aircraft, pilot, and flight attendants), analyzes the downline impact of any selected slot allocation pattern, and describes it quantitatively. This impact is represented in terms of delay of flights, misconnects of aircraft, crew, and passengers, as well as crew work rules violations (illegalities). Several experiments with hypothetical GDPs and actual airline schedules are presented. Results show fast convergence of the algorithm with an average improvement in the system performance of about 23% compared with the do nothing scenario.

A FORMAL APPROACH TO THE ANALYSIS OF AIRCRAFT PROTECTED ZONE

Rachelle L. Ennis and Yiyuan J. Zhao

The protected zone represents a region around a given aircraft that no other aircraft should penetrate for the safety of both aircraft, and defines the minimum separation requirements. In this paper, three major components of the protected zone and their interplays are identified: a vortex region, a safety buffer region, and a state-uncertainty region. A systematic procedure is devised for the analysis of the state-uncertainty region. In particular, models of trajectory controls are developed that can be used to represent different modes of pilot and/or autopilot controls, such as path feedback and non-path feedback. Composite protected zones under various conditions are estimated, and effective ways to reduce sizes of protected zones for advanced air traffic management are examined.