Arrival Flight Scheduling Through Departure Delays and Reroutes

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This paper presents a linear integer programming model for assigning departure delays and pre-departure reroutes to flights under airspace capacity restrictions. Experiments are performed in which the model is applied to control air traffic arriving at Chicago O’Hare International Airport over its eastern arrival fixes. The Federal Aviation Administration places miles-in-trail (MIT) restrictions at these fixes due to high traffic demand even on those days when there is no convective weather in the vicinity of the airport. Experimental results indicate that when the optimization model is applied to assign departure delays without any rerouting, total delays could be reduced by about 46–81% compared with those under current-day operations, i.e., passing back the MIT restrictions to adjacent Centers. It is illustrated that the solutions from the optimization model can be used to back-calculate the necessary MIT restrictions at the Center boundaries. This paper also uses the optimization model to analyze the effect of an increase in traffic demand on delays. Pre-departure rerouting is allowed along with assignment of departure delays to flights. Although rerouting is associated with additional flight times and costs, it provides flexibility to avoid congested airspace, and could be effective in reducing excessive departure delays. Sensitivity analysis suggests that if traffic demand increases significantly, allowing pre-departure rerouting along with departure delays could reduce total delay costs by 20–60% compared with those without any rerouting options.

Algorithms for Combining Airspace Sectors

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A heuristic algorithm for combining under-utilized airspace sectors to conserve air traffic control resources is described and analyzed. Simulations and analysis using historical air traffic data and operational sector combination data suggest that systematically combining under-utilized sectors can lead to fewer sectors and therefore a more efficient utilization of resources. Currently, sector combinations are restricted to occur within groups of sectors called areas of specialization. A second heuristic algorithm is proposed that defines new groups of sectors that may be combined. These new groups allow more sector combinations and could be building blocks for new areas of specialization. An analysis of the new groups of sectors suggests that they allow for more frequent sector combinations than existing areas of specialization, and therefore even further efficiencies. Feedback from managers at the Cleveland Air Route Traffic Control Center suggests that both of these algorithms would be useful in Center operations.
Apportioned ATC Safety Criteria Based on Accident Rates

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Changes to safety critical operations need to be assessed and judged as acceptably safe before operational introduction. In Air Traffic Management (ATM), this good practice has been cast into the EUROCONTROL Safety Regulatory Requirement on Risk Assessment and Mitigation (ESARR 4), and the European Commission Regulation No. 2096/2005 laying down common requirements for the provision of air navigation services. A severe complication in applying these regulations is that, whereas one wishes to limit safety assessments to the parts of the operation that might be affected by the change, no criteria for acceptable safety of such parts are given. In other words, one needs to breakdown overall safety criteria and apportion the associated overall risk budget in order to be able to limit safety assessments. This paper presents such an apportionment. More specifically, an overall frequency per flight is derived for so-called Air Traffic Control-related accidents, which essentially correspond to the collisions Air Traffic Control (ATC) is to prevent and which can be objectively determined from accident data. The resulting overall ATC-related risk is apportioned over so-called ATC sub-products, which are to be interpreted as parts of flights forming a logical element within an ATC service or unit, such as ‘Taxiing’, ‘Line up’ and ‘Take-off’. The distribution of risk over the ATC sub-products is differentiated according to statistical accident and flight data. LVNL is currently in the process of gathering and categorisation of its incident data according to the developed ATC sub-products, to verify the derived apportionment based on accident data.

It is obvious that very different circumstances may apply for the flights associated with a particular ATC sub-product: whereas one aircraft taxis a short route in good weather and quiet traffic circumstances, another aircraft taxis a long way, in poor weather and busy circumstances. Generally, the various circumstances are clustered into ‘states’ of the ATM system, which are characterized by weather, traffic condition and runway combination. For each ATC sub-product a risk acceptability interval around the average risk value is applied to allow for the different states in which the ATM system can exist.

The ATC safety criteria are presented together with examples giving insight into their application, and it is indicated how expected traffic growth is handled.