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Causal Analysis of Airline Trajectory Preferences to Improve Airspace Capacity

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Abstract

The problem of fitting the maximum number of aircraft into ATC sectors, keeping in mind aircraft separation and safety standards, area navigation direct routings and other factors, is known as the airspace capacity problem. Above the European airspace, a high density network of air traffic can be found which is determined by the workload of controllers. Constraint Programming (CP) is a powerful powerful paradigm for representing and solving a wide range of combinatorial problems. The PARTAKE project fosters adherence of air space user's trajectory preferences enhancing Trajectory Based Operations (TBO) concepts by identifying tight interdependencies between trajectories and introducing a new mechanism to improve aircraft separation at the hot spots by the mean of CP. The underlying philosophy is to capitalize present freedom degrees between layered ATM planning tools, when sequencing departures at airports by considering the benefits of small time stamp changes in the assigned slot departures.

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1. Introduction

As widely known, air transport industry plays a major role in world economic activity and remains one of the fastest growing sectors of the world economy. Because of the continued growth in civil aviation, in many places,

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demand often exceeds the available capacity of the air transport system to accommodate air traffic, resulting in significant downstream effects[1].

The processes used in the International Civil Aviation Organization (ICAO), such as the Flight Plan, have proved their efficiency, however it is well accepted that there are several shortcomings regarding their performance.

According to the ICAO (Doc. 9854), it was already recognized in the 1980s that the existing approach to the provision of Air Traffic Services (ATS) and the air navigation system was limiting continued aviation growth and constraining improvements in safety, efficiency and regularity. However, it became clear that the changes needed to improve the operational concept cannot be achieved by revolution but have to undergo an evolutionary process.

The ICAO ATM operational concepts are applied in several integrated service areas. To better understand the complex interrelationships a short description is summarized. In this research, the ATM System is understood as a holistic entity consisting of seven ATM conceptual components[1]:

- Airspace organization and management
- Demand/capacity balancing
- Aerodrome operations
- Traffic synchronization
- Conflict management
- Airspace user operations
- ATM service delivery management

In order to have a well-functioning ATM system, all these components have to be present and properly integrated. In addition to the seven concept components, the exchange and management of information used by the different processes and services is of great importance.

Furthermore, the airspace organization and management provides the strategies, rules and procedures by which the airspace will be structured to accommodate the different types of air activity, volume of traffic, and different levels of service and rules of conduct. These management activities are underlined by the demand and capacity balancing that can be divided into strategic-, pre-tactical-, and tactical stages[1].

In Europe, an Air Traffic Flow Management (ATFM) service has been established to use the given capacity to the maximum extent possible keeping in mind the guiding principles safety, continuity and expeditious for the flow of air traffic. On strategic level, demand and capacity balancing will respond to the fluctuations in schedules and demands using the Integrated Initial Flight Plan Service (IFPS) where Airspace Operators (AO) and Air Traffic Service Units (ATSU) can specify their most economic and efficient flight plan or repetitive flight plan. All activities are based on principles of the Air Traffic Flow and Capacity Management (ATFCM) and regional European supplementary procedures described in the ICAO document 7030. Information can be retrieved from the System Wide Information Management (SWIM) platform, an advanced technology program designed to facilitate greater sharing of ATM system information, such as airport operational status, weather information, flight data, status of special use airspace, and National Airspace System (NAS) restrictions. At this stage, planning activities are fulfilled with a timeframe of seven or more days before the operation day.

At pre-tactical and tactical stage demand and capacity balancing evaluates the current allocation of the ATM service provider, airspace user and aerodrome operator assets and resources against the projected demands applied approximately 6 days to 1 day before the operation day. Approaching the operation day, demand and capacity balancing focuses more detailed on demand management to adjust imbalances where activities take place between 5 days and 3 hours prior to departure. The system involved at this stage is the Enhanced Tactical Flow Management System (ETFMS) that receives metadata from the IFPS by Air Traffic Service (ATS) Data Exchange Presentation format and based on this input tracks the aircraft with accurate near-to-real-time data, recalculating 4D profiles of flights allowing traffic demand to be understood more precisely. Integrated in the ETFMS is the Computer Assisted Slot Allocation (CASA) system that operates under the “First-Planned, First-Serve” policy. The CASA system calculates the Estimated Time Over for each point of entry in each sector and allocates the Estimated Off-Block Time (EOBT) plus the taxi-time at the departure aerodrome and finally provides the Calculated-Take-Off-Time (CTOT) that must be followed within a -5 to +10 minutes’ slot window[2].