Flight centric ATC with airstreams ('FC2A')

Executive summary

Air traffic is currently facing a shift of paradigm due to changes in consumers' behaviour. The drop of air traffic in the last months is going to exhibit a slow recovery after the pandemic crisis ends while environmental concerns are gaining increasing importance. Recent reports from ICAO and ACI highlighted that recovery from the crisis will not occur unless the evolution of the demand and the customer confidence in the means of transportation are taken into account. More than ever, a reliable, safe, environment friendly and agile air transportation system, should be put in place. To address future challenges, an optimal use of resources is mandatory and can be achieved by dynamically fine-tuning the capacity of Air Navigation Service Providers (ANSP) according to the fluctuation of the demand. Within this frame, a new concept using flows to organize the air traffic emerged and aims at delegating some of the operations tasks to aircraft. It is pushed through the project Flight Centric Air Traffic Control with Airstreams (FC2A), funded by SESAR, whose final goal is to satisfy the initial demand of airlines to fly the most direct trajectory between city pairs while avoiding the high traffic complexity inherent to pure free flight. In this ongoing work, parallel flight lanes are created within a larger tubular volume thus creating a highway-like structure. Due to the high level of organization, complexity is significantly low within such a tube, allowing a denser traffic. The medial axis is found using a clustering procedure that extract major flows of traffic and is the most representative flown trajectory within a set of samples. It can be adjusted on the fly to cope with a structural change. To assess the performance of the FC2A concept of operations, both airline oriented KPI and complexity must be considered. While indicators pertaining to the first class are quite well known, the second one is still an area of active research and has several facets. It can be related to workload, which is a perception of a given situation by a human controller or to disorder, which is intrinsic.

In this context, FC2A project has developed two bundling approaches for clustering the traffic in order to extract and identify major flows.

The first one is to use the trajectories (an ordered list of timestamped positions) and is based on the k-medoids clustering algorithm. This algorithm is robust with respect to outliers. Furthermore, for each cluster, the central element is a member of the aggregate, thus it is always flyable in an operational context.

The second one is to consider city pairs. Considering there is no difference of treatment between flights of different airlines flying between the same airports, the focus is given here on Air-Links (direct path between each pair of considered airports) rather than in individual flights.

The goal of these bundling mechanism is to partition the traffic into groups/aggregates as homogeneous as possible and separated one to another as much as possible. The flight aggregates then define the backbone (main flows) of the so-called Airstream network. Each cluster is allocated to an Airstream which is built using the intrinsic characteristics of the aggregated traffic.

A first set of rules are proposed to build the tri-dimensional structure of an Airstream. The main characteristics selected are the cruise flight level and the speed. The distribution of speed throughout the complete sample allows to define Speed Families (SF) which are used to build the longitudinal (i.e horizontal) structure of an Airstream. The vertical structure is built using the vertical levels found in the aggregate. A first set of elementary rules are applied on the aggregate, for building the final vertical structure of an Airstream. These rules consider the global schema of the network such as crossings and define free flight levels to allow smooth management of these crossings.

The first results of the project are promising, as the actual amount of traffic allocated to the Airstream network represents the lower limit of the concept, due to the hypotheses used. There is potential improvement of the methodology for defining the tri-dimensional structure of the Airstream and the allocation of traffic which should allow to reach the expected ratio of 60 to 70%.

Finally, the flight trajectories are re-calculated for the traffic allocated to the Airstream network.

The project has developed a complexity calculation by enhancing a method based on local linear models and a representation of traffic situations as images whose pixels are covariance matrices. This algorithm has been improved to be used on larger areas by extending the model on the sphere, using stereographic projection. The evaluations done on the samples show a potential decrease of 30 to 40% of the structural complexity of the traffic with the introduction of an Airstream network in the European airspace.

This project has received funding from the SESAR Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No 783287.