A Data-drIven approach for dynamic and Adaptive trajectory PredictiON ('DIAPasON')

Summary

To face the increasing air traffic demand, the future Air Traffic Management (ATM) system will rely on the Trajectory Based Operations (TBO) approach, which will require aircraft to follow an assigned 4D-trajectory (time-constrained trajectory) with high precision. TBO involves separating aircraft via strategic (long-term) trajectory definition, rather than the currently-practicing tactical (short-term) conflict resolution. The main goal is to increase air traffic capacity by reducing the controllers' workload. Nevertheless, real time measures (over the trajectory) will be required to improve reliability, react to unplanned conditions and thus maintain the expected capacity.

The 4D-trajectory concept is based on the integration of time into the 3D aircraft trajectory, defining each point by position (latitude, longitude and flight level) and time. In the same way that there are restrictions associated with flight levels, the future operational framework foresees restrictions regarding time. It aims to ensure the flight is on a practically unrestricted, optimum trajectory for as long as possible in exchange for the aircraft being obliged to meet very accurately an arrival time over a designated point. In the context of TBO, Airspace Users (AUs) will agree a preferred trajectory with Air Navigation Service Providers (ANSPs) and airport operators (AOs). Aircraft and ground systems will exchange information regarding the trajectory and the expected airspace capacity, in order to foreseen the ability to meet the assigned Controlled Time of Arrival (CTA).

The benefits of the 4D-trajectory approach on the ATM framework are: (a) improvement of air traffic operations reliability by increasing the overall traffic predictability; (b) optimal operations for airlines (aircraft using preferred routes and levels); (c) better service provided (due to ground-ground and air-ground interoperability) and fewer trajectory distortions; (d) potential absorption of delays; (e) enhanced safety with less controller workload (fewer conflicts, strategic management, information-rich environment with data in advance); (f) reduction of costs (e.g. fuel and/or time); (g) increased airspace capacity; and (h) reduction of the environmental impact through reduction of emissions and noise. To exploit these benefits accurate and reliable trajectory prediction (TP) is required. Enhanced traffic forecasts (which integrate uncertainty assessment and include different sources of relevant flight information) may enable improved demand-capacity balancing and conflict detection and resolution (CD&R) models. Moreover, new methodological approaches, as the exploitation of historical data by means of machine learning techniques is expected to boost TP performance.

The DIAPasON project's aim is to develop a methodology for TP and traffic forecasting in a pre-tactical phase (one day to six days before the day of operations), when few or no flight plans are available. This should be adjusted to different time scales (planning horizons), taking into account the level of predictability of each of them. This initial step will be completed with a model that considers advanced tactical data to validate/enhance the previous pre-tactical prediction and incorporate "uncertainty" to Trajectory Prediction (as a probabilistic approach).

We plan to obtain a data-driven, dynamic and adaptive TP framework. It will be data-driven as the main project outcomes will be based on data analysis and interpretation, dynamic as will be adjusted to different planning horizons and adaptive as it will be enhanced iteratively with new tactical data. A fourth objective of the project is for the TP framework to adapt to different Airspace Users' characteristics and strategies. AUs will exhibit different strategies, as far as flight intentions and execution are concerned. The implication is that different methodologies need to be used to develop the best TP for each AU. DIAPasON will validate the TP framework on a case study. The proposed method aims to anticipate the needs of the ATM system; main applications of the model are related to: reduction of complexity, demand-capacity balancing, conflict resolution, separation management, ANSP resource allocation.

The DIAPasON project is structured as an extension of the work achieved in previous studies. Therefore, its impact is focussed on maturing exploratory research further towards applications and operational contexts. Our preliminary analyses indicate that the proposed methods can potentially increase the accuracy of trajectory prediction by 5% and reduce the uncertainty associated by 10%.

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