



# **Project Summary**

May 2018

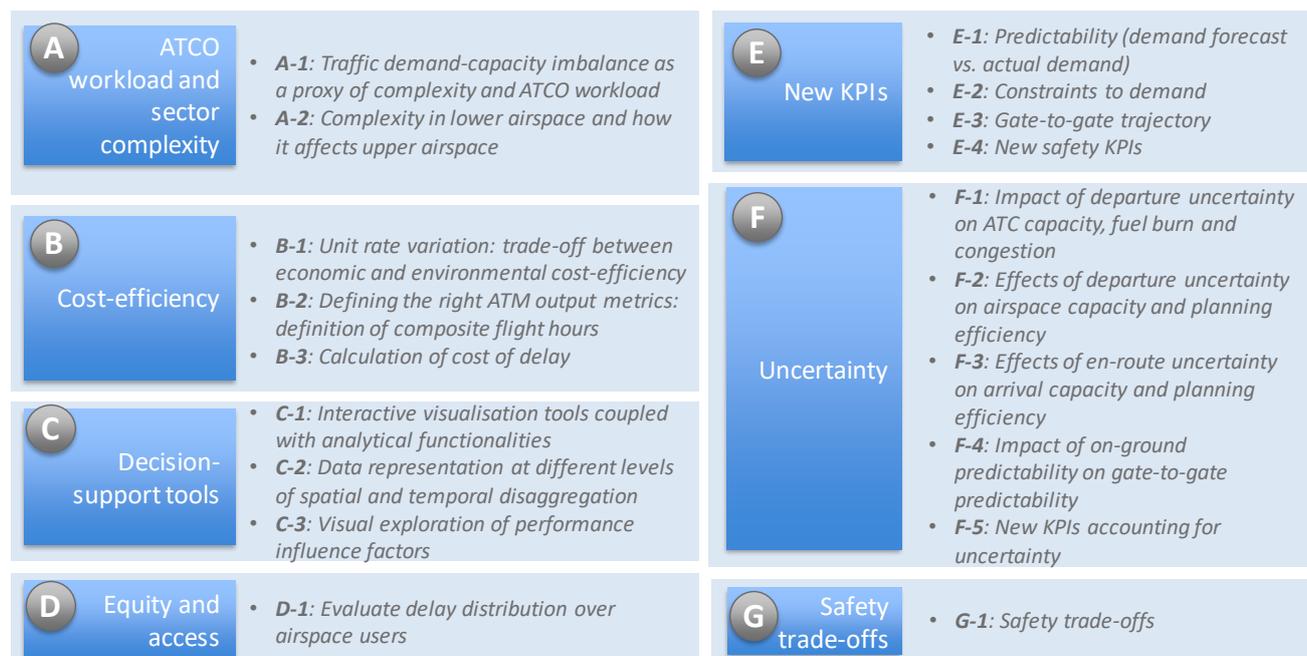
## INTUIT - Interactive Toolset for Understanding Trade-offs in ATM Performance

Performance orientation in Air Traffic Management (ATM) is one of the cornerstones of the Single European Sky (SES) and of its technological pillar, SESAR. A performance-based approach is defined by ICAO as one based on defining policy in terms of qualitative performance objectives, making them measurable by defining appropriate indicators, developing the data and methodologies necessary to calculate the indicators, and having the expertise to maintain data quality and assess the link between indicator trends and management actions. However, realising these elements is not an easy task: ATM performance results from the complex interaction of interdependent policies and regulations, stakeholders, technologies and market conditions, and trade-offs arise not only between Key Performance Areas (KPAs), but also between stakeholders, as well as between short-term and long-term objectives. The need for improved performance modelling methodologies, able to grasp the interdependencies between different Key Performance Indicators (KPIs) and allow the assessment of the possible future impacts of a range of policies and technologies, has been acknowledged by the ATM stakeholders and the research community. INTUIT is a SESAR Exploratory Research project that has explored the **potential of visual analytics and machine learning to improve our understanding of the trade-offs between ATM KPAs and develop new decision support tools for ATM performance monitoring and management**. The project has been conducted by a consortium composed by Nommon Solutions and Technologies (Project Coordinator), ALG, Fraunhofer-IAIS, the Technical University of Madrid, and Transport & Mobility Leuven.

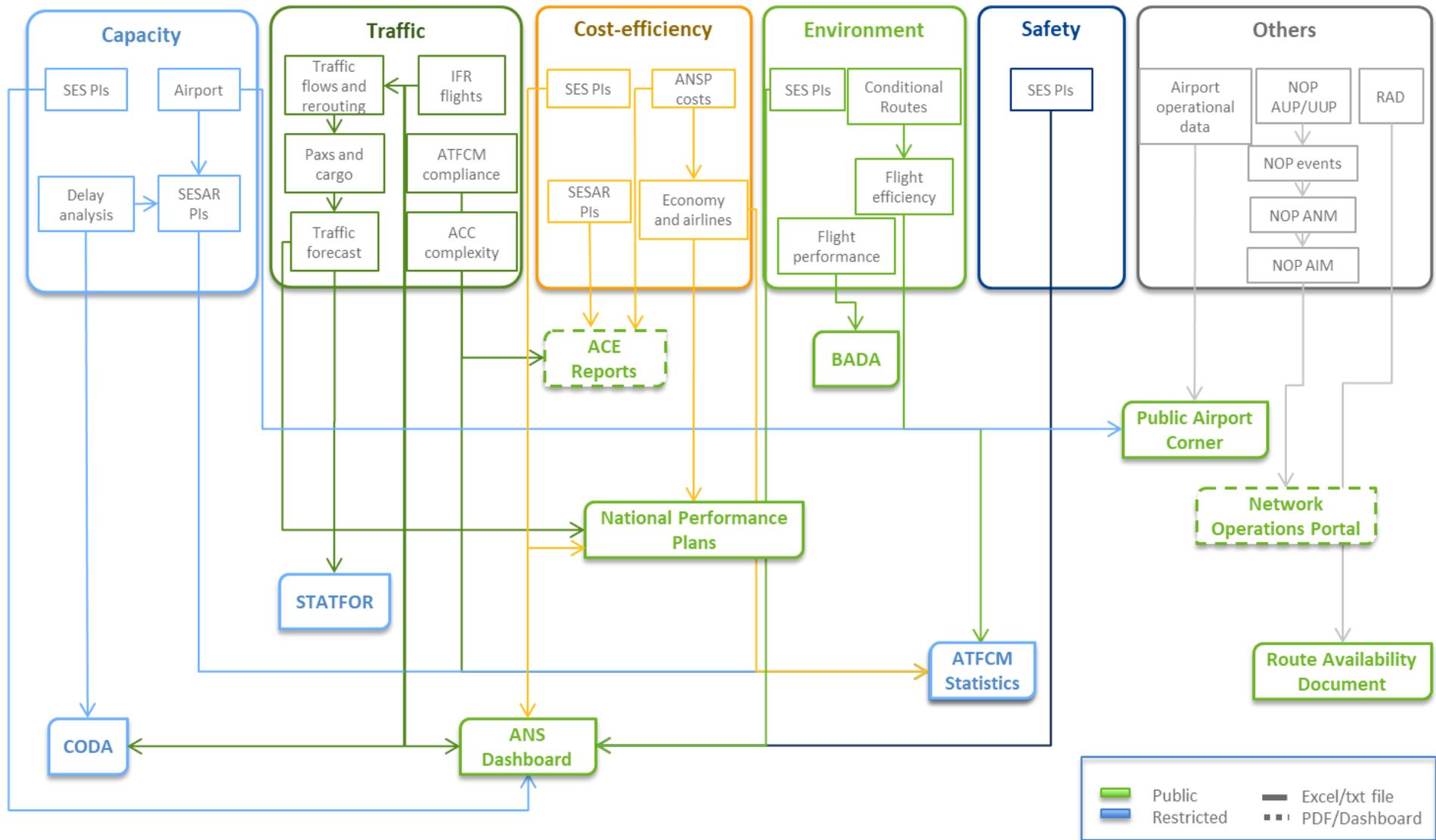
### Approach and methodology

The project started by identifying the available data sources on European ATM performance and conducting a detailed assessment of the validity, the quality and the geographical and temporal resolution of each dataset. This work led to the production of a set of **Performance Data Factsheets** characterising each data source and a **Performance Data Guide** that links the different ATM KPAs and KPIs with the sources where such data can be found.

Taking this work as a starting point, a combination of literature review and stakeholder consultation allowed the definition of a **Research Agenda on Data Science and ATM Performance**.



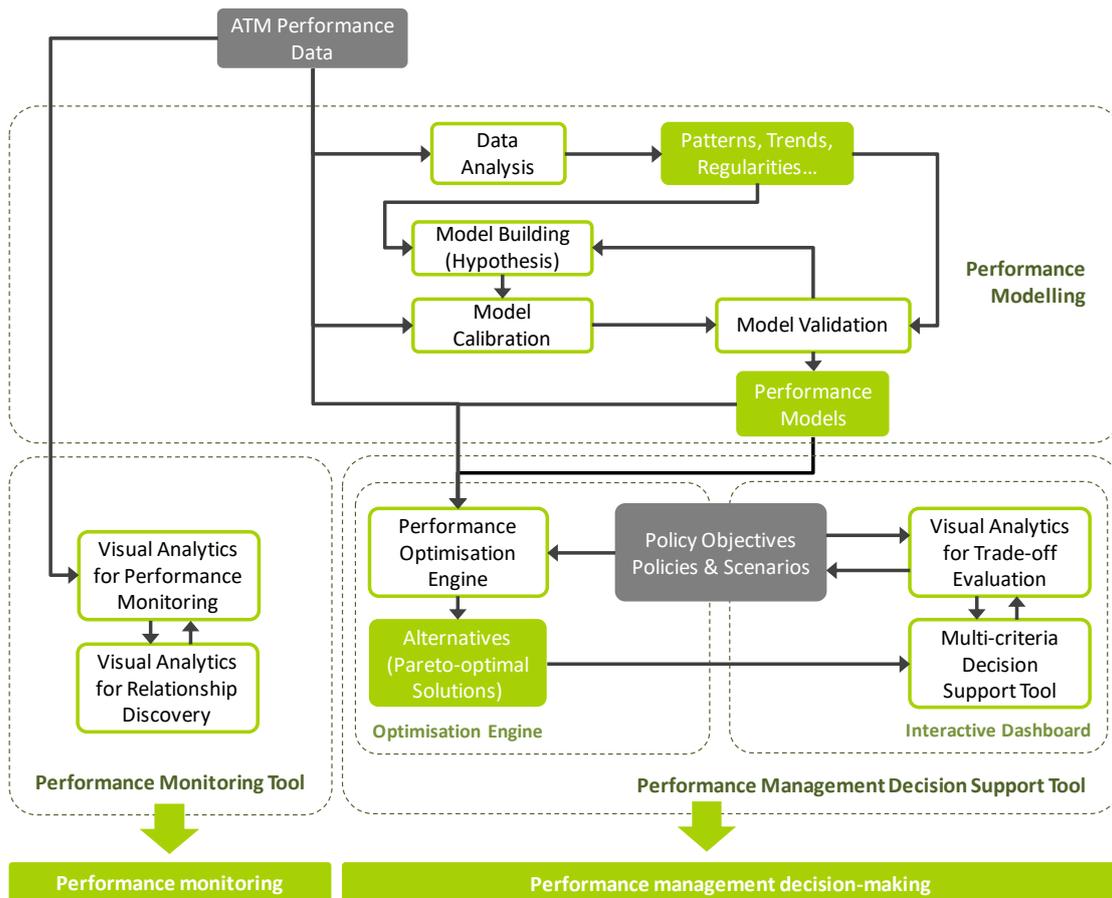
***Towards a Research Agenda at the Intersection of Data Science and ATM Performance***



INTUIT Performance Data Guide

As a general rule, the approach proposed to tackle the ATM performance problems identified in the research agenda comprises three main steps:

1. **Exploratory data analysis**, which involves the use of visual analytics and statistical analysis to identify patterns and trends and suggest potential modelling approaches.
2. **Data-driven modelling**, which investigates how artificial intelligence and machine learning can be used to build predictive models able to complement or replace more conventional mechanistic models.
3. **Development of decision support tools**, by integrating the newly developed models into an interactive dashboard facilitating the exploration and analysis of the modelling results.



### INTUIT Approach

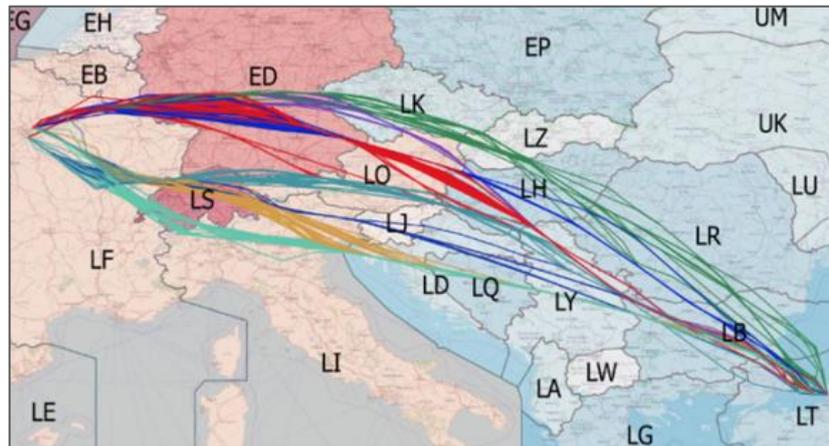
Based on a combination of factors, including the relevance of the research question, the expected impact of the results and the availability of sufficient data, a subset of the identified research questions was selected to be investigated in the form of three Case Studies (CS):

- CS-1: Effect of unit rates on airline route choices and impact on ATM performance.
- CS-2: Sources of en-route flight inefficiency.
- CS-3: Multi-scale representation of ATM performance indicators.

### Effect of unit rates on airline route choices and impact on ATM performance

Airline route choice decisions are an important factor influencing ATM performance (e.g., environmental performance) that is not sufficiently well understood. During the Air Traffic Flow and Capacity Management (ATFCM) strategic and pre-tactical planning phases, when flight plans are not available yet, demand forecasting has traditionally relied on certain hypotheses about airline preferences and the permanence of airlines' behaviour over time, due to the sensitive nature of information such as airline cost of delay and

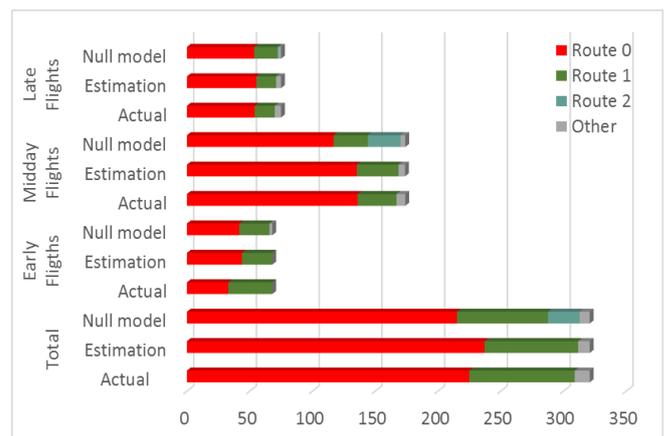
aircraft take-off weight. To avoid this problem, INTUIT has proposed the development of **data-driven models that are trained on the basis of the observed airline behaviour**, by relying on historical data such as that available from EUROCONTROL’s Demand Data Repository 2 (DDR2). First, historical airline route choices for a number of city pairs within the European Civil Aviation Conference (ECAC) area were analysed by means of different visual analytics techniques. This led to the identification of a set of relevant variables to be considered in the modelling of airline route choices.



Cluster	No of flights	Average length (NM)	Average charges (EUR)	Regulations per flight
0	139	1277	1188	0.15
1	110	1314	1144	0.11
2	190	1273	1199	0.06
3	218	1274	1203	0.06
4	117	1256	1207	0.07
5	73	1274	1204	0.10
6	29	1271	1229	0.03
7	24	1304	1152	0.04

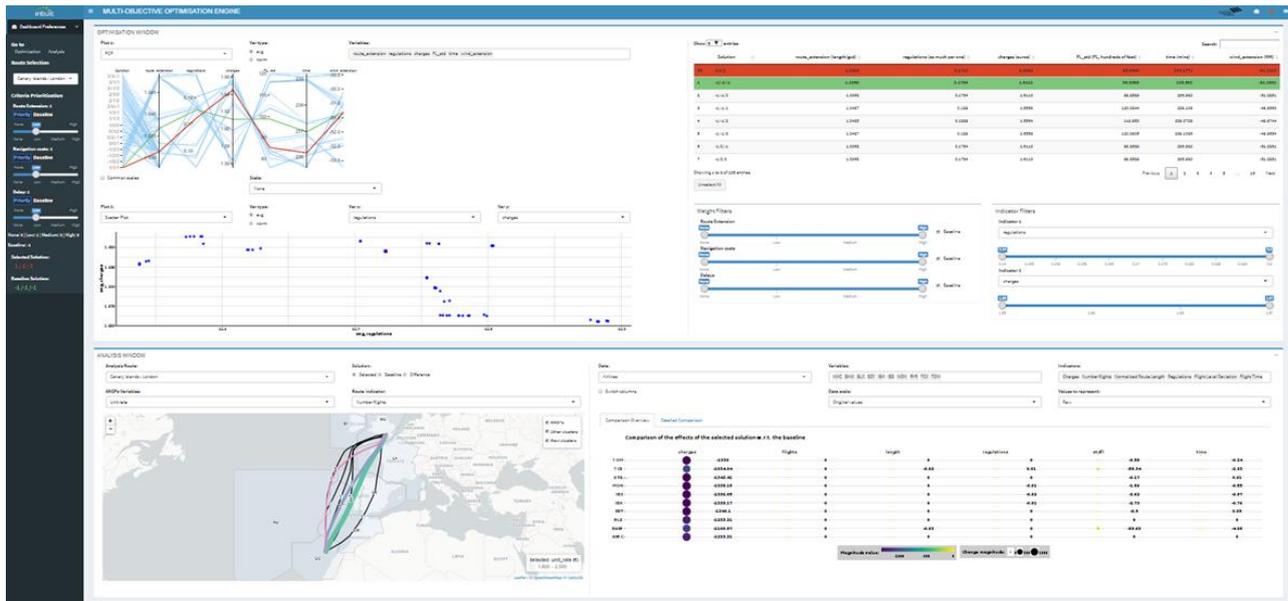
**Exploration of Airline Route Choices: the Example of Paris-Istanbul**

Based on this initial data exploration, a variety of machine learning techniques, such as logistic regression, decision trees and neural networks, were used to develop models for the prediction of airline route choices. For a given Origin-Destination (OD) pair, the proposed models **predict the routes chosen by the different airlines serving such OD pair as a function of the characteristics of the available route options (route length, air navigation charges, expected congestion, etc.)**. The models were trained and evaluated using historical data from DDR2, showing significant potential to outperform traditional approaches such as those currently employed for pre-tactical traffic forecast.



**INTUIT Route Choice Model: Model Evaluation**

Finally, the route choice predictor was coupled with a multi-objective optimisation tool and integrated into an interactive dashboard allowing the **exploration of the effects of a particular setting of unit rates and supporting the user in the selection of the unit rates that optimise a certain cost function**. The dashboard provides a set of interactive visualisation tools that allow the user to assess how different combinations of unit rates on the flights serving a certain OD pair would affect flight efficiency, cost efficiency and capacity, and to explore the resulting impact on relevant airlines and Air Navigation Service Providers (ANSPs).

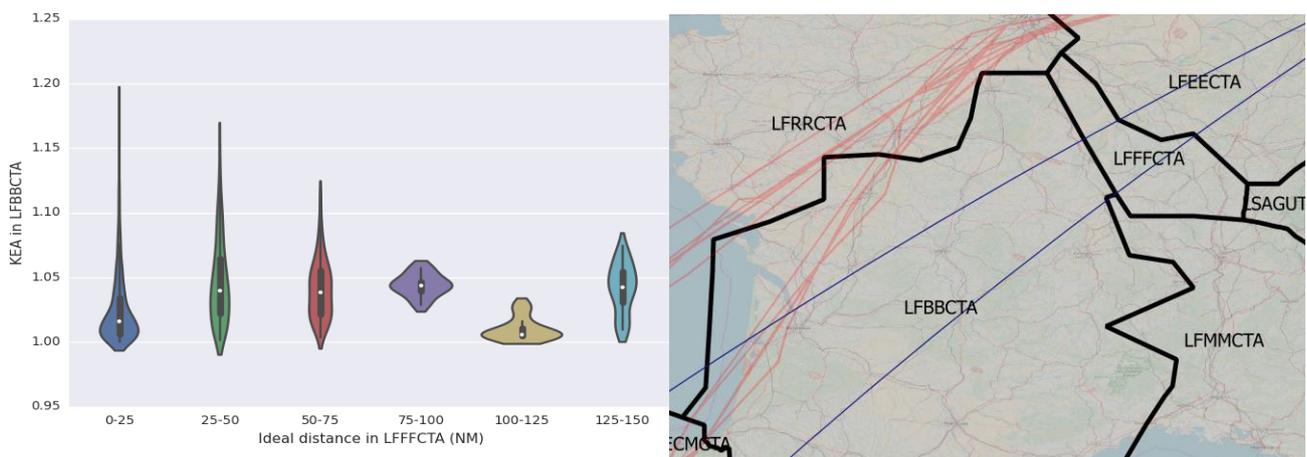


**INTUIT Interactive Dashboard for Airline Route Choice Prediction and Optimisation of Unit Rates**  
(to see a short video of the tool, [click here](#))

### Identification of sources of en-route flight inefficiency

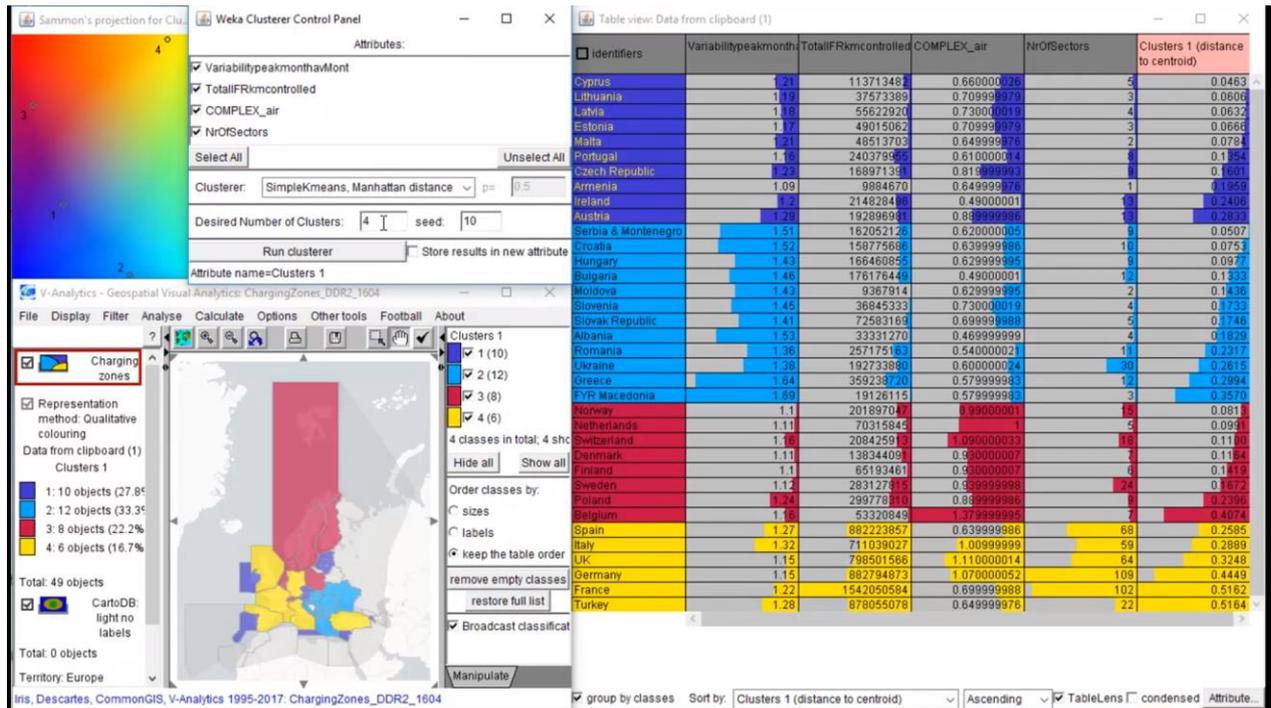
The second INTUIT case study focused on analysing the **influence factors that drive the horizontal flight efficiency of the flights crossing a certain airspace area**, in order to isolate the contribution of different factors and stakeholders. We were interested, for example, in knowing how much of the inefficiencies measured in a certain ACC are actually due to the closure of a certain airspace area in adjacent ACCs. The case study was conducted for the Bordeaux ACC (LFBFBCTA).

We started by a visual exploration of the correlation between horizontal flight efficiency and other variables such as take-off time, number of flights per ATCO, the distance between the ideal and the planned entry/exit points, the heading of the orthodromic trajectory, and the ACCs crossed by such orthodromic trajectory immediately before and after the ACC under study.

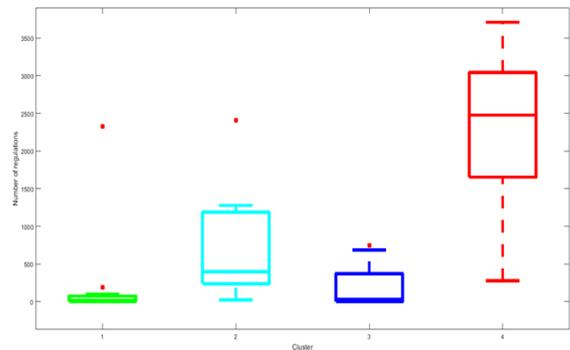
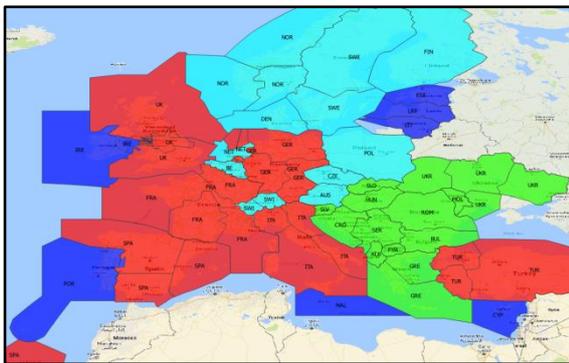


**Visual Exploration of Sources of En-Route Flight Inefficiency**  
(Left: probability density function of flights crossing LFBFBCTA grouped per ideal distance flown in LFFFCTA, showing how flights crossing transversally LFBFBCTA (25-100 NM) have lower flight efficiency; Right: example of deviated flights that would ideally cross LFFFCTA transversally).

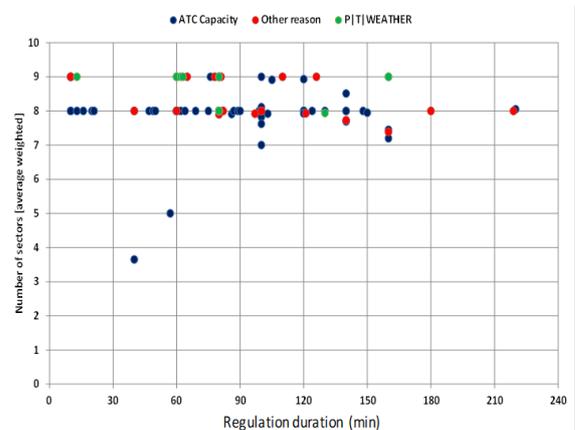
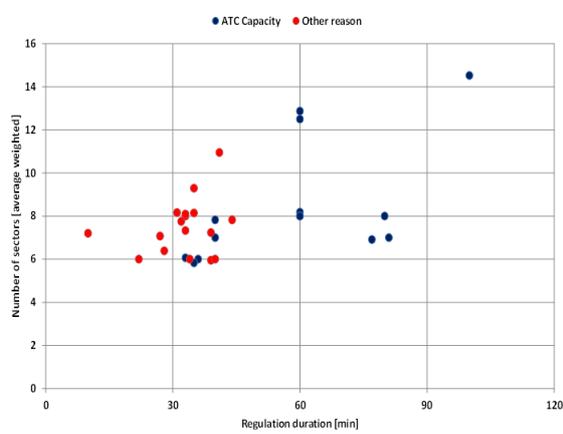




**INTUIT Visual Analytics Tool for ANSP Clustering Analysis**  
 (to see a short video of the tool, [click here](#))



**ANSP Clustering according to Seasonal Traffic Variability, Flight-km Controlled, Complexity, and Number of Sectors**



**ATFM Delay for Different Sector Configurations in the ACCs of Warsaw (Left) and Madrid (Right)**

## Conclusions and future directions

INTUIT has developed a structured approach and a set of prototype performance analysis tools that have demonstrated the potential of visual analytics and machine learning to improve the state-of-the-art in ATM performance analysis. Different development paths are envisaged in terms of both fundamental research and industrial research.

The research questions identified in the INTUIT Research Agenda that were not covered by the INTUIT case studies will be investigated in future research exploratory projects. Additionally, the case studies have allowed the identification of new research avenues, such as the combination of data-driven and mechanistic modelling approaches.

In terms of innovation, we believe that the project results include a number of 'quick wins' ready to be fed into the next stages of the R&I cycle. In particular, the most prominent opportunities lie in three areas:

- **Data-driven characterisation of Airspace User (AU) behaviour.** Performance assessment is sometimes limited by the non-availability of sensitive information about AU preferences. Data-driven techniques provide a tool to infer such preferences. The approach developed by INTUIT could be upscaled to the whole European airspace and be used as an input to performance consolidation methodologies and cost-benefit analyses.
- **Identification and characterisation of performance influence factors.** The work developed by INTUIT to analyse the influence factors driving flight efficiency could be extended to identify the influence factors behind other KPIs and measure their relative influence. Such an approach would be useful to validate and/or refine the influence diagrams used within SESAR to evaluate the benefits of a solution, which in their current version are largely based on expert judgement.
- **Performance dashboards bringing together interactive visualisation tools and analytic functionalities.** INTUIT has explored a variety of classical and state-of-the-art visualisation techniques, which are ready to be integrated into ATM planning and decision support tools and can contribute to the implementation of more effective and efficient performance monitoring mechanisms and management actions.

## Project website and contact details

For more detailed information about INTUIT, please visit the project website ([www.intuit-sesar.eu](http://www.intuit-sesar.eu)) or contact the Project Coordinator, Ricardo Herranz López ([ricardo.herranz@nommon.es](mailto:ricardo.herranz@nommon.es)).



# intuit

Interactive Toolset for Understanding  
Trade-offs in ATM Performance

[www.intuit-sesar.eu](http://www.intuit-sesar.eu)

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