



Visual Analytics and Machine Learning for Air Traffic Management Performance Modelling

Rodrigo Marcos

Data Scientist, Nommon Solutions and Technologies

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Founding Members



1. The Challenge of ATM Performance Modelling
2. INTUIT Project
3. ATM Data Quality Assessment
4. Proposed Research Questions
5. Case Study 1: Visual Analytics for ATFM Delay Analysis
6. Case Study 2: Visual Analytics for Navigation Charges Analysis

ATM Performance Modelling: Challenges

SESAR performance orientation:

- Policy – qualitative performance objectives
- Objectives – measurable indicators
- Management actions – indicator trends

European ATM performance governed by SES Performance Scheme:

- Performance targeting
- Benchmarking

Needs:

- Analyse interdependencies/trade-offs between KPAs
- Characterise performance drivers
- Effective target setting and benchmarking

Data Science: Opportunities

Data Science:

- Discover patterns and extract knowledge from data
- Variety of techniques: statistics, machine learning...
- Synonym for Business Intelligence, Data Analytics...

Opportunities:

- Increasing availability of data
- Big data technologies
- New data analysis and visualisation techniques

How can we apply these ideas to ATM performance modelling?

What is their potential for ATM performance monitoring and management?

The INTUIT Project

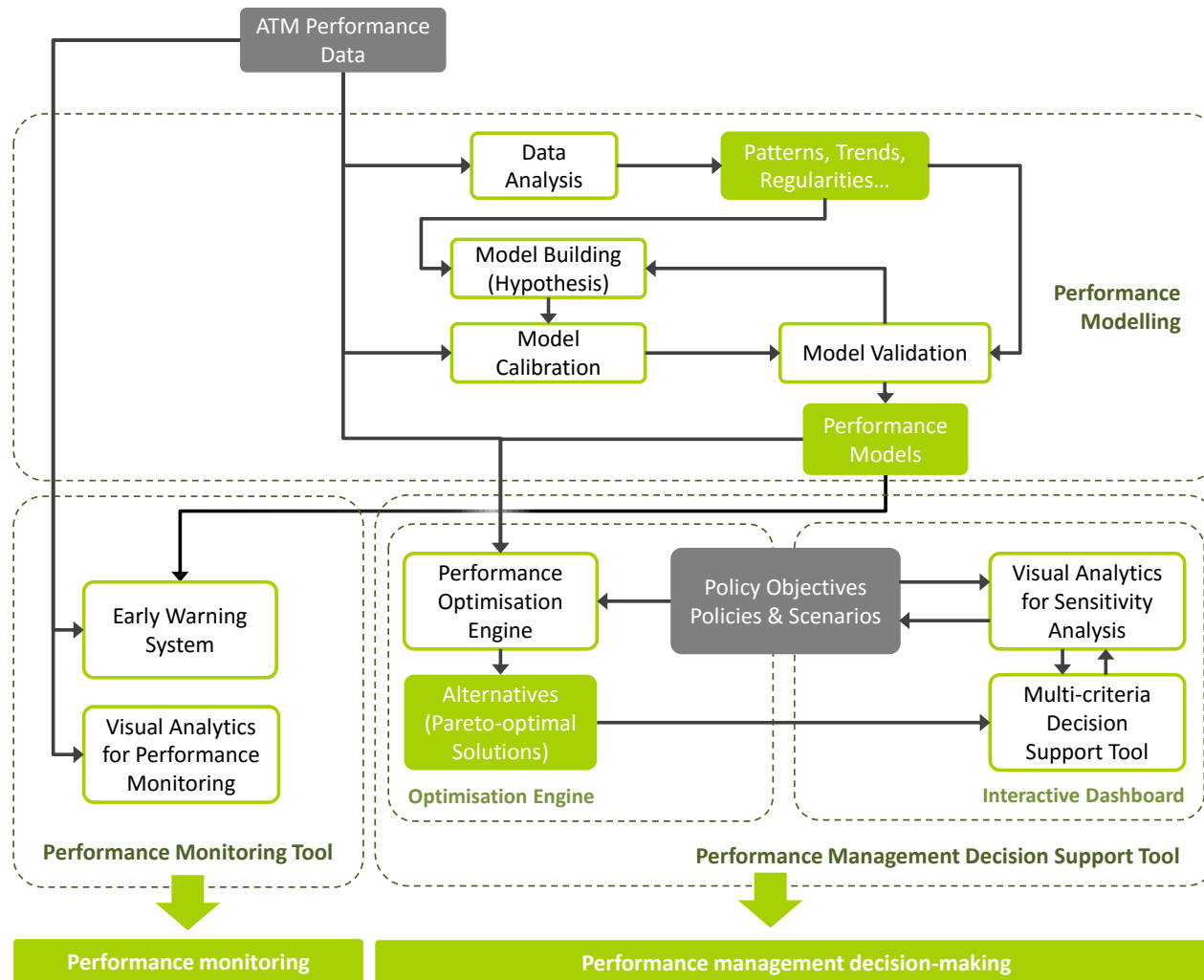


Explore the potential of **visual analytics**, **machine learning** and systems modelling to improve our **understanding of the trade-offs between ATM KPAs**, identify cause-effect relationships between KPIs, and develop **new decision support tools** for ATM performance monitoring and management

- Start March 2016, duration 24 months
- Website: www.intuit-sesar.eu
- Partners:



The INTUIT Project



1. Multiscale characterisation of ATM performance data:

- Data collection and quality assessment
- Qualitative analysis of performance drivers and trade-offs

⇒ **INTUIT reference datasets + set of research questions**

2. Data analysis and performance modelling

- **Visual analytics of performance data: exploratory data analysis**
- Machine learning and statistical analysis: identification of patterns and relationships between indicators
- Models of KPI evolution explaining and/or reproducing the observed patterns and trends

⇒ **ATM performance analysis techniques**

3. Performance monitoring and management tools

⇒ **Interactive dashboard**

Data Sources



ANS performance monitoring online dashboard developed by the PRU



Delay analysis data from the Central Office for Delay Analysis (**CODA**)



Network operations monitoring and reporting (public reports and **ATFCM Statistics**)



Data about network events disrupting the network from Network Operations Portal (**NOP**)



Air traffic demand from the Demand Data Repository (**DDR2**)



Data on capacity, labor and cost per air traffic control centre, as provided in the yearly ATM Cost-Effectiveness (**ACE**) reports



Performance plans and reports elaborated by EU Member States and approved by the PRB



Statistics and forecasts on expected levels of air traffic in Europe produced by EUROCONTROL's Statistics and Forecast Service (**STATFOR**)



Base of Aircraft Data (**BADA**)



EUROCONTROL **Public Airport Corner**

Data Sources Classification

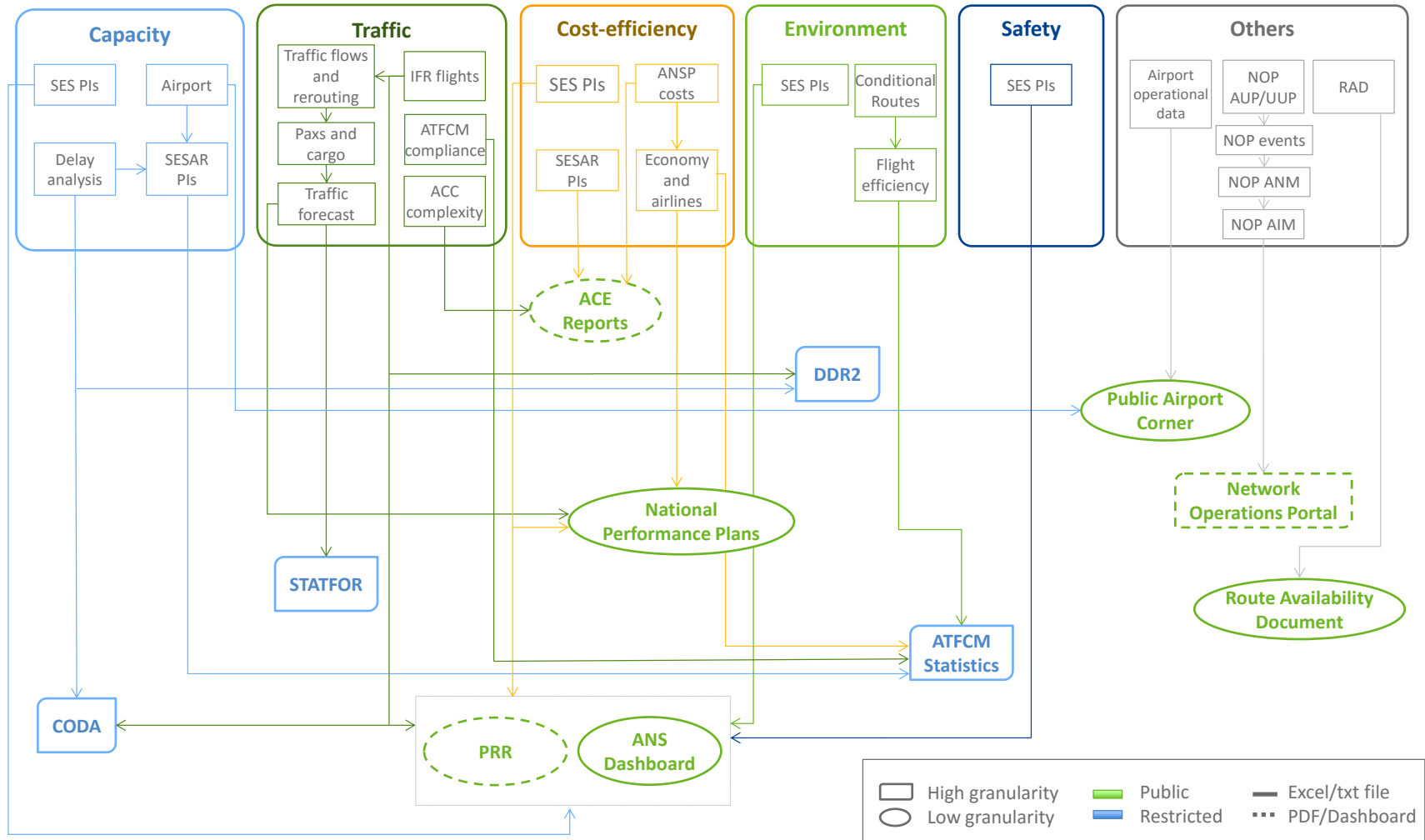
Low granularity

- ACE reports
- PRR
- ANS Performance Monitoring Dashboard
- National Performance Plans
- Public Airport Corner

High granularity

- DDR2
- ATFCM Statistics
- NOP
 - ANM
 - AUP
 - AIM
 - Events
- CODA
- STATFOR

Data Guide



Definition of Research Questions

Research questions obtained from:

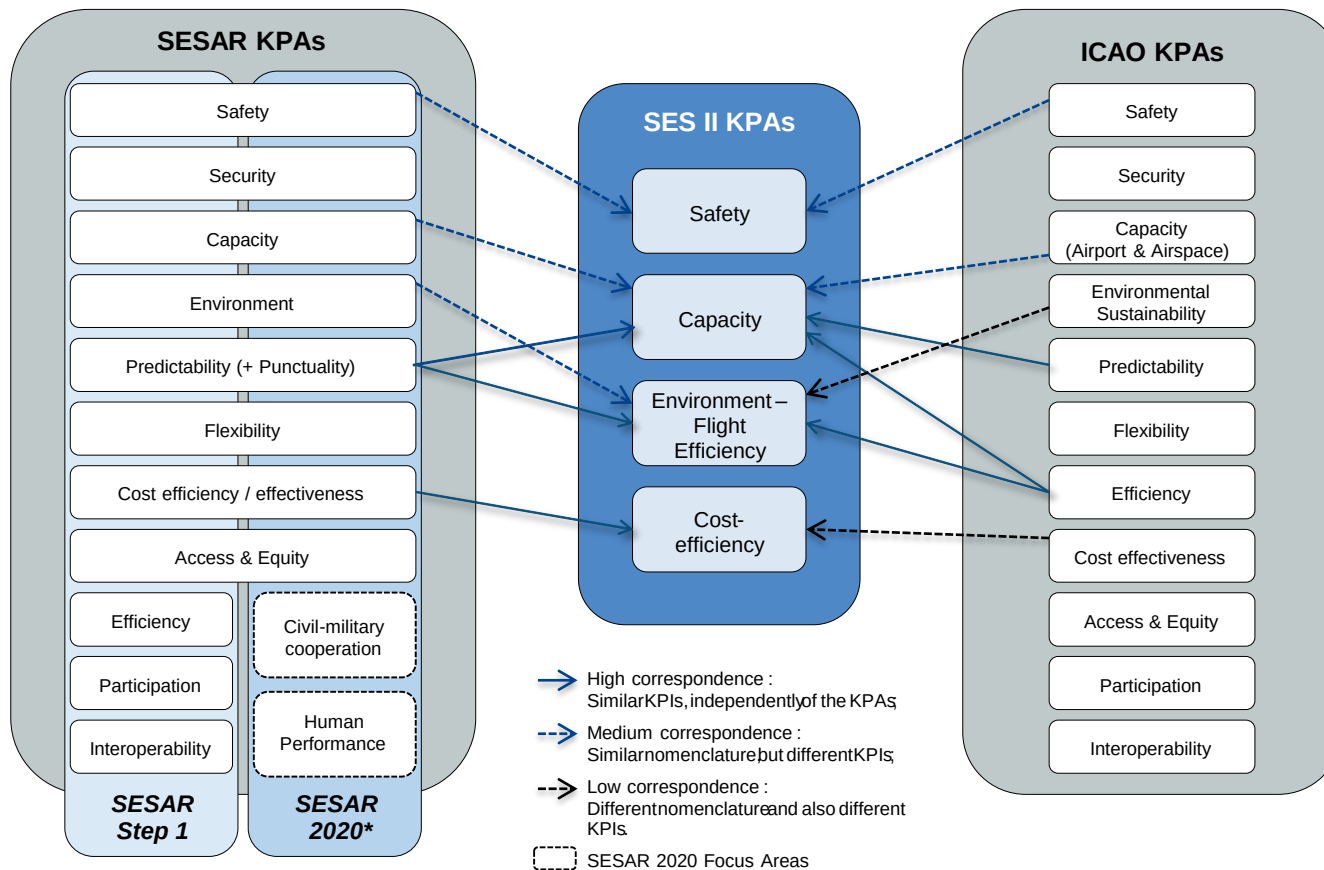
- Desk research: research papers and policy studies
- Consultation: ATM stakeholders (PRU, NM, EASA, ANSPs, airports, airlines)

Selection criteria:

- Availability of data
- Relevance to INTUIT
- Interest of stakeholders



Performance Frameworks: Relationships



*Source: D108 SESAR 2020 Transition Performance Framework ed. 00.01.00

Safety

SESAR is focused on **accidents measurements**, whilst in SES more on their **prevention** (safety management)

Capacity

SES establishes «**ATFM delay**» as target, while SESAR focuses on **throughput**, which is linked

Environment – Flight Efficiency

SES targets are based on **flight efficiency** and SESAR addresses **fuel efficiency** directly

Cost-efficiency

Partial consistency between **DUC** and **Technology Cost per flight** and **ATCO productivity**

Macro focus:

- Broad geographical scale
- Multiple KPAs
- Simplified assumptions

Literature threads:

- Prediction accuracy
- Spill-over effects
- Unit costs

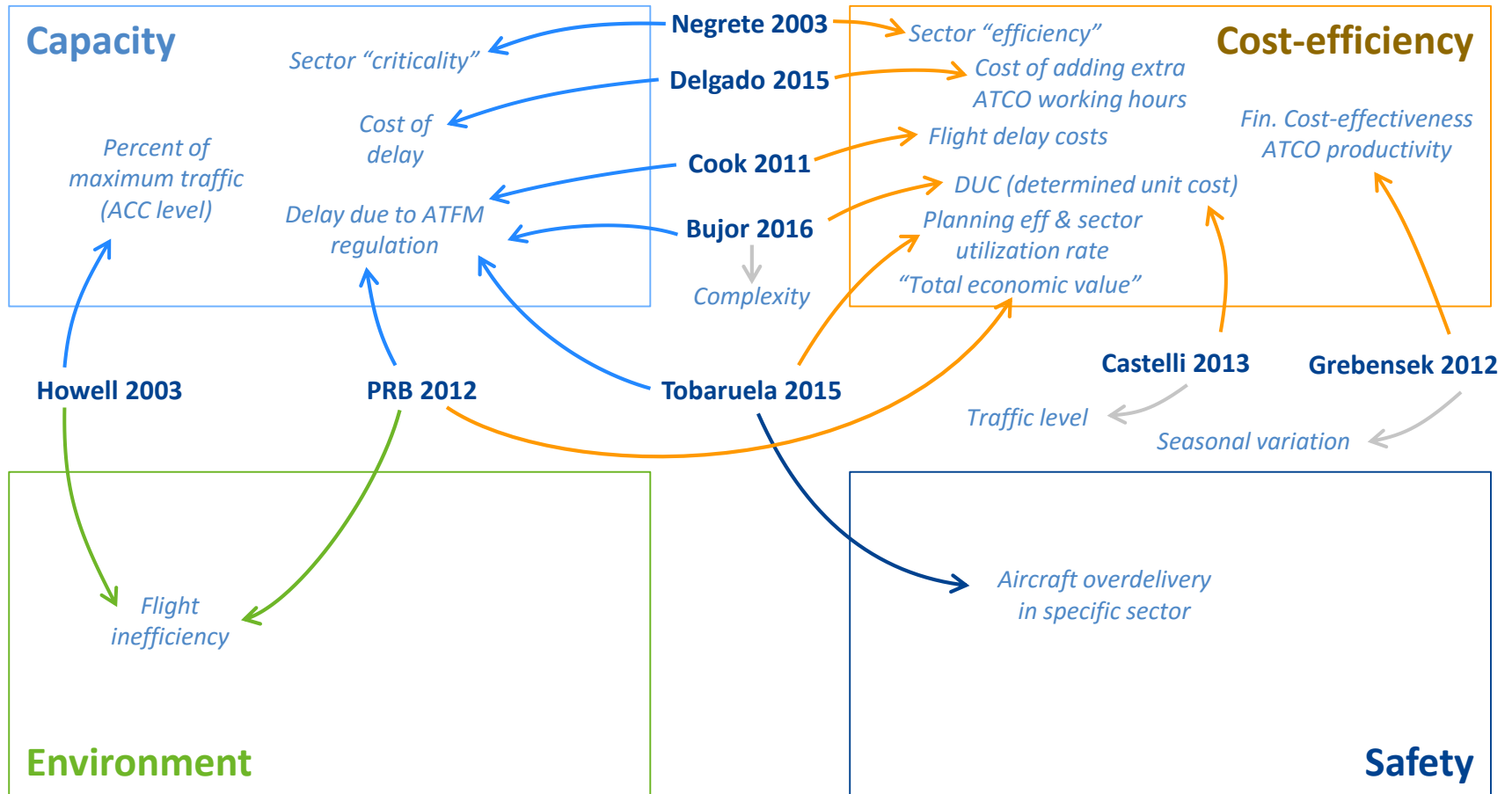
Micro focus:

- Small number of sectors
- Two KPAs
- Detailed case-study

Literature threads:

- Optimisation of ATCO workload
- External drivers of cost-efficiency
- Capacity-flight efficiency trade-off

Literature Review: Interdependencies



Interdependencies

- ATCO workload:
demand – capacity drivers
- Cost of delay vs
environment
- Uncertainty impact:
ATOT – en-route – arrival
- Safety trade-offs

Decision-support tools

- Spatial disaggregation of
metrics
- Different time-scales
visualisation
- New metrics:
 - demand constraints
 - gate to gate indicators
 - safety
 - predictability

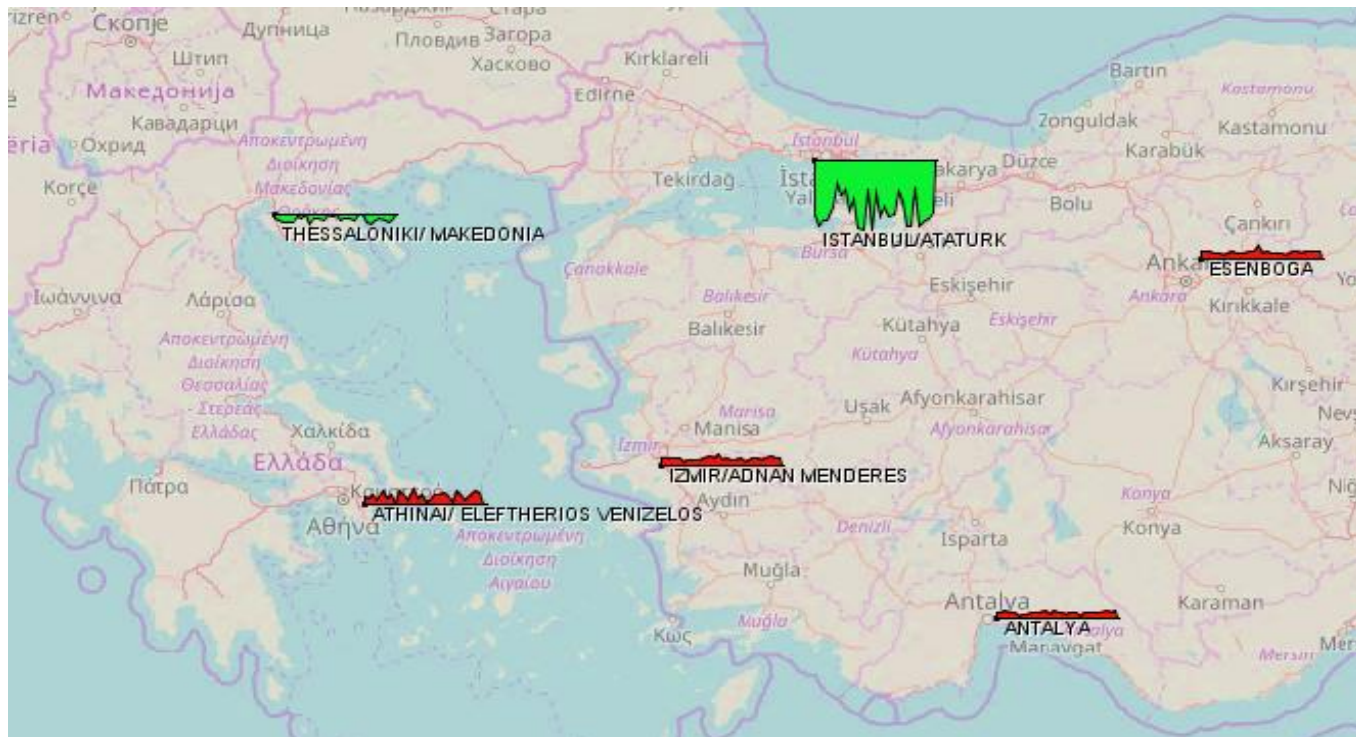
Case Study 1:

Visual Analytics for ATFM Delay Analysis

Objective: airport network bottleneck identification

Metric:

ATFM delayed outgoing flights - ATFM delayed incoming flights



Case Study 1: Visual Analytics for ATFM Delay Analysis

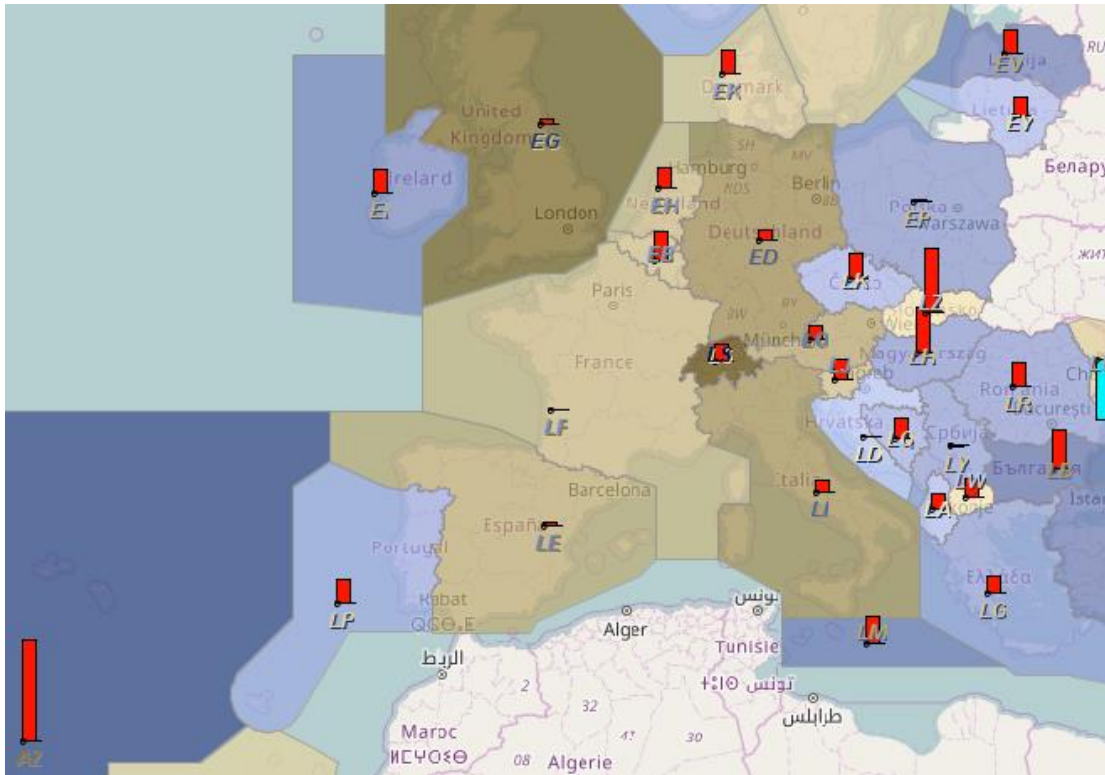
Objective: external impact of regulations on the airport

Metric:

flights delayed by external regulations



Case Study 2: Navigation Charges Visual Analysis



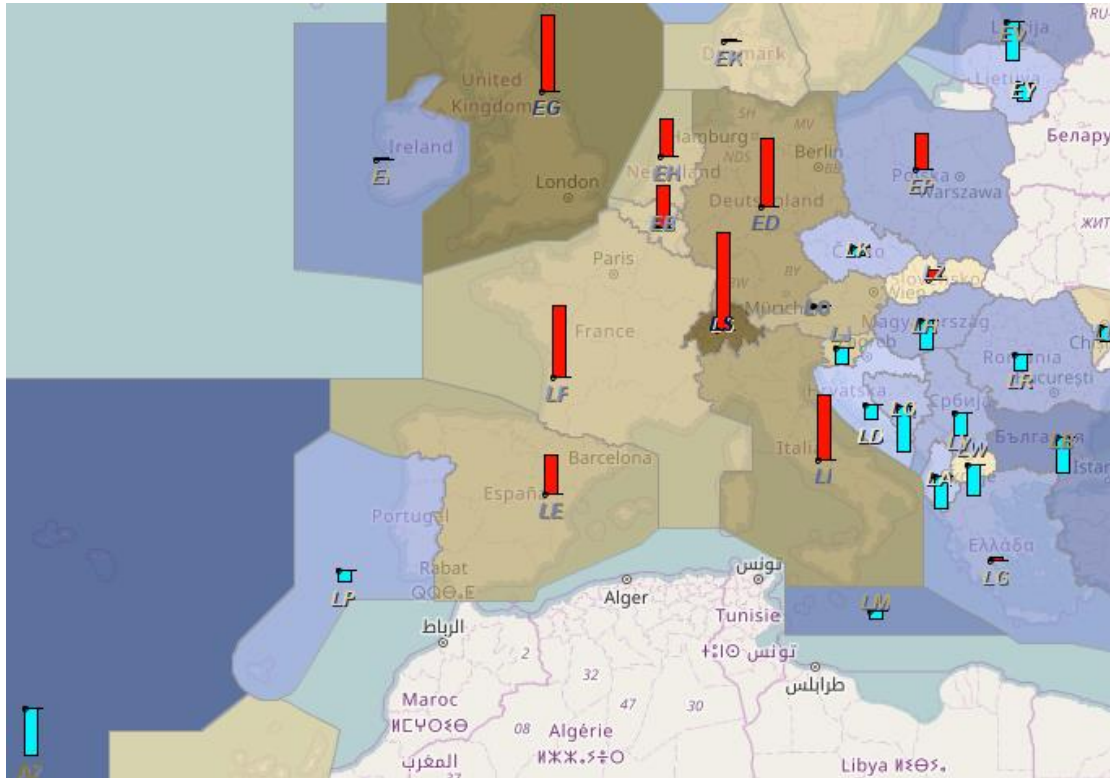
Objective: charges vs
traffic interdependency

Metrics:

number actual ODs /
number great circle ODs
flying over each area

normalized unit rate

Case Study 2: Navigation Charges Visual Analysis



Objective: route efficiency
vs traffic interdependency

Metrics:

average flown distance /
average distance factor

normalized unit rate

Conclusions & Future Steps



- INTUIT approach:
 - Machine Learning + Visual Analytics
 - ATM Performance Modelling + Decision Support
- Preliminary results:
 - Research challenges
 - Potential of visual analytics
- Future activities:
 - Visual analytics exercises for pattern discovery
 - Study a sub-set of research questions through machine learning and statistical analysis techniques



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Thank you very much for your attention!



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Founding Members



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Macro approaches

- **Bujor & Ranieri (2016):** Assessing air traffic management performance interdependencies through Bayesian networks: Preliminary applications and results
- **Castelli, Labbé & Violin (2013):** A network pricing formulation for the revenue maximization of European ANSPs. Transportation research part C: emerging technologies
- **EUROCONTROL PRB (2012):** Proposed regulatory approach for a revision of the SES performance scheme addressing RP2 and beyond
- **Negrete, Urech & Saez-Nieto (2003):** ATM system status analysis methodology

Micro approaches

- **Cook & Tanner (2011):** airline delay cost reference values
- **Delgado, Cook, Cristobal & Plets (2015):** Controller time and delay costs – a trade-off analysis
- **Grebensek & Magister (2012):** Effect of seasonal traffic variability on the performance of air navigation service providers
- **Tobaruela, Schuster, Majumdar & Ochieng (2015):** Framework to assess an area control center's operating cost-efficiency: a case study
- **Howell, Bennett, Bonn & Knorr (2003):** Estimating the en-route efficiency benefits pool