Application of Machine Learning for ATM Performance Assessment

Identification of Sources of En-Route Flight Inefficiency

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Founding Members

EUROPEAN UNION EUROCONTROL

INTUIT

Challenges: KPA interdependencies, target setting, ANSP performance benchmarking, performance drivers → need for effective performance modelling approaches

Opportunities: increasing data availability, big data technologies, data science

Goal: explore the potential of data science to improve our understanding of KPA trade-offs, identify cause-effect relationships between performance drivers and KPIs, and develop new decision support tools for ATM performance monitoring and management

- Visual analytics and machine learning algorithms for pattern extraction
- New data-driven modelling techniques
- Prototype DST integrating the new analytical and visualisation functionalities

Sources of Flight Inefficiency
Problem Statement

The problem of target setting and performance evaluation:

- How to isolate the effects of different performance drivers?
- How to link decisions at ANSP/ACC level with overall performance?
    - Diagnosis of low performance episodes
    - Prediction of potential performance gains

Sources of Flight Inefficiency
Case Study and Approach

$$HFE_j = \frac{\sum L_{fjp} - \sum H_{fjp}}{\sum H_{fjp}}$$

Approach:

- Case study: February 2017, Bordeaux ACC
- Flight efficiency indicator: interface HFE
- Trajectory data (DDR2, CPR)
- Visual exploration of influence factors and feature selection
- Machine learning model for efficiency prediction trained with historical data
    - Comparison of data sources
    - Analysis of influence factors

Sources of Flight Inefficiency
Data Exploration and Feature Selection

Features:

- Flight plan efficiency
- Reference FL
- Take-off time
- Flights per sector
- Distance between ideal and planned entry/exit point
- Route length
- Heading
- Airspace crossed

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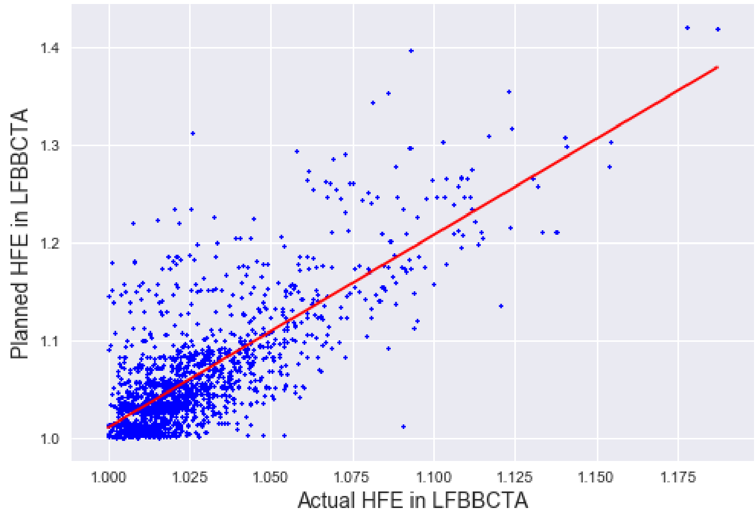

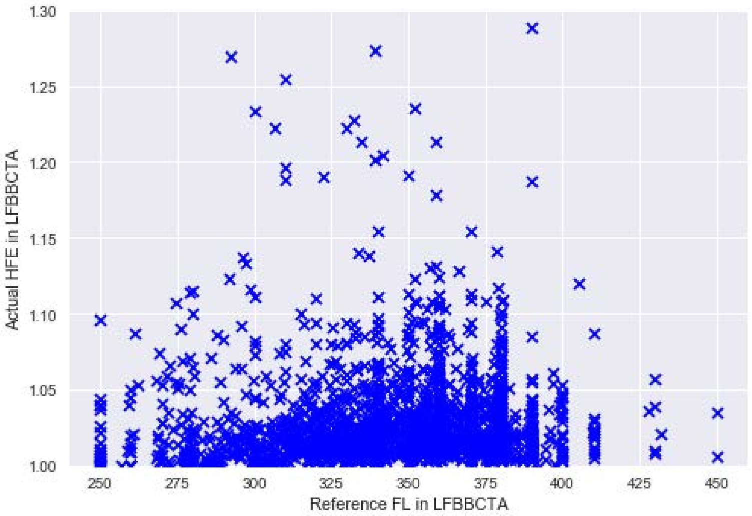

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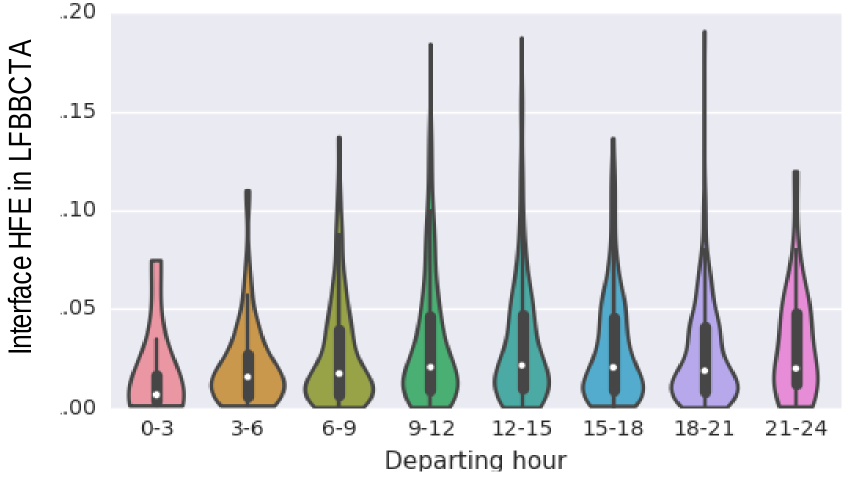

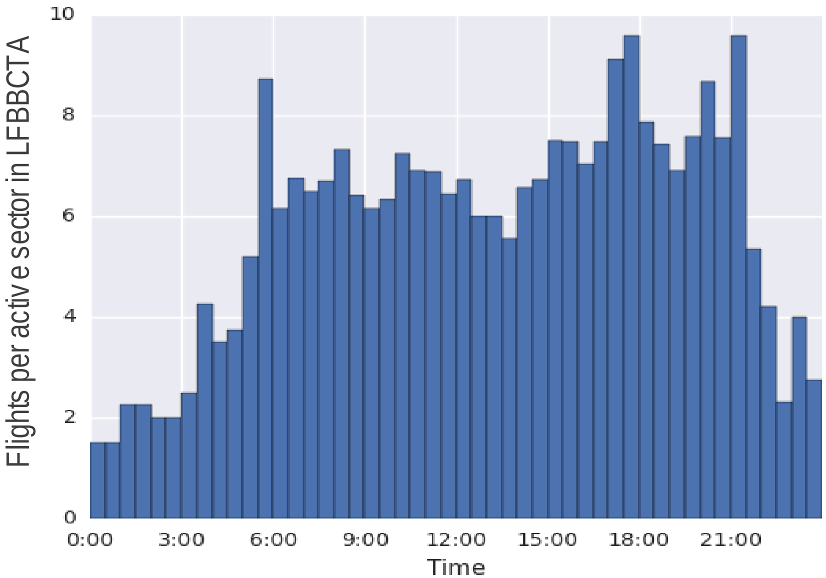

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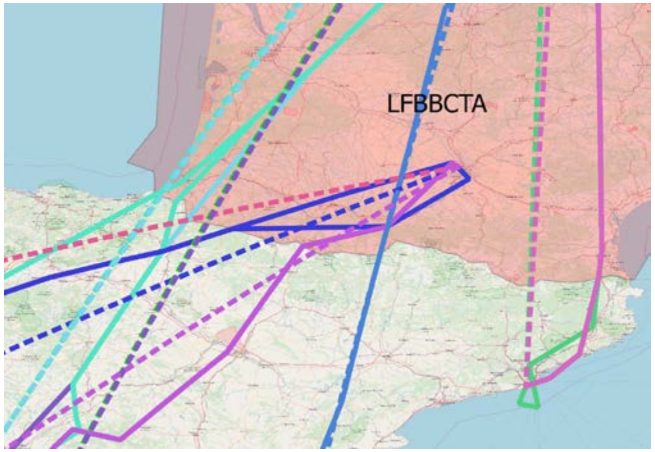

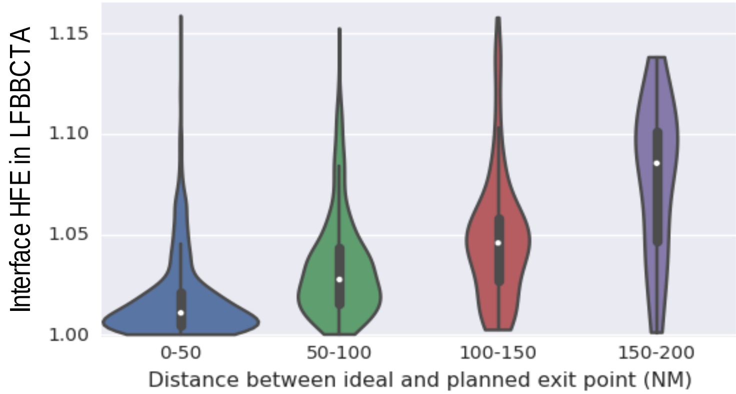

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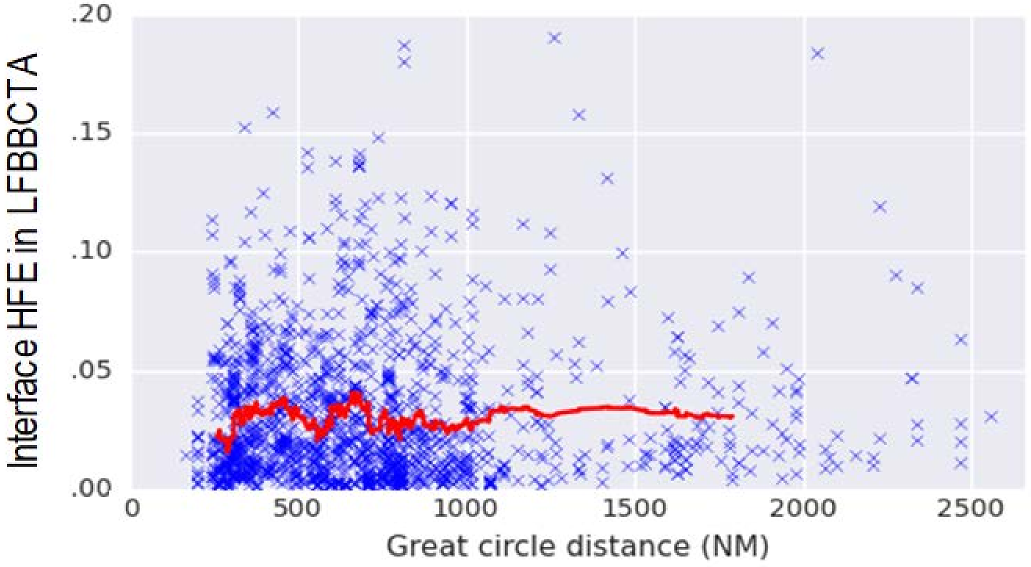

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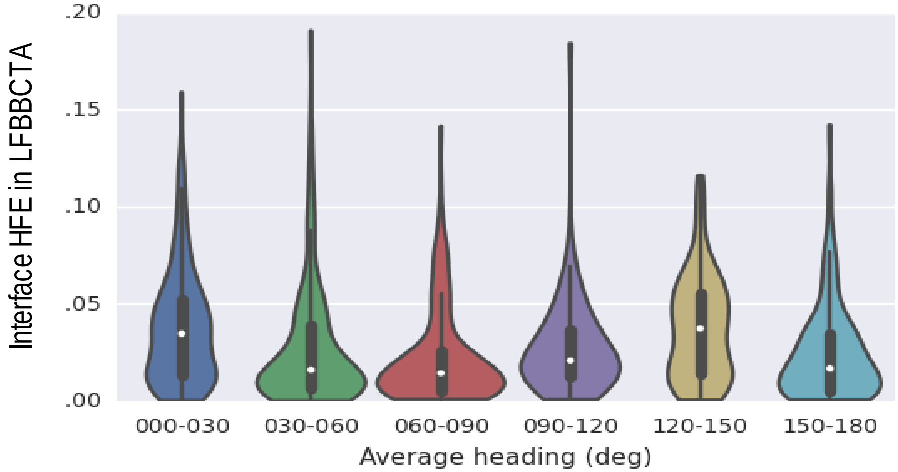

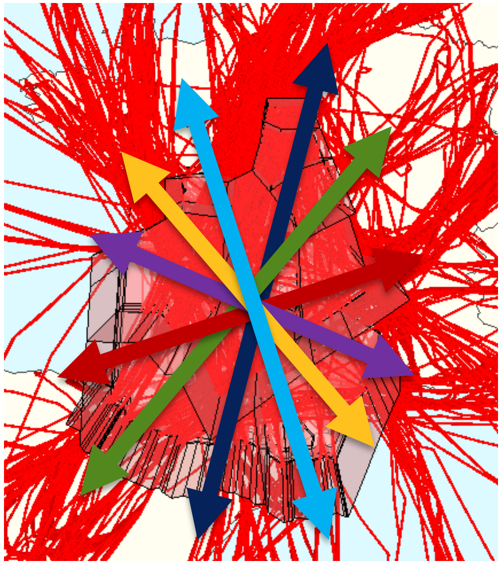

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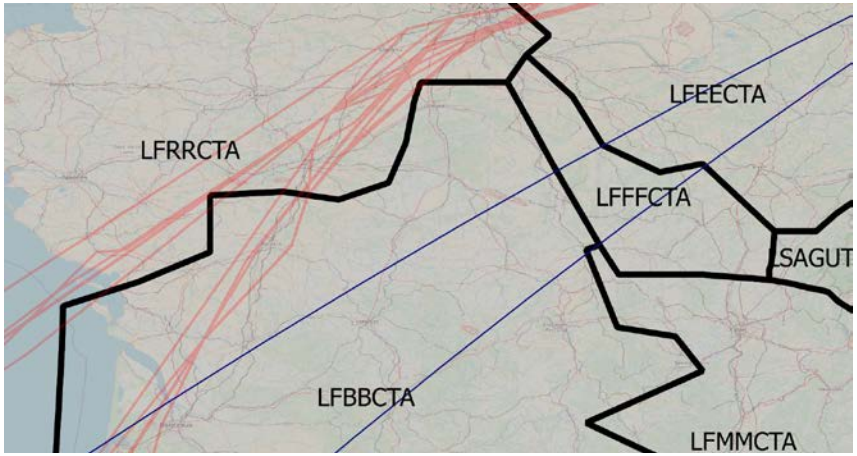
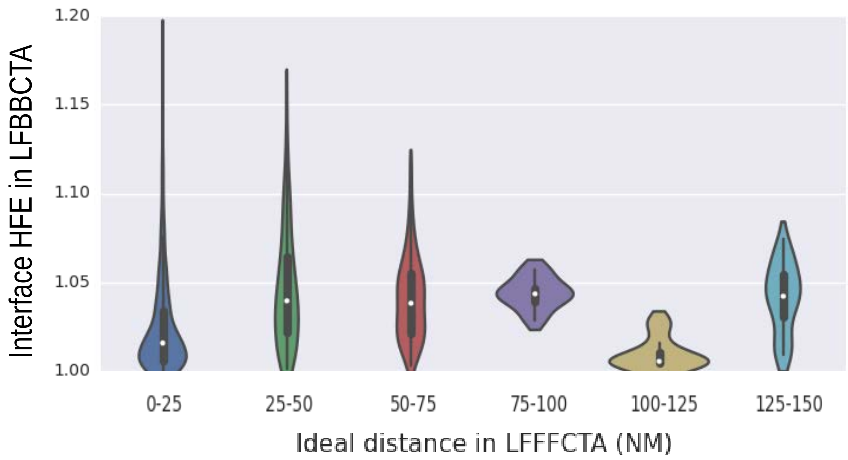
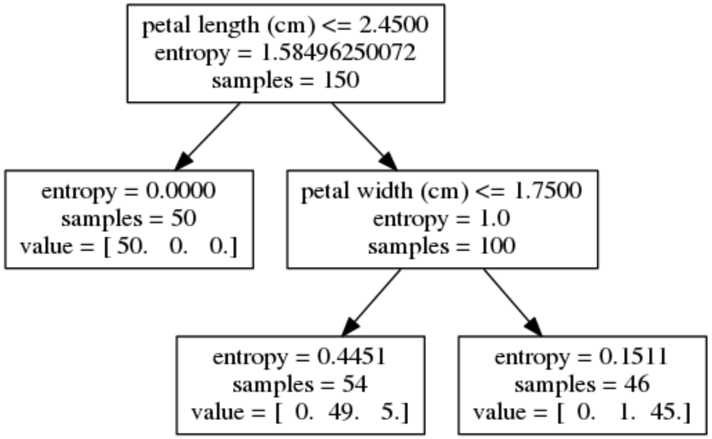
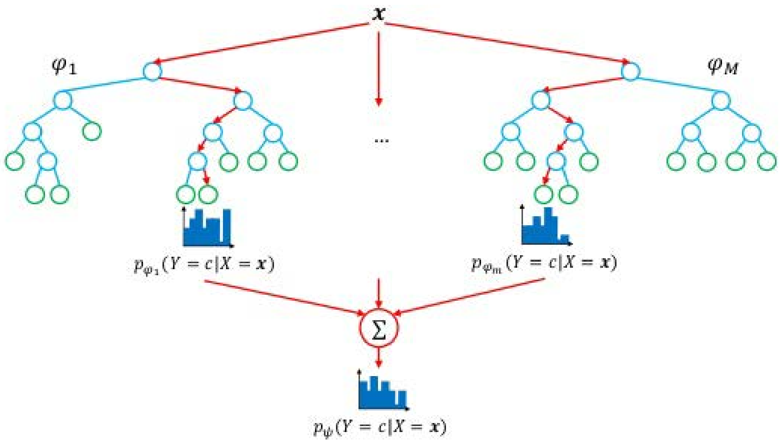




Sources of Flight Inefficiency
Comparison of data sources

	Random forest regressor R^2 score	
Data	DDR	CPR
Training	0.973	0.980
Validation	0.804	0.836
Testing	0.770	0.757





Sources of Flight Inefficiency
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	Random forest regressor R^2 score	
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Feature	**Relative importance**	
Data Source	DDR	CPR
Planned interface HFE in LFBBCTA	42.08%	43.55%
Distance between planned and ideal exit point from LFBBCTA	17.57%	17.06%
Distance between planned and ideal entry point to LFBBCTA	6.02%	7.56%
Ideal distance in LFFFCTA	4.42%	4.14%
Ideal distance in LFBBCTA	3.94%	3.52%
Ideal distance	3.79%	4.20%
Planned local HFE in LFBBCTA	3.17%	3.18%
Average heading	2.99%	2.62%
Ideal distance in LECMCTA	2.52%	2.18%
Ideal distance in LFRRCTA	2.42%	1.50%
Ideal distance in LFMMCTA	1.65%	1.63%
Ideal distance in LECBCTA	1.37%	1.48%
Reference FL in LFBBCTA	1.37%	1.52%
Flights per sector in LECBCTA	1.12%	0.80%
Flights per sector in LECMCTA	1.00%	0.75%
Flights per sector in LFMMCTA	0.85%	0.82%
Take-off time - cosine	0.83%	0.84%
Take-off time - sine	0.81%	0.81%
Flights per sector in LFFFCTA	0.74%	0.67%
Flights per sector in LFBBCTA	0.73%	0.59%
Flights per sector in LFRRCTA	0.62%	0.55%

Sources of Flight Inefficiency
Influence Factors

AIRAC 1702

Testing NRMSE: 4.3 %

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\+ **Flights crossing LFBBCTA**

\+ **Weekday**

\+ **Number of the day**

Feature	Relative importance
Planned interface HFE in LFBBCTA	51.16%
Distance between planned and ideal exit point from LFBBCTA	14.22%
Distance between planned and ideal entry point to LFBBCTA	6.41%
Ideal distance in LFBBCTA	4.86%
Ideal distancein LFFFCTA	4.36%
Average heading	3.42%
Ideal distance	3.17%
Ideal distance in LFRRCTA	2.34%
Planned local HFE in LFBBCTA	1.89%
Ideal distance in LECMCTA	1.87%
Ideal distance in LFMMCTA	1.84%
Ideal distance in LECBCTA	1.75%
Reference FL in LFBBCTA	0.69%
Take-off time - cosine	0.43%
Flights per ATCO in LECMCTA	0.22%
Take-off time - sine	0.20%
Flights per ATCO in LFBBCTA	0.17%
Flights per ATCO in LFFFCTA	0.16%
Flights per ATCO in LFMMCTA	0.16%
Flights per ATCO in LFRRCTA	0.16%
Flights per ATCO in LECBCTA	0.15%
Number of the day	0.11%
Flights crossing LFBBCTA	0.10%
Weekday - cosine	0.07%
Weekday - sine	0.07%

Sources of Flight Inefficiency Applicability and Future Research

Applications:

- Performance assessment
- Performance optimisation

Future developments:

- Include further factors: weather, military…
- Include further KPIs: fuel, delay…
- Study seasonality effects
- Upscale to the Network, study specificities and commonalities

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Contact: aviation@nommon.es

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