User-centric Cost-based Flight Efficiency and Equity indicators

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Abstract and Outline

The current implementation of efficiency measurement (as defined in the SES Performance Scheme) affects the ANSPs view on efficiency since the ANSPs have to report on specific KPIs to evaluate their performance and management of the air traffic. This implementation takes into consideration only the horizontal portion of the flight, measuring the excess horizontal en-route distance compared to the orthodromic. This approach lacks of important information from airspace users’ objectives since it leaves out the vertical component of the flight or wind conditions.

In order to introduce the airspace users’ objectives into the global net efficiency measurement, it is key to develop advanced metrics that consider fuel consumption, schedule adherence or cost of the flight. These new efficiency metrics require the design of user-preferred trajectories as the main reference for performing comparisons. Additionally, airspace users are claiming for equity metrics showing how these inefficiencies are distributed between them in certain areas such as Flight Information Regions or city-pairs.

This paper presents the methodology followed for the design of advanced user-centric cost-based efficiency and equity indicators as well as a flight efficiency and equity assessment of the European traffic flow in two particular days in February 2017 taking into consideration the airspace users’ perspective.

This research was conducted under the AURORA project (Grant 699340) supported by SESAR Joint Undertaking under European Union’s Horizon 2020 research and innovation programme. AURORA aims to propose new metrics to assess the operational efficiency of the ATM system and to measure how fairly the inefficiencies in the system are distributed among the different airline operators.

**Keywords** Airlines; ANSP; Flight Efficiency; KPI; Air Traffic Management; SESAR; ADS-B.

- Motivation and current status
- Methodology
- Results
- Conclusions
WHY ASSESING OPERATIONAL EFFICIENCY?

▪ Airlines have their perspective of what is an efficient flight (punctuality, less fuel,...) -> LESS COST

▪ Regulators /ANSPs may have a different perspective on what is an efficient flight (Filed flight plan? Tactical decisions/updated flight plan? Direct flights? Free flight?....

▪ ANSPs are measured to make airlines flight efficiently according to their view on efficiency
  ▪ Not Vertical Profile nor Fuel Consumption considered;
  ▪ Not Weather taken into account;

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ICAO defines 11 KPAs to motorize the evolution of air traffic services [1]: SAFETY, ENVIRONMENT, COST-EFFECTIVENESS, CAPACITY, ....

The European Commission formally designated Eurocontrol as the Performance Review Body (PRB) for ECAS ANSPs [2]

Eurocontrol launched the Performance Review by creating the independent Performance Review Commission (PRC), supported by the Performance Review Unit (PRU)

“to ensure the effective management of the European Air Traffic Management system through a strong, transparent and independent performance review”

PRU provides metrics and methodology to calculate those metrics and review and harmonize the different local ANSPs reports into the annual Performance Review Report [3]

[2]. Regulation (EC) No 549/2004 laying down the framework for the creation of the single European sky (the framework Regulation)
Regulation (EU) No 691/2010 laying down a performance scheme for air navigation services and network functions.
**PRU definition of Efficiency (under Environment KPA)**

**Performance Indicator – Horizontal Flight Efficiency, EUROCONTROL, 2014**

http://ansperformance.eu/references/methodology/horizontal_flight_efficiency_pi.html

The comparison between the length of a trajectory and the shortest distance between its endpoints

<table>
<thead>
<tr>
<th>INDICATOR</th>
<th>DEFINITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>KEP</td>
<td>Horizontal flight efficiency of last filed flight plan taking as reference minimum flown distance (achieve distance for local)</td>
</tr>
<tr>
<td>KEA</td>
<td>Horizontal flight efficiency of actual trajectory taking as reference the minimum flown distance (achieve distance for local)</td>
</tr>
</tbody>
</table>
To accomplish with their target ANSP´s try to adapt as much as possible the flown trajectory to the geodesic, but...
What happen if the Geodesic route is more inefficient in terms of fuel, cost...?
THE AURORA PROJECT

OBJECTIVES

- Define new efficiency indicators that better accommodate airline’s view on efficiency based on fuel and cost (*).
- Data, methodology and tools that need to be deployed for an advanced operational efficiency assessment.
- Explore big data techniques for real time efficiency measurement
- Propose an open framework for global and local efficiency assessment

(*) Delays are considered by the PRU under a different KPA: Capacity
# Example of AURORA new Indicators

<table>
<thead>
<tr>
<th>INDICATOR</th>
<th>MEASURE</th>
<th>DEFINITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>KEA</td>
<td>Distance</td>
<td>Quantifies the horizontal deviations of the Actual Flown Trajectory (AFT) in comparison with the Optimal Distance Trajectory (ODT)</td>
</tr>
<tr>
<td>FEA-DW</td>
<td>Fuel</td>
<td>Quantifies the extra-fuel consumption of the Actual Flown Trajectory (AFT) in comparison with the Optimal Distance Trajectory (ODT).</td>
</tr>
<tr>
<td>FEA-FW</td>
<td>Fuel</td>
<td>Quantifies the extra-fuel consumption of the Actual Flown Trajectory (AFT) in comparison with the Optimal Fuel Trajectory (OFT).</td>
</tr>
<tr>
<td>CEA-CW1</td>
<td>Cost</td>
<td>Quantifies the extra-costs of the Actual Flown Trajectory (AFT) in comparison with the Optimal Cost Trajectory (OCT1).</td>
</tr>
<tr>
<td>CEA-CW2</td>
<td>Cost</td>
<td>Quantifies the extra-costs of the Actual Flown Trajectory (AFT) in comparison with the Optimal Cost Trajectory (OCT2).</td>
</tr>
<tr>
<td>EQ-3</td>
<td>Equity</td>
<td>Net difference in AU's fuel consumption in comparison with the mean value (based on standard deviation of average percentage of actual and planned fuel consumption for each airline)</td>
</tr>
<tr>
<td>EQ-4</td>
<td>Equity</td>
<td>Quantifies the standard deviation of the mean ratio between the actual costs and the planned costs of all flights belonging to each airline</td>
</tr>
</tbody>
</table>

**LESS IS BETTER!!**
## Indicators Scheme

### Increasing complexity in calculations

<table>
<thead>
<tr>
<th>Indicators subset</th>
<th>Geodesic trajectory</th>
<th>Fuel-efficient trajectory</th>
<th>Cost-efficient trajectory (Time &amp; Fuel)</th>
<th>Cost-efficient Trajectory (Time &amp; Fuel &amp; Taxes)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Distance-based</strong></td>
<td>KEP</td>
<td>KEA</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Fuel-based</strong></td>
<td></td>
<td>Actual</td>
<td>Planned</td>
<td></td>
</tr>
<tr>
<td><strong>Time &amp; Fuel Cost-based</strong></td>
<td></td>
<td>Actual</td>
<td>Planned</td>
<td></td>
</tr>
<tr>
<td><strong>Total Cost-based</strong></td>
<td></td>
<td></td>
<td></td>
<td>Actual</td>
</tr>
</tbody>
</table>

Increasing representativeness
Methodology

Compare real flights (surveillance) with artificial what-if flights: flight plan, optimal in distance, optimal in fuel, optimal in cost,…

Reference Trajectories obtained from FR24 ADS-B Tracks, NM Flight Plans and trajectory optimization algorithms
Methodology: Reference Trajectories

Actual Flown Trajectory (also reconstructed trajectory) (AFT):

Optimal Cost Trajectory 1 (OCT1): Free routing or unconstrained optimal trajectory establishing as optimization criteria minimum cost (cost of fuel + cost of time, or fuel consumed + CI x Time).

Optimal Cost Trajectory 2 (OCT2): flying following the route in the flight plan, but optimizing the vertical profile (speeds and altitudes) to minimize cost.

Optimal Distance Trajectory (ODT): This is the shortest distance trajectory, the one that follows the Great Circle from origin to destination. This trajectory is aligned with how efficiency is currently measured by SES Performance Scheme through the Achieved Distance methodology;

Flight Plan Trajectory (also Procedure-Optimal Trajectory) (FPT): This trajectory corresponds to the filed flight plan and contains all procedural constraints.
Methodology: Vertical Profiles

Trajectory comparison, vertical profile

Altitude [m]
0 2000 4000 6000 8000 10000 12000
0 0.5 1 1.5 2 2.5 3
Distance [m]

ACTUAL FLOWN TRAJECTORY
FLIGHT PLAN TRAJECTORY
OPTIMAL DISTANCE TRAJECTORY
OPTIMAL FUEL TRAJECTORY
OPTIMAL COST TRAJECTORY 1

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Scenarios

The study presented corresponds to the analysis of all real ADS-B equipped flights that took-off and landed inside the European Civil Aviation Conference (ECAC) area occurring on February 20th and 24th 2017 (~ 15,000 flights per day)

<table>
<thead>
<tr>
<th>TYPE</th>
<th>FORMAT</th>
<th>SOURCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surveillance</td>
<td>ADS-B message</td>
<td>FR24</td>
</tr>
<tr>
<td>Flight Plan</td>
<td>FTFM point profile from ALLFT+ file</td>
<td>EUROCONTROL</td>
</tr>
<tr>
<td></td>
<td>BADA 3.10 APF files</td>
<td></td>
</tr>
<tr>
<td>Aircraft Performance</td>
<td>BADA 3.10</td>
<td>EUROCONTROL</td>
</tr>
<tr>
<td>Weather</td>
<td>GFS data as grib2 files</td>
<td>NOAA</td>
</tr>
<tr>
<td>CI</td>
<td>One value per aircraft type</td>
<td>Aircraft manufacturers’ documentation</td>
</tr>
</tbody>
</table>

Summary of input data

- Is it feasible?
- Will the picture of the European traffic change depending on the metric chosen?
- Can we observe some degree of correlation between simpler and complex KPIs?
- Could we use KPIs values to identify certain lost of efficiency events?
Scenarios: Weather

20/02/2017

24/02/2017
Results – Cost Efficiency (1/4)

CEA-CW1: Flown cost vs. Optimal cost O-D.

<table>
<thead>
<tr>
<th>Date</th>
<th>KEA* Mean Value</th>
<th>CEA-CW1 Mean Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>20/02/2017</td>
<td>9.7%</td>
<td>9.3%</td>
</tr>
<tr>
<td>24/02/2017</td>
<td>10.2%</td>
<td>10.0%</td>
</tr>
</tbody>
</table>

\[ R^2 = 0.76 \]
Results – Cost Efficiency (2/4)

IBE481 from OVD to MAD - CEA_CW1: 30.2%

IBE04VM from MAD to OVD - CEA_CW1: 13.7%
Results – Cost Efficiency (3/4)

CEA-CW2: Flown cost vs. Optimal cost O-D.

<table>
<thead>
<tr>
<th>Date</th>
<th>KEA* MEAN VALUE</th>
<th>CEA-CW2 MEAN VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>20/02/2017</td>
<td>9.7%</td>
<td>4.6%</td>
</tr>
<tr>
<td>24/02/2017</td>
<td>10.2%</td>
<td>6.2%</td>
</tr>
</tbody>
</table>

$R^2 = 0.45$
Results – Fuel Efficiency (4/4)

FEA-FW: Flown fuel consumption vs. Optimal fuel O-D.

<table>
<thead>
<tr>
<th>Date</th>
<th>KEA* MEAN VALUE</th>
<th>FEA-FW MEAN VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>20/02/2017</td>
<td>9.7%</td>
<td>14.9%</td>
</tr>
<tr>
<td>24/02/2017</td>
<td>10.2%</td>
<td>15.3%</td>
</tr>
</tbody>
</table>

$R^2 = 0.68$
Equity Indicators Calculation

A1 mean → Mean → A2 mean → Standard deviation: EQUITY → A3 mean
Results – Equity

<table>
<thead>
<tr>
<th>BY REGION</th>
<th>BY CITY-PAIR</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EQ-4 region (%)</strong></td>
<td><strong>EQ-4 Distribution (%)</strong></td>
</tr>
<tr>
<td><strong>Associated Mean</strong></td>
<td><strong>Associated Mean</strong></td>
</tr>
<tr>
<td>3.09</td>
<td>5.9</td>
</tr>
<tr>
<td>2.49</td>
<td>5.1</td>
</tr>
<tr>
<td>3.04</td>
<td>1.3</td>
</tr>
<tr>
<td>3.29</td>
<td>0.8</td>
</tr>
<tr>
<td>0.94</td>
<td>2.0</td>
</tr>
<tr>
<td>1.03</td>
<td>2.8</td>
</tr>
<tr>
<td>1.48</td>
<td>1.6</td>
</tr>
<tr>
<td>1.07</td>
<td></td>
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</tbody>
</table>

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On-Line Calculation of Indicators
Conclusions and Final Remarks

- Lack of operational efficiency diminishes aircraft capabilities.
- ANSPs are currently evaluated in a way that is not clearly beneficial for the airlines.
- New indicators might close the gap on the different visions of efficiency.
- New indicators requires new trajectory computation capabilities, data management and access.
- Due to the methodology proposed, ADS-B data could serve as a reliable source on the performance monitoring at the ECAC level, providing a new paradigm in where ANSP’s performance is only evaluated locally, i.e., at the level of an ANSP area of responsibility, but globally, i.e., how the actions of the ANSP impacts the overall ANSPs involved.
- ADS-B seems a global and reliable source for this process: fully exploited in online efficiency assessment

[www.aurora-er.eu]
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The opinions expressed herein reflect the author’s view only. Under no circumstances shall the SESAR Joint Undertaking be responsible for any use that may be made of the information contained herein.
QUESTIONS?
## MOTIVATION

<table>
<thead>
<tr>
<th>Airline Perspective</th>
<th>ANSP Perspective (European View)</th>
</tr>
</thead>
<tbody>
<tr>
<td>▪ Punctuality, Fuel efficiency, Cost efficiency</td>
<td>▪ PRU define the metrics based on ICAO KPA.</td>
</tr>
<tr>
<td>▪ Airlines would like to fly their network optimal, or to adjust their Network to the new routes, not always allowed in the airspace structure</td>
<td>▪ Local Efficiency vs Global efficiency</td>
</tr>
<tr>
<td></td>
<td>▪ Currently, Horizontal Flight Efficiency</td>
</tr>
</tbody>
</table>

**CAN WE PROVIDE AIRLINES and ANSPs with a set of METRICS to assess their performance with a common view?**
WHY ASSESING OPERATIONAL EFFICIENCY?

Flight Orly - Madrid
WHY?

Flight Orly – Madrid
20-February-2017

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WHY?

Flight Orly – Madrid
24-February-2017
WHY?

Very frequent “direct to” Spanish airspace

Airline carries extra fuel for planning a longer route
KEA & FEA-DW - Example I

<table>
<thead>
<tr>
<th>KEA</th>
<th>FEA-DW</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.91</td>
<td>7.78</td>
</tr>
</tbody>
</table>
KEA & FEA-DW - Example II

<table>
<thead>
<tr>
<th>KEA</th>
<th>FEA-DW</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.32</td>
<td>0.53</td>
</tr>
</tbody>
</table>
**KEA & FEA-FW - Example I**

<table>
<thead>
<tr>
<th>KEA</th>
<th>FEA-FW</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.77</td>
<td>18.47</td>
</tr>
</tbody>
</table>

![Graph 1](Image 1)

![Graph 2](Image 2)
KEA & FEA-FW - Example II

<table>
<thead>
<tr>
<th>KEA</th>
<th>FEA-FW</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.68</td>
<td>59.35</td>
</tr>
</tbody>
</table>
KEA & CEA-CW1 - Example 1

Cost Based (Free route and CI>0) Reference trajectory

Fuel Based (Free route and CI=0) Reference trajectory

<table>
<thead>
<tr>
<th>THY4LF</th>
<th>Zurich-Istanbul</th>
</tr>
</thead>
<tbody>
<tr>
<td>KEA</td>
<td>10.05 %</td>
</tr>
<tr>
<td>FEA-FW</td>
<td>20.53 %</td>
</tr>
<tr>
<td>CEA-CW1</td>
<td>17.37 %</td>
</tr>
</tbody>
</table>
KEA & CEA-CW1 - Example 1

Cost Based (Free route and CI>0)
Reference trajectory

Fuel Based (Free route and CI=0)
Reference trajectory

THY4LF - Zurich - Istanbul
KEA 10.05 %
FEA-FW 20.53 %
CEA-CW1 17.37 %
KEA & CEA-CW1 - Example 2

Cost Based (Free route and CI>0)
Reference trajectory

Fuel Based (Free route and CI=0)
Reference trajectory

KLM1074 - MAN-AMS

KLM1074 - MAN-AMS

KLM1074 Manchester-Amsterdam
KEA 9.22 %
FEA-FW 15.67 %
CEA-CW1 3.76 %
KEA & CEA-CW1 - Example 2

Cost Based (Free route and CI>0) Reference trajectory

Fuel Based (Free route and CI=0) Reference trajectory

<table>
<thead>
<tr>
<th>KLM1074</th>
<th>Manchester-Amsterdam</th>
</tr>
</thead>
<tbody>
<tr>
<td>KEA</td>
<td>9.22 %</td>
</tr>
<tr>
<td>FEA-FW</td>
<td>15.67 %</td>
</tr>
<tr>
<td>CEA-CW1</td>
<td>3.76 %</td>
</tr>
</tbody>
</table>
KEA & CEA-CW2 - Example 1

Cost Based (Flight Plan and CI>0)
Reference trajectory

Fuel Based (Free route and CI=0)
Reference trajectory

<table>
<thead>
<tr>
<th>THY9WR</th>
<th>Istanbul-Nuremberg</th>
</tr>
</thead>
<tbody>
<tr>
<td>KEA</td>
<td>9.60 %</td>
</tr>
<tr>
<td>FEA-FW</td>
<td>20.77 %</td>
</tr>
<tr>
<td>CEA-CW2</td>
<td>11.49 %</td>
</tr>
</tbody>
</table>

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**KEA & CEA-CW2 - Example 1**

**Cost Based (Flight Plan and CI>0)**
Reference trajectory

**Fuel Based (Free route and CI=0)**
Reference trajectory

<table>
<thead>
<tr>
<th>THY9WR</th>
<th>Istanbul-Nuremberg</th>
</tr>
</thead>
<tbody>
<tr>
<td>KEA</td>
<td>9.60 %</td>
</tr>
<tr>
<td>FEA-FW</td>
<td>20.77 %</td>
</tr>
<tr>
<td>CEA-CW2</td>
<td>11.49 %</td>
</tr>
</tbody>
</table>

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KEA & CEA-CW2 - Example 2

Cost Based (Flight Plan and Cl>0)
Reference trajectory

Fuel Based (Free route and Cl=0)
Reference trajectory

<table>
<thead>
<tr>
<th>Flight</th>
<th>KEA</th>
<th>FEA-FW</th>
<th>CEA-CW2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Madrid-Rome</td>
<td>11.49 %</td>
<td>16.70 %</td>
<td>-0.17 %</td>
</tr>
</tbody>
</table>

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KEA & CEA-CW2 - Example 2

Cost Based (Flight Plan and CI>0)
Reference trajectory

Fuel Based (Free route and CI=0)
Reference trajectory

<table>
<thead>
<tr>
<th>Flight Plan</th>
<th>Madrid-Rome</th>
<th>KEA</th>
<th>FEA-FW</th>
<th>CEA-CW2</th>
</tr>
</thead>
<tbody>
<tr>
<td>AEA1043</td>
<td>11.49 %</td>
<td></td>
<td>16.70 %</td>
<td>-0.17 %</td>
</tr>
</tbody>
</table>
KEA

Horizontal flight efficiency of actual trajectory taking as reference the minimum flown distance (achieve distance for local)

Covered Gaps (according to RP2):

• Its main purpose is for statistics to drive stakeholder behaviour to improve route design.
• It can be computed very precisely, checked and understood by everyone.
FEA-DW
Comparison between calculated fuel consumption of actual flown route and minimum distance route, considering weather

Covered Gaps:

• Weather.
• Fuel Consumption.

Hypothesis for the minimum horizontal distance trajectory:

• It starts and ends at the same point than the actual trajectory.
• Cruise Flight Level for minimum distance route is the highest flown Flight Level.
• Cruise Speed is the average of the actual cruise speed.
• Geodesic route from point to point (not aware of TMA configurations).
Comparison between calculated fuel consumption of actual flown route and minimum fuel consumption route, considering weather

Covered Gaps:
  • Weather.
  • Fuel Optimization.

Hypothesis for the minimum fuel consumption trajectory:
  • It starts and ends at the same point than the actual trajectory.
  • Minimum fuel consumption trajectory from point to point (not aware of TMA configurations).
  • Free flight.
CEA-CW1

Comparison between calculated cost of actual flown route and free route trajectory optimizing costs, considering weather

Covered Gaps:

- Weather.
- Cost (fuel, time and route charges)

Reconstruction criteria for the free route trajectory minimizing costs:

- It starts and ends at the same point than the actual trajectory.
- Set Cost Index (C.I.) for aircraft type.
- Set fuel price according to IATA.
CEA-CW2
Comparison between calculated cost of actual flown route and flight plan horizontal trajectory optimizing costs, considering weather

Covered Gaps:
- Weather.
- Cost (fuel, time and route charges)

Reconstruction criteria for the route following flight plan horizontal profile and minimizing costs:
- It starts and ends at the same point than the actual trajectory.
- The horizontal profile is the last filed flight plan, assuming this path as the minimum route charges path.
- Set Cost Index (C.I.) for aircraft type.
- Set fuel price according to IATA.
CORRELATION KEA & FEA-DW

FEA-DW vs KEA

\[ y = 0.839x - 0.6676 \]

\[ R^2 = 0.8199 \]
CORRELATION KEA & FEA-FW

\[ R^2 = 0.68 \]
CORRELATION KEA & CEA-CW1

$R^2 = 0.76$
CORRELATION KEA & CEA-CW2

KEA vs CEA-CW2

\[ R^2 = 0.45 \]
Correlation CEA-CW1 & CEA-CW2

$R^2 = 0.54$
CORRELATION FEA-FW & CEA-CW1

\[ y = 1.2021x + 3.8055 \]
\[ R^2 = 0.7666 \]
Take Away messages

- **Tools at your disposal (used in this Project):**
  - Aircraft Performance Model library (based on BADA 3 and 4) - APML
  - Trajectory prediction service - INCEPT
  - Trajectory reconstruction service - INTRAC
  - Extensive data base of Flight data – ADAPT
    - ADS-B track data - FR24, Flight Aware, BR&TE ADS-B network
    - Weather data - NOAA
    - Flight plans – EUROCONTROL
    - Aeronautical information – SWIM services from EUROCONTROL Network Manager
  - Data visualization
  - Metrics calculation
Trajectory Modeling (Intent Inference)

Trajectory Modeling World

Surveillance Track

Intent Inference

Meteo Model

Aircraft Intent

Initial Conditions

Trajectory Synthesis

Aircraft Performance Model

Meteo Model

Reconstructed Trajectory

Real World

NEED TO BE ESTIMATED!

Atmospheric conditions

Actual Trajectory

Aircraft
Trajectory Modeling (Intent Generation)

Trajectory Modeling World

- Flight Intent
- Initial Conditions
- User Preferences Model
- Operational Context Model
- Aircraft Intent
- Aircraft Performance Model
- Meteo Model
- Generated Trajectory

Real World

- Flight Plan
- Pilot
- FMS
- Guidance targets
- Aircraft
- Atmospheric conditions
- Actual aircraft state (position, speed, weight...)
- Actual Trajectory
- Tactical Amendments to Flight Plan
- AT or ABOVE FL290

SAME MODELS

NEED TO BE ESTIMATED!
PERCEPT: Characteristics

- Interfaces with NOAA (weather), FIXM and DDR (flight plans), ADS-B (surveillance), BADA (performance data)
- AIDL-based core (computation engine)
- Optimization capabilities (using optimal control)
- Very detailed trajectories: all the variables, from lat. lon. altitude time, to thrust, flaps setting, fuel flow or measured wind
- Leverage big data technologies:
  - Link to HDFS databases
  - Calls are distributed (cluster) and totally parallelised