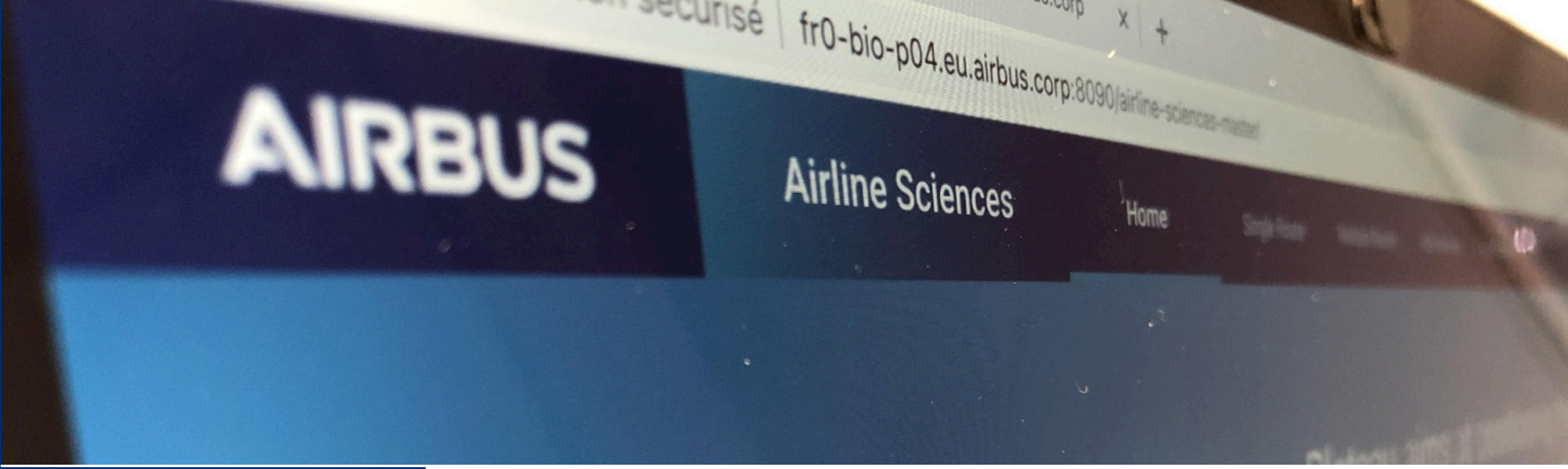


# Airline Sciences@Airbus

Workshop ITA-MIT on Big Data Analytics for Air Transportation, August 20th 2019

José Alexandre Fregnani – ATM Stream Leader

Digital Transformation Office, Airbus

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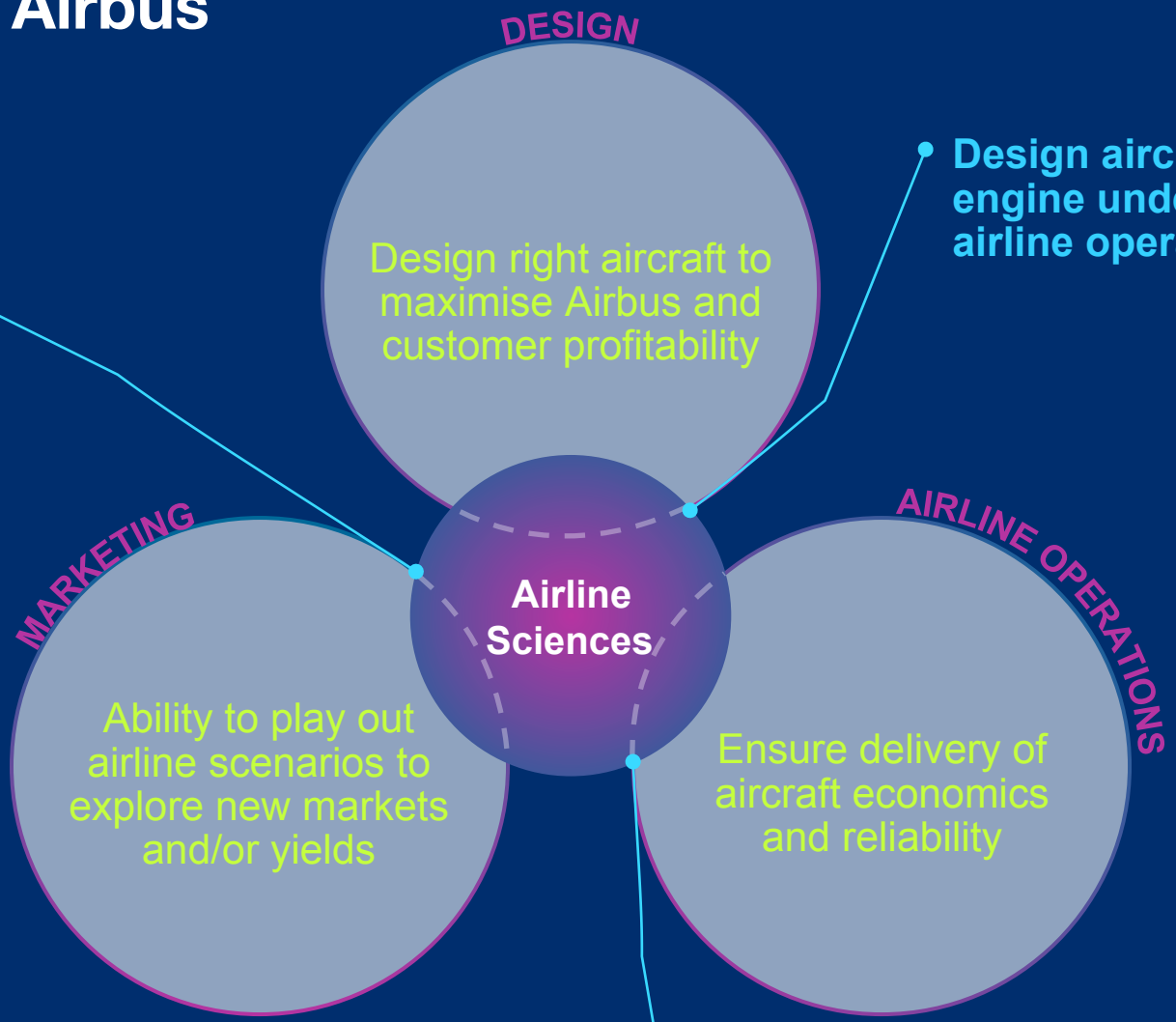
# Airline Sciences @ Airbus




**Design aircraft and engine under *actual* airline operations**

**Combine market forecasts and airline simulations**

2 years old
35+ people

**Ensure a continuum in aircraft representation and feedback enabling airline tactical gains**



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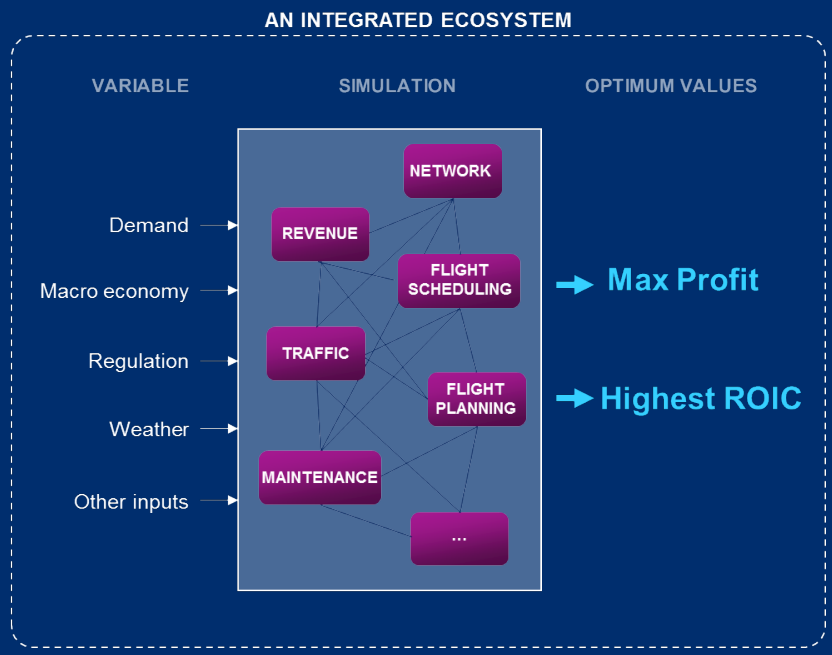
# Our Goals of this new area

## Create a bottom-up airline simulation

- Fuse observations and recorded data with high fidelity single aircraft and engine models
- Trade-off between airline economic efficiency and traffic management
- Rooted in operational realism.

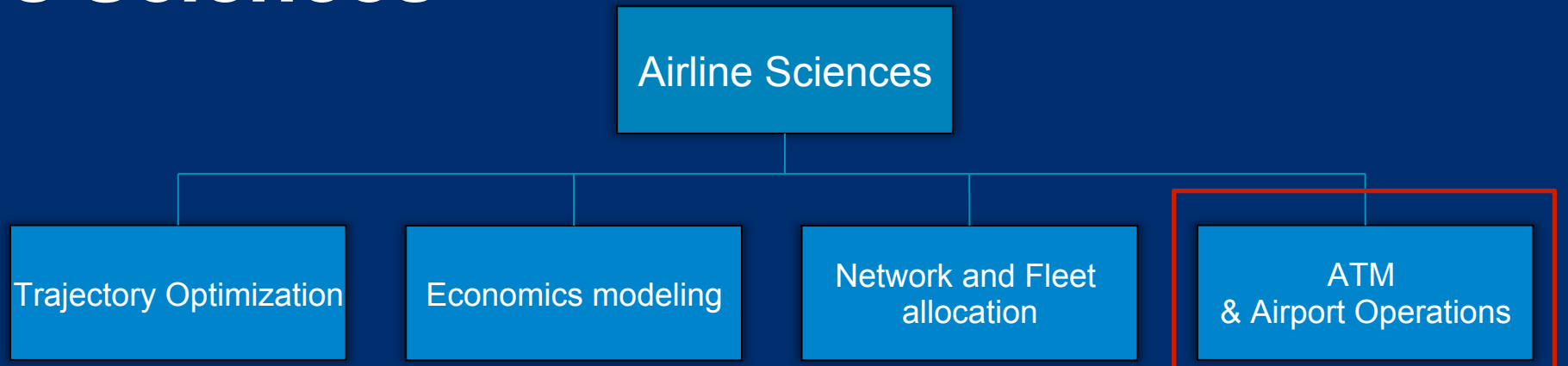
## Enable Design to Operations

- Test aircraft design on detailed operational scenarios.
- Create designs that are flexible to changing environments and markets.
- Simulate effect of environmental and regulatory impact on daily operations.
- Ability to conduct detailed trade-offs
- Anticipate future needs.




**Objective is to design best A/C to help customers to achieve maximum whole-life values of the asset**

# Airlines Sciences




- **Optimize trajectory**
  (for max payload, min fuel, min noise, max weight, max air quality) in the vicinity of a given airport, for a given aircraft model (including ETOPS, Fuel policy…)
- **Optimize Cost revenue**
  profiling
- **Optimize airline network**
  design and exploitation for max profitability
- **Optimize ATM & Airport Operations**
  for max performance (including: capacity, safety, emissions…)



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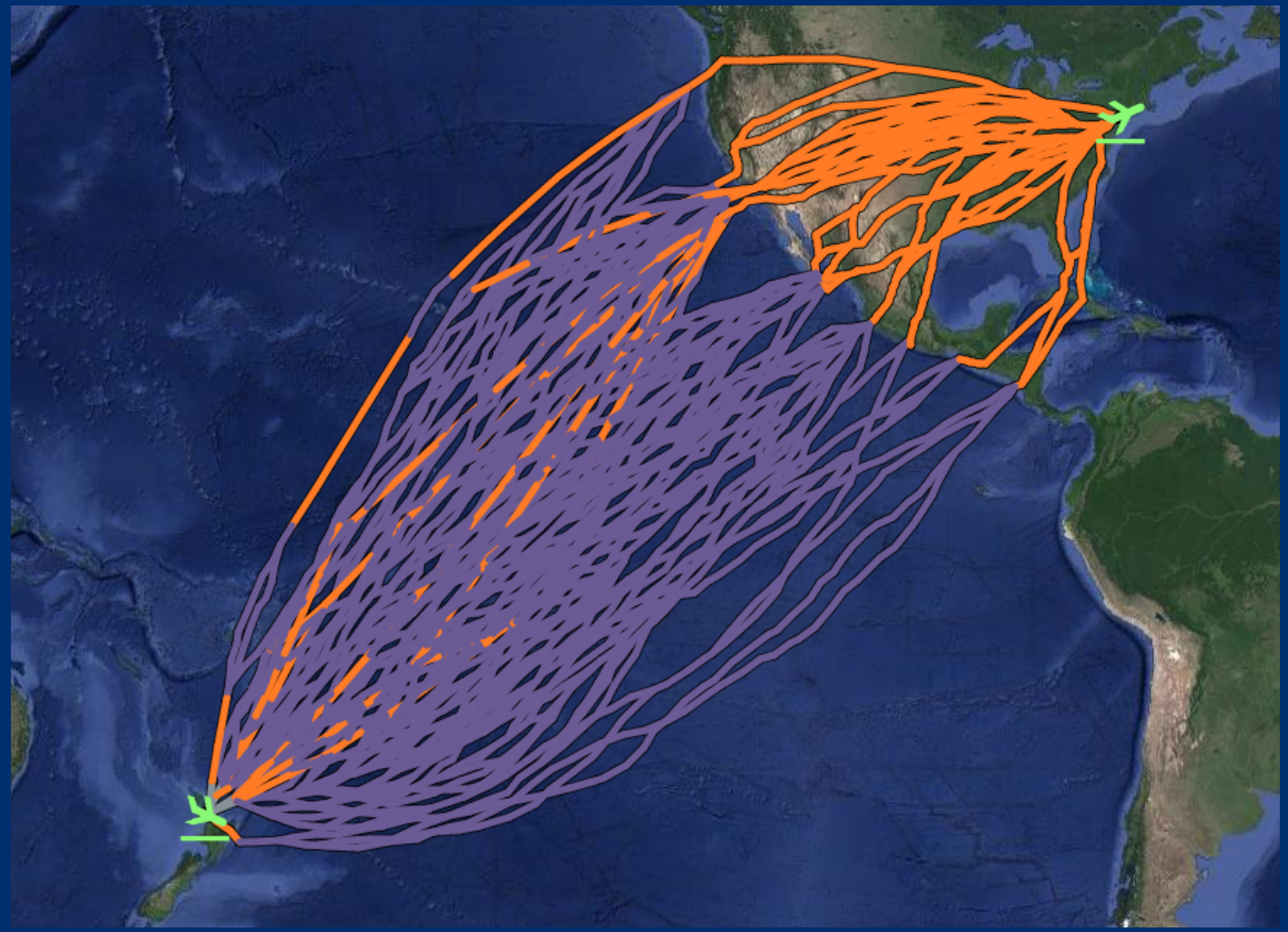
# Big data Computation



**NEW YORK – AUCKLAND**

Best paths computation
from last 10 years taking
into account weather



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# Evaluation methods are far from operational reality




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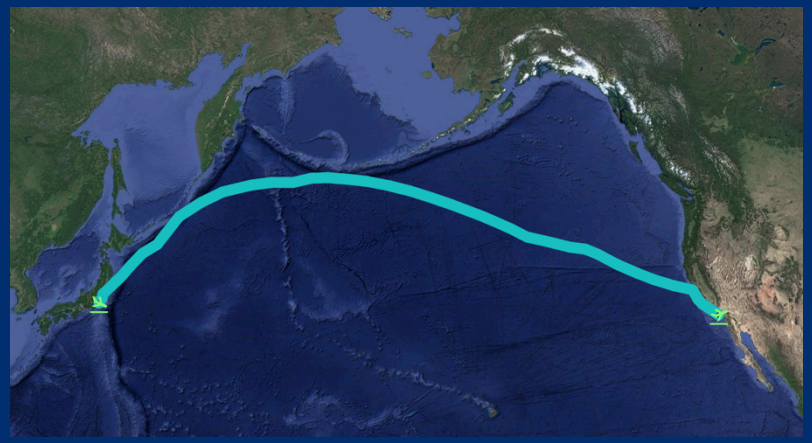
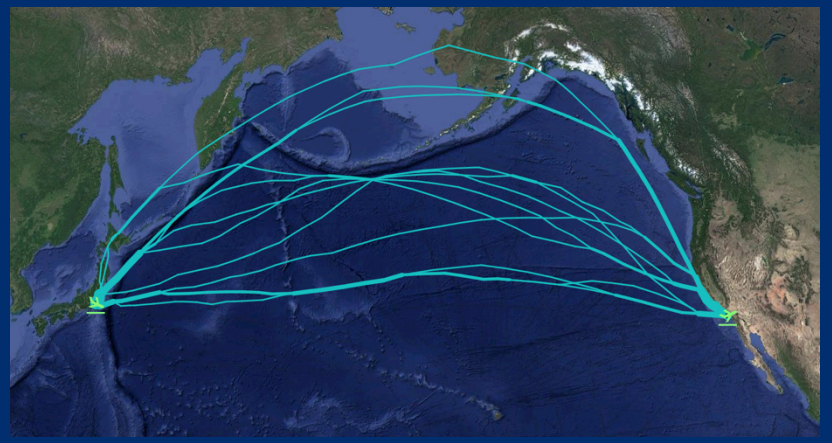
# Trajectory optimisation - The better twin of the flight planning system

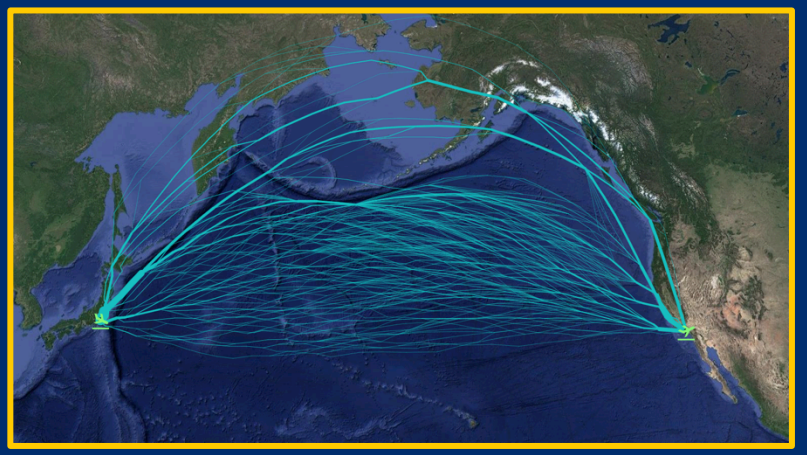
**Current Method - Simple Mode**



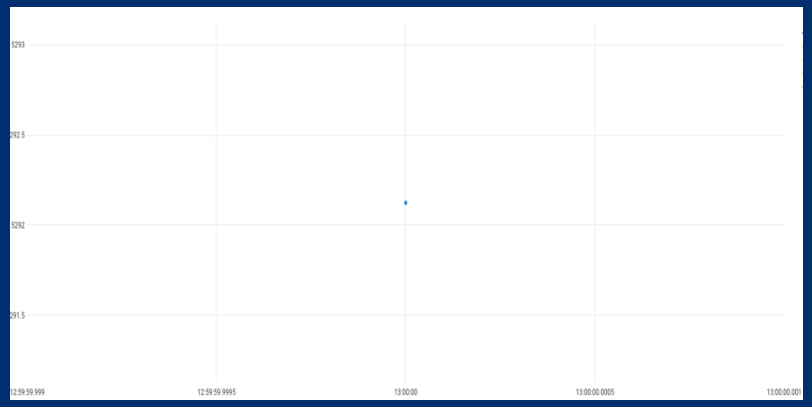
**Current Method - Advanced Mode**

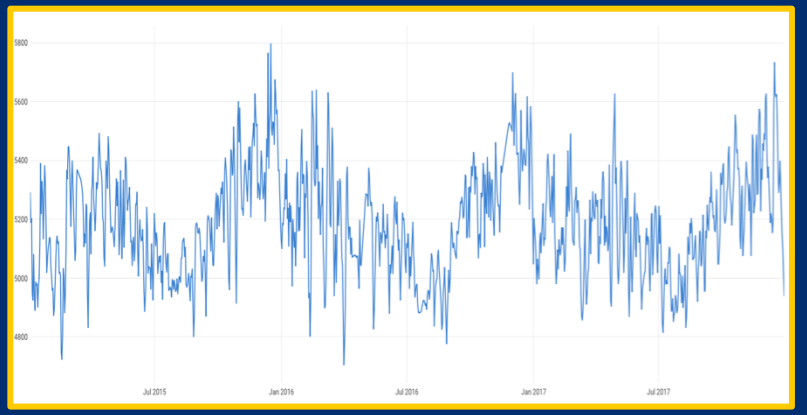


**Tomorrow**



**Less** → **Operational Realism** → **More**







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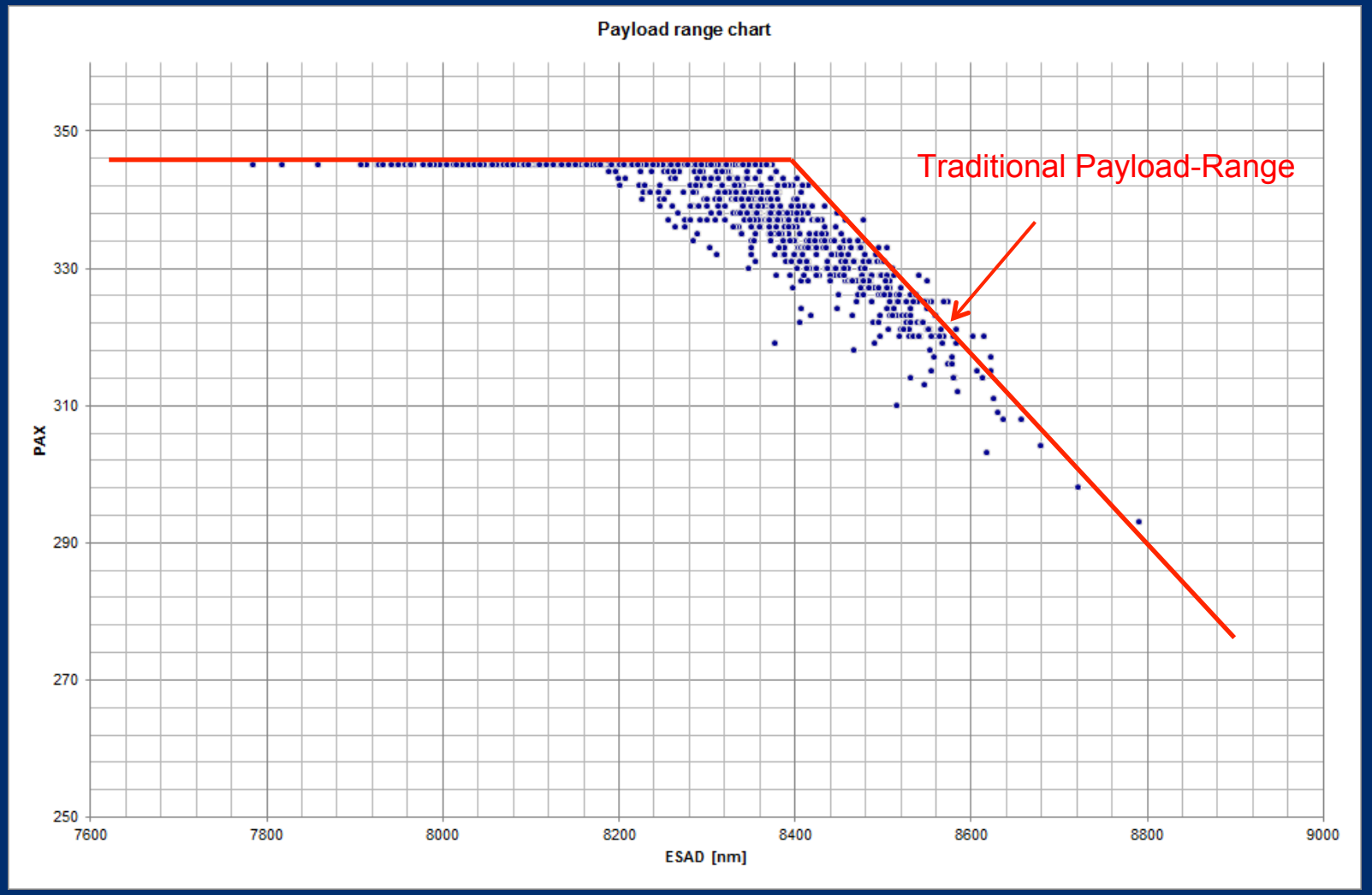
# Changing aircraft perception in industry – effect of operations.



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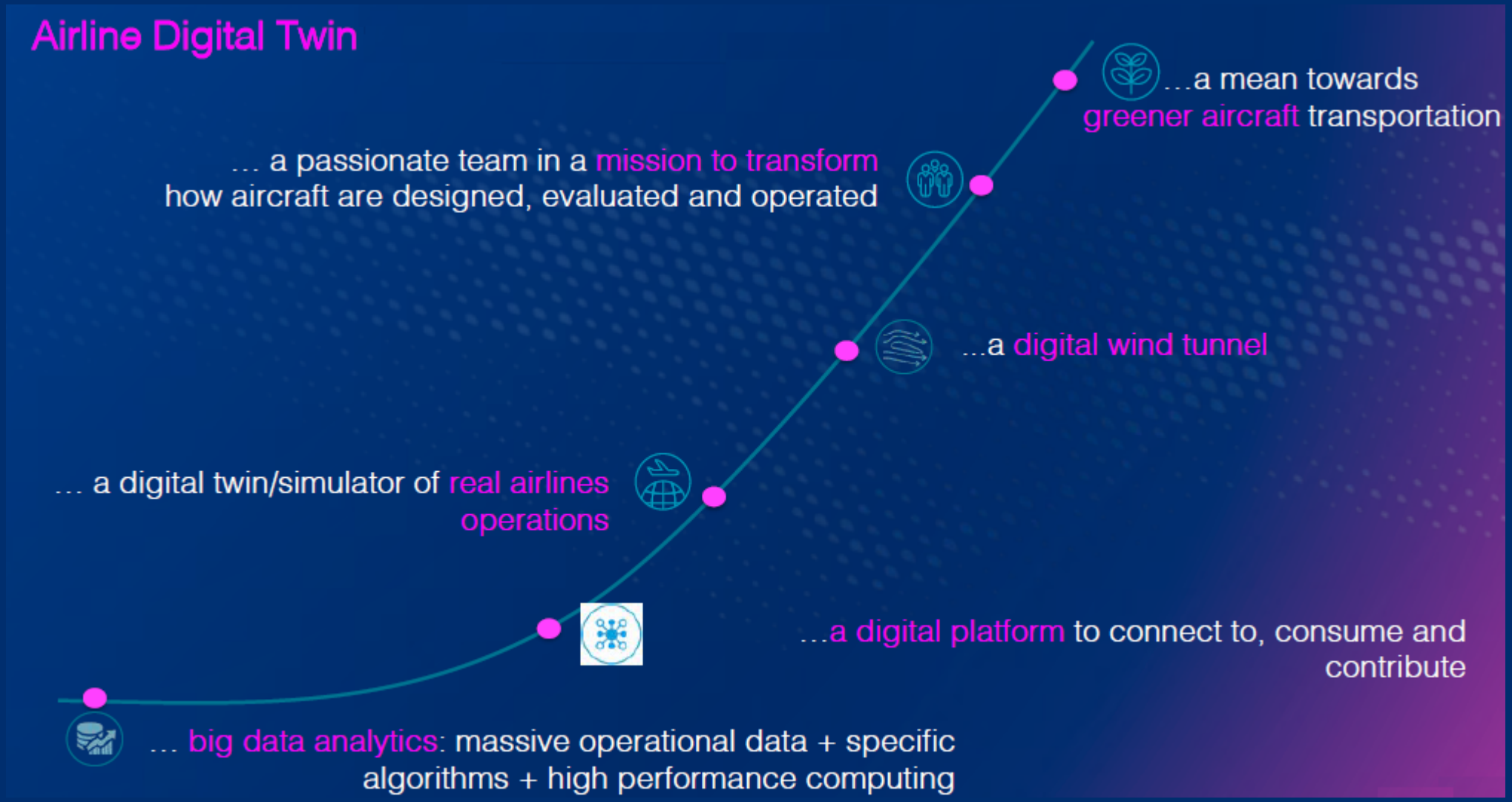
# Digital Transformation



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# Using the past to better know the future

## Historical

Daily weather
- Wind
- Temperature

Air Navigation Data
- Arinc 424

Operations Data
- ADS-B
- SWIM

Demand and yields
- Skyscanner
- Sabre

....

## Tomorrow

Aircraft Performance
- Block Fuel
- Block Time
- Payload

Operational constraints

Economics
- Demand
- Cost
- Revenue
- Commercial Capacity

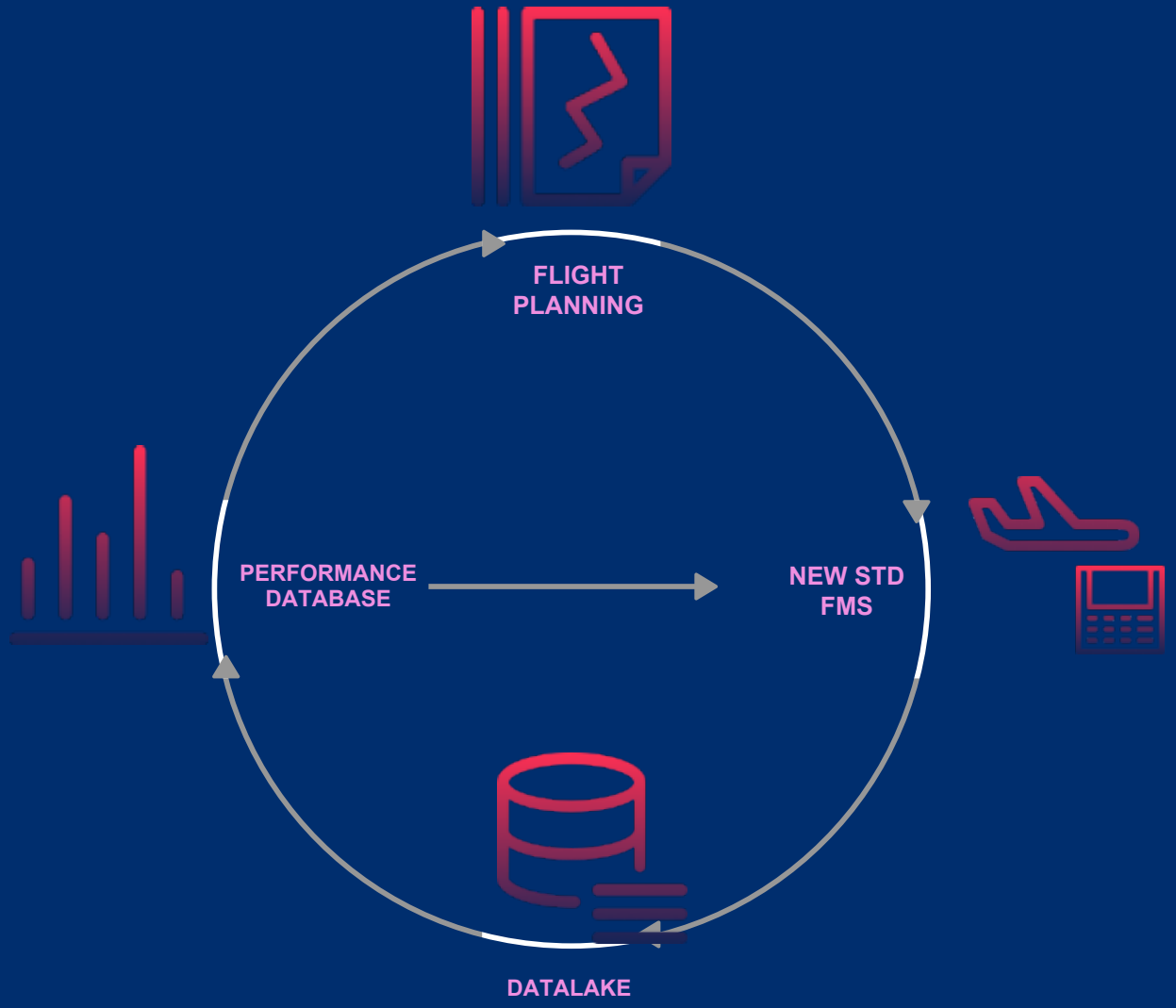
Network
- Optimal routes
- Optimal schedule
- Optimal type assignment
- Optimal aircraft rotation

# Tailored aircraft models based on field data

## Complete Tail Centric Loop

**AIRCRAFT SENSOR DATA** used to adjust performance model

**PERFORMANCE MODELS** used to derive a consistent Tail-Centric FMS database & compute flight plan



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# Air Traffic Management - The information mine

- The predictability of **non-published constraints** in the airspace is crucial for airlines to operate more efficiently.

- Many times these constraints are difficult to track and may not be included into the flight planning process or AIPs;

- They represent unscheduled holdings, altitude steps, route shortcuts, offsets, speed variations, etc…

- Derived from tactical actions inflight:
  - Pilot´s decisions;
  - FIR coordination via informal deals;
  - Frequent weather deviations.


Flight planning optimization is maximized if airspace constraints are likely to be considered into the process.



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# Air Traffic Management - The information mine

- We propose a new way to optimize airline´s network for maximum performance considering ATM aspects.

- How ?
  1. Using flight trajectories, extracted from surveillance data streams (i.e. ADS-B), operational event patterns are detected. Three types of related events are identified:
     - ✓ Lateral profile (i.e. regular route shortcuts)
     - ✓ Vertical profile (i.e. intermediate alt steps)
     - ✓ Airport specific (i.e. unscheduled holdings)

  2. Once identified, machine learning algorithms are applied to construct prediction models to determine WHERE and WHEN these events are happening (at some level of statistical confidence) in airline's route network;

  3. Then these events are injected as constraints into the flight plan to be optimized during the dispatch process.


*Predictability aims on minimizing extra fuel loaded and therefore maximizing payload.*



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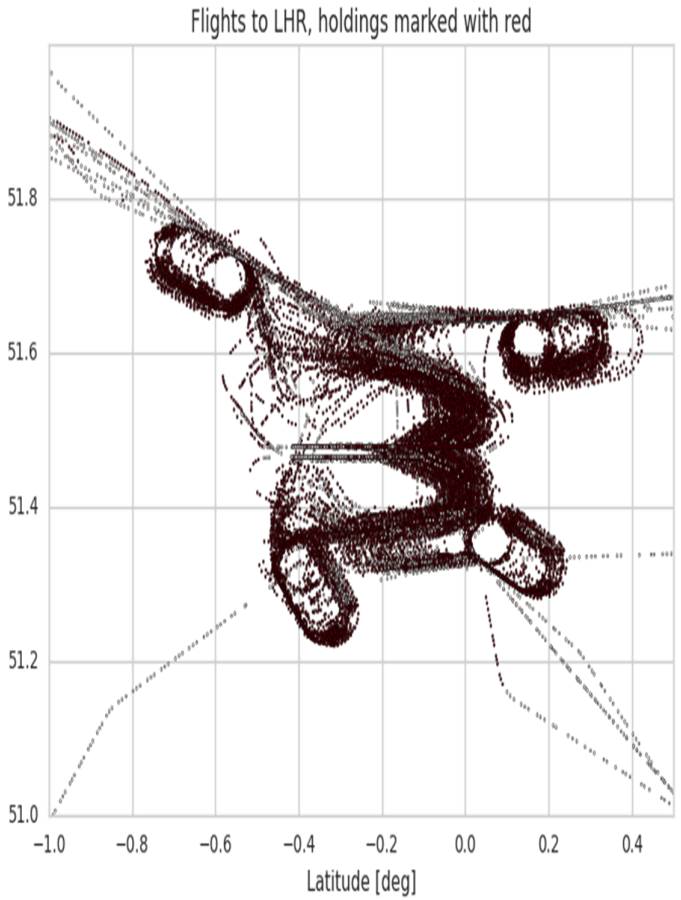
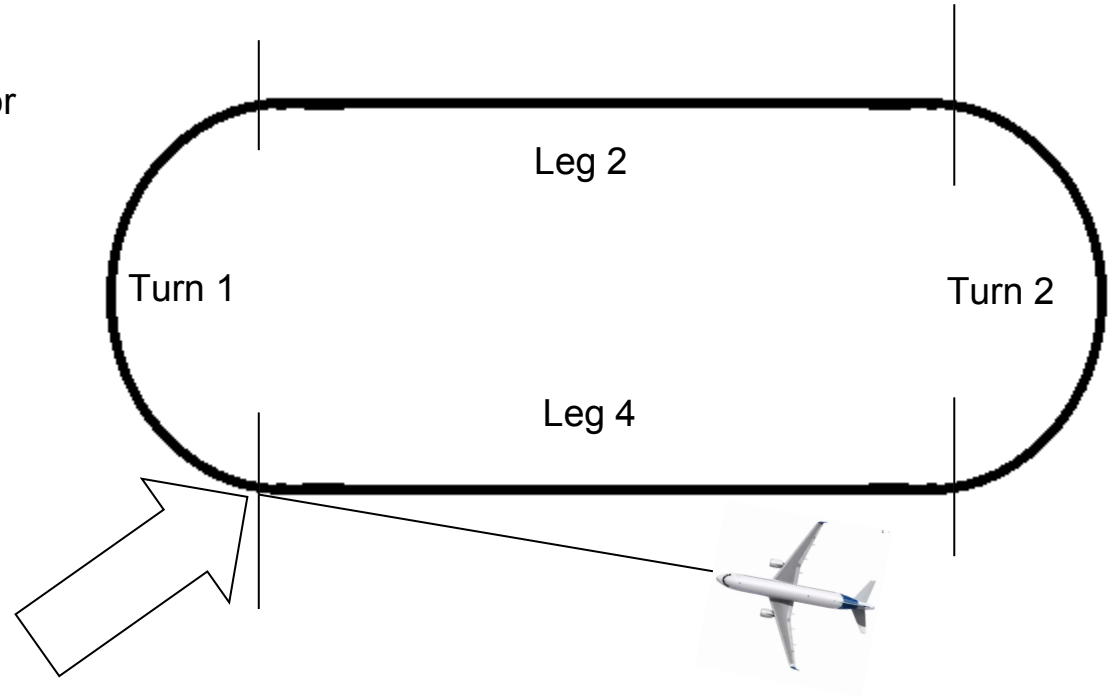
# Air Traffic Management - The information mine

Extracts actual data from ADS-B data to detect operational events. Ex: HOLDINGS




Exit Point:
Accum HDG >350 deg or
Accum HDG<-350 deg
within 10 min

Note:
"snake" or "trombones" are captured using
abs (Accum HDG)

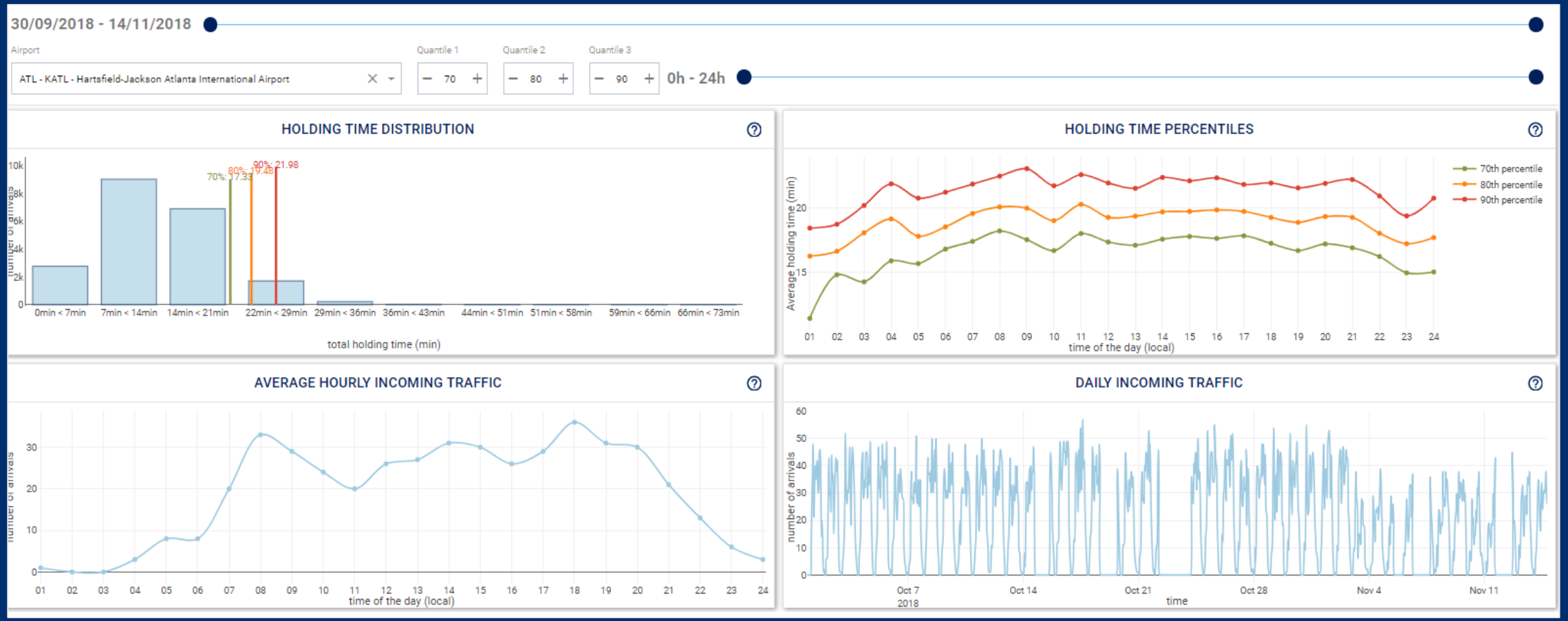



Trigger point:
Abs(dHDG/dt) >= 1.5 deg/s

Number of Holdings = Accum Heading/360

# Air Traffic Management - The information mine

And then turn into analytics



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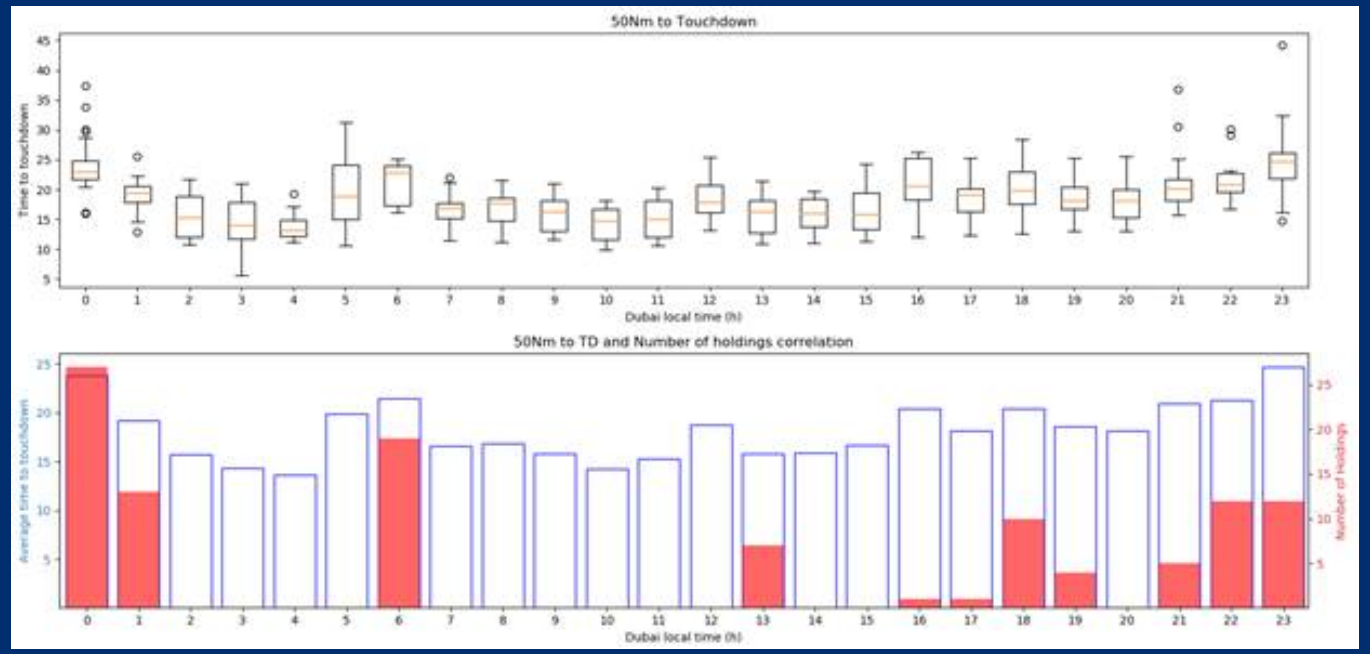
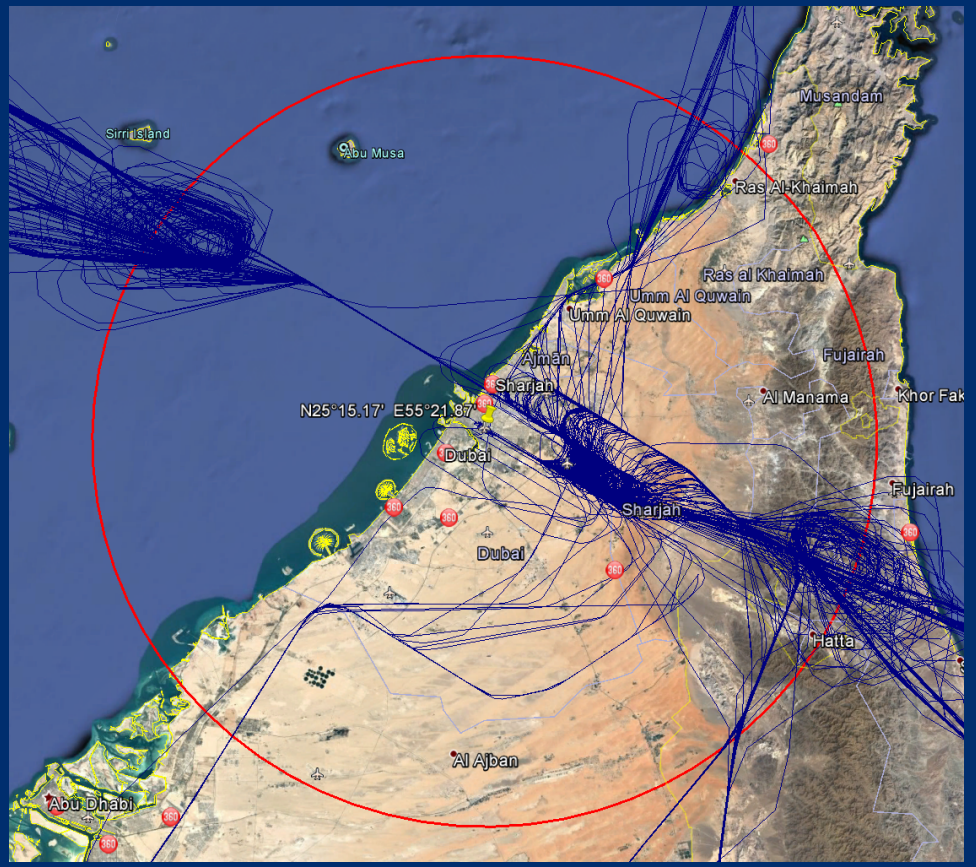
# Air Traffic Management - The information mine

DXB Analysis:
Time required from 50nm to tochdown relates closely with the number of Holdings
Several Peak Times noticeable:

- Around Midnight (10 PM - 2 AM)
- Early morning (5 - 6 AM)
- Around Midday (12 - 1 PM)
- Early evening (4 - 6 PM)



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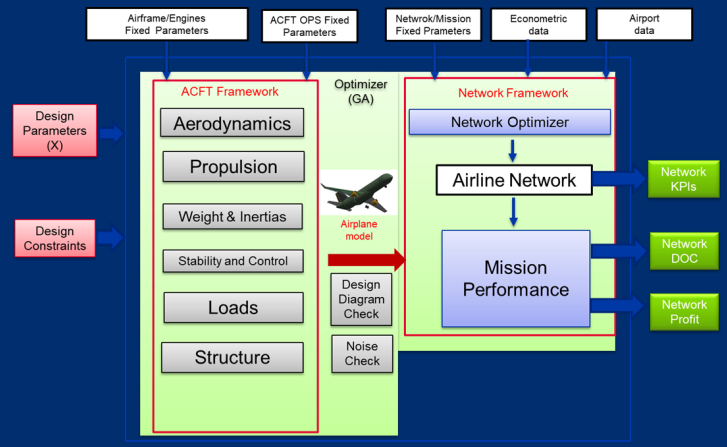
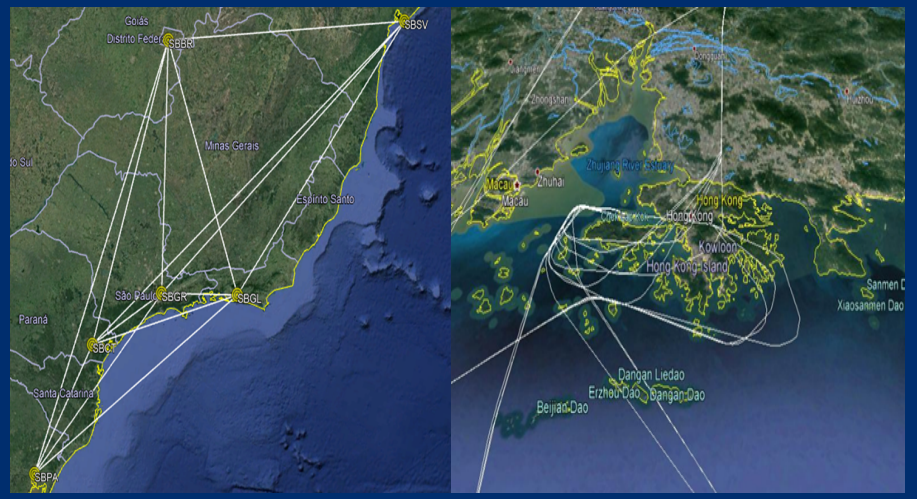
# ITA-Airbus Collaboration Project

*Integrated airplane and airline network design optimization considering airspace constraints*

- Active since April 2019, hosted at ITA´s Aeronautical Engineering Department
- Research conducted by Dr. Bento Mattos, Dr. Antonio Hernandes and Alejandro Rios (PhD candidate) - under Airbus Airline Sciences advice.
- Research on integration of the airline design and air transport network into a Multidisciplinary Design Optimization (MDO) framework, using genetic algorithms;
- Realistic airline operational profiles and airspace constraints are included;
- The final product is an application capable to determine optimum aircraft designs for specific demand scenarios within a certain operational area;
- Consideration of Airspace Constraints into the fremework;



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# ITA-Airbus Collaboration Project

*Integrated airplane and airline network design optimization considering airspace constraints*

- Working paper as first research output.
- Proposes an unsupervised machine learning framework which carries out a binary classification on trajectories clustering.
- Allows the identification of possible off-route tracks, without the need of a naviation database.
- Direct Operational Costs (DOCs) are evaluated for different clusters, showing the importance of real data modeling.

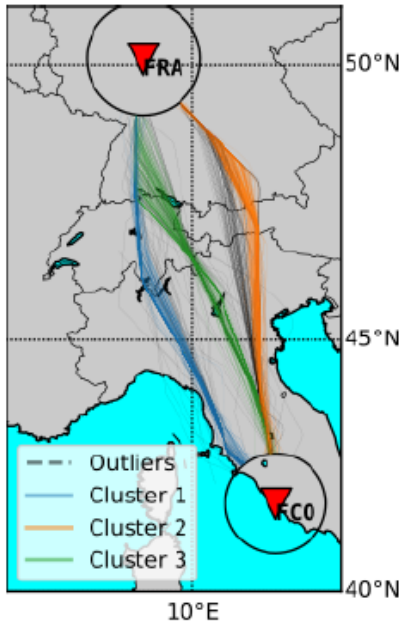


FIG. 7. Cluster identification from processed data.

Learning Airline Route Constraints from Flight Trajectory Data for Aircraft Design Applications

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The state of art in aircraft design in the early stages of conceptual design include the application of optimization techniques where several disciplines, such as aerodynamics, performance, stability and control, among others, are included in the loop in order to decrease costly project changes in the following stages. These disciplines are evaluated with the aid of Multidisciplinary Design Optimization (MDO) algorithms that provides as output the geometrical characteristics of the fitness individuals. In recent works, airworthiness constraints and airline network optimization have been incorporated into aircraft optimization, envisioning the reduction of the Direct Operational Cost (DOC). Although these implementations have shown considerable improvements, they still used simplistic models (such as Great Circle distances to approximate route distances in the airline network optimization). this paper aims to provide a methodology to obtain more realistic approximations by including airline route constraints learned from automatic dependent surveillance-broadcast (ADS-B) in the airline network optimization. To this end, a framework is developed to deal with trajectory data in two separated modules. The first module is comprised of an unsupervised machine learning framework that carries out of data clustering to split the airspace into navigable and non-navigable. The second module is comprised of a supervised machine learning framework that carries out trajectory classification. A binary classification is conducted where the well defined clusters (identified with index $\geq 0$ ) are considered as navigable airspace while the identified outliers (index $= -1$) form part of the non-navigable airspace. Tests are performed in order to evaluate the reliability of the model in terms of airspace classification. Besides, a simplified comparison of horizontal (In)efficiency and Direct Operational Cost (DOC) is presented to highlight the importance of considering real data in the model.

**Keywords:** ATM, Machine Learning, Clustering, Classification, Aircraft Design



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# Conclusion

- *Airline Sciences* makes use of large data sets, new algorithms and new computing capability to enable aircraft design to operations. For that we developed:
  - Capability to play out real life operational scenarios that speak to airlines.
  - Capability to test new regulations and long terms environmental impact of daily operations.
  - Capability to measure economical impact on decisions.

- We believe on the development of top quality academic collaborations to research new methodologies.

With this…

***We deliver the ability for Airbus to anticipate future customer and market needs.***

external

# *Thank You!*


José A. Fregnani
ATM Stream Leader

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