Vista Project
Building a Holistic ATM Model for Future KPI Trade-Offs

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Goals and objectives

Vista aims to study the main forces (‘factors’) that will shape the future of ATM in Europe at the 2035 and 2050 horizons

More specifically:

• trade-off between, and impacts of, primary regulatory and business (market) forces;

• trade-offs within any given period;

• trade-offs between periods;

• whether alignment may be expected to improve or deteriorate as we move closer to Flightpath 2050’s timeframe

Focus on five stakeholders: airlines, ANSPs, airports, passengers, and environment.
Project overview

Workflow:

• Build an extensive list of **business** and **regulatory** factors likely to impact the ATM system.

• Classify the factors: short-term/long-term, likelihood of occurrence, importance of their impact on the ATM system, etc.

• Build current and future scenarios.

• Building model requirements:
  • *consider as many (important) factors as possible in a flexible way*;
  • *produce level of detail required and achievable to capture relevant metrics*.

• Iterative model development in consultation with stakeholders.

• Trade-off analysis.
Scenario definition in Vista

Vista model is a ‘what-if’ simulator

• *What happens if I do this in the system?*
  And *not:*
  • *What will happen in 2035 or 2050?*

=> Scenario definition. Aim is *not* to compute the likelihood of a given scenario.

=> Factors entering scenario subdivided into two main categories:

• **Business factors:** cost of commodities, services and technologies, volume of traffic, etc. => demand and supply

• **Regulatory factors:** from EC or other bodies, e.g. ICAO, => ‘rules of the game’
Objective of the model

• Vista model aims at:
  • Simulating a typical day of traffic in Europe to the level of individual passengers
  • Being able to change the operational environment and see their impact on several stakeholders and at several levels
• Vista model takes a holistic approach:
  • Because the behaviour of the system is not a simple sum of the individual behaviours.
  • Because the heterogeneity of behaviours among actors shapes the system.
Model presentation

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**Objective** of the economic model: take into account macro-economic factors to forecast the main changes of flows in Europe.

Desired output:
- Main flows in Europe,
- Market share of different airline types
- Capacities of ANSPs and Airports
- Average prices for itineraries.
Strategic layer – economic model

Should take into account:

- **Main changes in demand:**
  - volume
  - types of passengers

- **Major business models changes:**
  - Point-to-point vs hub-based (airlines)
  - competition vs cooperation (ANSP)
  - privatization vs nationalisation (ANSP and airports)

- **Capacity restriction:**
  - Congestion at airports
  - ATCO limits

- **Major changes of prices in commodities:**
  - Fuel,
  - airport and airspace charges, etc
Model description

Deterministic agent-based model

In a nutshell:

• Step-by-step multi-agent model

• Individual agents are currently:
  • Individual airports
  • Individual airlines, part of alliances (or not)
  • Passenger aggregated at an OD level per airline
  • Individual ANSPs

• Agents compete with peers, try to predict different values (delays, future demand, prices) and act accordingly
Network Based Model

- Supply: airport pairs (edges)
- Demand: itineraries (collection of edges)

Supply and demand? Price?
ABM flow

- Airlines choose their supply, based on cost and price of tickets,
- Passengers choose between different itineraries, based on prices,
- Supply and demand are compared, prices evolve,
- Agents compute profit and form expectations,
- Short-list of airports assess a potential capacity extension,
- ANSPs choose their capacity based on target and set their unit rate.
Simple example: LLC vs trad

- Simplified setup: four airports, two airlines LCC/trad

Simple scenario:
- Increase in demand (higher income) on 0->3
- Increase of capacity of airport 3
- Increased fuel price for everyone
Number of passengers

Income increase

Capacity increase

Price of fuel increase

(Trad. from hub)
(Trad. to hub)
(lcc)

Number of passengers

Simulation step

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Airport profit

Income increase

Capacity increase

Price of fuel increase

Simulation step

Airport profit

0 (hub)
1 (origin)
2 (origin)
3 (final dest.)
Pre-tactical layer

- From strategic high-level to tactical executable detail
**Pre-tactical layer – flight plan generation**

### Flight plans

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### Flight plans

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**Schedules**
Pre-tactical layer – flight plan generation

Flight level requested vs. Flight plan distance (NM)
Tactical layer -- Mercury

E.g. uncertainty, cost of delay, reaccommodation rules

Tactical Layer

Mercury (mobility model)

Flight plans
ATFM delay
Passengers itineraries
Tactical delays, reaccommodations, etc
Tactical layer -- Mercury

- Data-driven mesoscopic approach, stochastic modelling
- Individual passenger DOOR-TO-DOOR itineraries
- Regulation 261/2004 – pax care & compensation
- Disruptions, cancelations, re-accommodations, compensations costs
- Airline decisions based on costs models or rule of thumb
- Full Air Traffic Management model, demand/capacity balance
Conclusions

Overall model:

• Aim at simulating *what* happens a typical day of *if* you change something in the system.

• **Macro to micro** model in different layers of increasing detail

Economic model:

• **High-level description**, dependence of main flows on macro-economic parameters.

• **Deterministic agent-based model**, featuring ANSPs, airlines, airports and passengers

• **Complex economic feed-back**, emerging phenomena coming from network-based interactions
Potential next steps

Academic developments:
• Study of emergent phenomena related to more specific changes in the model, for instance introduction of different drone management systems
• Refinements of the economic side of the model by extending the financial aspect: capital of companies, loans, etc.
• Refinements of the strategies used by agents, game theory.

Application-oriented development:
• Support to projects like PJ19, development of performance tools and general views like EATMA
• Support to projections of demand at the ANSP level (stakeholder demand)
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Vista project

Thanks for listening!
Passenger demand

- **Pax demand**: given all the possibilities (itineraries) to go from \( i \) to \( j \) with associated prices, travel times, etc, how to choose one?

\[
D_k = D_k^0 (1 - \alpha \Delta p_k + \beta \Delta i_k + ... ) C(p_k, \{p_l\}_{l \neq k})
\]

**Volume term**

\[
C(p_k, \{p_l\}_{l \neq k}) = 1 - \frac{1}{S} \left( \Delta p_k - \sum_{l=1, l \neq k}^{n} \frac{\Delta p_l}{n-1} \right) + ...
\]
Airline supply

- **Airline supply**: profit maximizer, choosing their capacity on each branch.

\[ r = S \hat{p} - c(S) \]

\[ c(S) = c + c_o S + c_c S^\alpha \]

\[ \alpha > 1 \]

- Overhead, constant
- Cost of capital, superlinear
- Operational cost, linear

\[ S^* = \left( \frac{\hat{p} - c_o}{c_c} \right)^{\frac{1}{\alpha - 1}} \]
Airline supply

- Operational cost depends on a lot of parameters:

\[ c_o = \chi \Delta \delta t_O + \chi \Delta \delta t_D + c_f(d) + c_{ATC} + \cdots \]

Cost of delay
Cost of fuel
ATC charges
Market clearing and convergence

- Demand disaggregated itineraries -> airport pair
- Demand and supply are compared on each edge, price is updated:

\[ p_{t+1}^k = p_t^k \left( 1 + \lambda \left( \frac{S_k - D_k}{(S_k + D_k)/2} \right) \right) \]
Airport delay management

- Airports compute their total traffic, which produces an extra level of delay given by
  \[ \delta t = \delta t_0 + \frac{T}{C} \]

  - Traffic
  - Capacity (fitted)

- Airports try to maximise their profit by increasing (or not) their capacity:
  \[ r = T\hat{P} - c(C) \]

  - Cost of capacity (linear in the model)