Vista - market forces trade-offs impacting European ATM performance
Delgado, L., Gurtner, G. and Cook, A.J.

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Vista
Market forces trade-offs impacting European ATM performance

Drs Luis Delgado, Gérald Gurtner & Andrew Cook
University of Westminster, London

COCTA Workshop –
Improving Performance in ATM
Overview of presentation

• Objectives of Vista

• Overview of the model
  • principles and construction
  • The tactical layer
    • most mature – presented elsewhere
  • The pre-tactical layer
    • key bridge
  • The strategic layer
    • setting up objectives

• Trade-off analysis

• Discussion
  • not conclusions, rather an open dialogue
Objectives of Vista
Objectives of Vista

KPIs established for 2015 (all in SES PS, RP2)

- Current
- 2035
- 2050

(+ airports)
Objectives of Vista

• Market/business forces working with/against regulation – unintended consequences?
  • cheaper to cancel a flight? (Reg. 261)
  • delay recovery v. emissions impact? (ETS; Directive 2008/101)
  • ANSP delay levels driven too low? (SES PS; Reg. 549/2004)

• Impact metrics
  • classical (e.g. average delay) & complexity (e.g. community detection)
  • monetised (e.g. cost of delay) and quasi-cost (NO$_x$, $\sigma^2_{\text{arr}}$)
Objectives of Vista

WP3 Market forces
- Business forces
- Regulatory forces
- Scenarios

WP4 Evaluation framework
- Passengers
- Airlines
- ANSPs
- Airports
- Environment

WP5 Impact trade-offs
- Full cost
- Quasi-cost

WP6 Stakeholder assessment & dissemination
Overview of the model
Overview of the model

• The forces/factors considered are subdivided into two main categories:
  • **Business factors (37):** cost of commodities, services and technologies, volume of traffic, etc. => demand and supply
  • **Regulatory factors (22):** from EC or other bodies, e.g. ICAO, => ‘rules of the game’; some of these are enablers of the business factors

• 85 references consulted

<table>
<thead>
<tr>
<th>Id</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROR1</td>
<td>Passenger provision schemes</td>
</tr>
<tr>
<td>BTO4</td>
<td>Passengers reaccomodation tool</td>
</tr>
<tr>
<td>BTO3</td>
<td>Virtual control centre</td>
</tr>
</tbody>
</table>
Overview of the model

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• 85 references consulted
• Further split into ‘background’ and ‘foreground’ factors:
  • **Background** (often drive fundamental system evolution)
    • expected small impact on the system
      or
    • highly consensual/less interesting *per se*
  • **Foreground**
    • factors whose impact are to be studied explicitly, in more detail
### Background scenarios

<table>
<thead>
<tr>
<th>Period</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current</td>
<td>Current</td>
<td>Default</td>
</tr>
<tr>
<td>2035</td>
<td>L35: Low economic</td>
<td>Economic growth slow in Europe</td>
</tr>
<tr>
<td></td>
<td>Low Techno</td>
<td>Technological &amp; operational changes not supported</td>
</tr>
<tr>
<td></td>
<td>M35: High economic</td>
<td>Economic growth high in Europe</td>
</tr>
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<td></td>
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</tr>
<tr>
<td></td>
<td>H35: High economic</td>
<td>Economic growth high in Europe</td>
</tr>
<tr>
<td></td>
<td>High Techno</td>
<td>Technological &amp; operational changes are supported</td>
</tr>
<tr>
<td>2050</td>
<td>L50</td>
<td>(As per 3035)</td>
</tr>
<tr>
<td></td>
<td>M50</td>
<td></td>
</tr>
<tr>
<td></td>
<td>H50</td>
<td></td>
</tr>
</tbody>
</table>
### Overview of the model

#### Foreground factors

<table>
<thead>
<tr>
<th>ID</th>
<th>Business factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>BTS5</td>
<td>4D Trajectory Management</td>
</tr>
<tr>
<td>BTS9</td>
<td>Traffic synchronisation</td>
</tr>
<tr>
<td>BTO4</td>
<td>Passenger reaccommodation tools</td>
</tr>
<tr>
<td>BEO1</td>
<td>Fuel prices</td>
</tr>
<tr>
<td>BEO2</td>
<td>Airspace charges</td>
</tr>
<tr>
<td>BEO3</td>
<td>Airline business models (output)</td>
</tr>
<tr>
<td>BEO4</td>
<td>Smart, integrated ticketing</td>
</tr>
</tbody>
</table>

<table>
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<th>ID</th>
<th>Regulatory factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROR1</td>
<td>Passenger provision schemes</td>
</tr>
<tr>
<td>ROR3</td>
<td>Emission schemes</td>
</tr>
<tr>
<td>ROR4</td>
<td>Noise pollution (implicit)</td>
</tr>
<tr>
<td>RAD1</td>
<td>Airport slots</td>
</tr>
<tr>
<td>RAD2</td>
<td>Regional airport development</td>
</tr>
<tr>
<td>RAA1</td>
<td>Airport access</td>
</tr>
<tr>
<td>ROR9</td>
<td>Operation of air services</td>
</tr>
</tbody>
</table>

#### Foreground groups

<table>
<thead>
<tr>
<th>EM: Environmental mitigation policies</th>
<th>PF: Passenger focus</th>
</tr>
</thead>
<tbody>
<tr>
<td>RI: Regional infrastructures</td>
<td>SES: Single European Sky</td>
</tr>
</tbody>
</table>
Overview of the model
The tactical layer

E.g. regulations, technologies, forecasts

E.g. (near-firm) capacities and demand

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

Initial Mobility State

Adjusted Behaviour

Learning Loop
Comparison with targets
Setting new initial state

Pre-tactical Layer

Passenger assignment
Flight plan generation

ATM Regulation

Strategic Layer

Economic Model

Schedule mapping

Airports

14
The tactical layer

Flight plans
ATFM delay
Passengers itineraries
The tactical layer

Door-to-door context and 2050 (also courtesy DATASET2050)

Airport access: data-driven stochastic processes

Pax profiles linked with itineraries

Confidential access to airport process times
The pre-tactical layer

- **Environment**
  - **Pre-tactical Layer**
    - **Strategic Layer**
      - **Economic Model**
      - **Schedule Mapping**
  - **Tactical Layer**
  - **Learning Loop**
    - **Comparison with targets**
    - **Setting new initial state**
    - **KPIs**
  - **Initial Mobility State**
  - **Final Mobility State**
  - **Impact Trade-offs**

- **Foreground Factors**
- **Background Factors**
- **Exogenous Variables**

- **E.g. regulations, technologies, forecasts**
- **E.g. linear-linear capacities and demand**
- **E.g. uncertainty, cost of delay, reaccommodation rules**
The pre-tactical layer

- Flight schedules
- Flight plans
- ATFM delays
- Passenger itineraries

IATA, GDS; MCTs; traffic (high effort)
The strategic layer

- Strategic layer – economic model (takes into account macro-economic factors)
- Desired outputs:
  - main flows in Europe
  - market share of different airline types
  - capacities of ANSPs and airports
  - average prices for itineraries
- Need to take into account:
  - main changes in demand (volume, pax heterogeneity)
  - major business model changes:
    - point-to-point v. hub-based (airlines)
    - competition v. cooperation (ANSP)
    - privatisation v. nationalisation (ANSP and airports)
  - capacity restrictions (congestion at airports; ATCO resource constraints)
  - major changes of commodity prices (e.g. fuel, airport and airspace charges)
The strategic layer

- Turn-based, multi-agent model
- Currently features three types of agents:
  - airport (one agent per airport)
  - airline (one agent per airline)
  - passengers (one agent per OD pair, including all possible itineraries)
  - ANSPs (coming soon; able to adjust prices after several turns -> AO choice)

- Each agent has its own objective, with a specific cost function:

  AO flight cost function
  - fuel
  - airport charges
  - ATC charges
  - delay costs

  Pax utility function
  - price
  - frequency of flight
  - income
  - delay

  Airport revenues and costs
  - aeronautical charges
  - operating cost of capacity
The strategic layer

Turns:

- **airlines**
  - estimate prices of each itinerary (based on past prices)
  - estimate delays at airports (based on past delays)
  - choose operated capacity by airport pair (based on est. delays & prices)
- **airports**
  - estimate their traffic
  - decide whether to expand capacity* (based on expected traffic, & costs)
- **passengers** choose between itineraries for given OD pairs
- **selling price** of each itinerary is updated
  - based on balance between supply & demand
- **delays** are updated (based on ‘actual’ traffic)
- **airports and airlines** compute final profit

* availability lagged by several turns
The strategic layer

Simple scenarios to test / illustrate the model

Scenario:

Increased income on high-yield leg: Increase in income of all passengers on the 0->3 leg
The strategic layer

Simple scenarios to test / illustrate the model

- ‘mainline’, hub-based
- ‘low-cost’, P2P
The strategic layer

Simple scenarios to test / illustrate the model

1

0

3

2

‘mainline’, hub-based

‘low-cost’, P2P

Airline Profit

mainline

low-cost

0 10 20 30 40

Step
Trade-off analysis
Trade-off analysis

COCTA Workshop – Improving Performance in ATM – Innovative institutions, mechanism and incentives, Frankfurt, 27 September 2017
Trade-off analysis
Discussion
Discussion

• Three stage model to capture the impact of factors at each operational level
• The objective of Vista is not the individual value of the metrics per se but the trade-off between them in different scenarios
• Produce trade-offs between metrics for different time-frames, background scenarios and factors

• At this stage in the design process, we’d very much welcome feedback
  • Prioritisation of trade-offs to measure
  • KPIs refinement
  • Archetype definition of stakeholders and their behaviour

• Workshops coming up:
  • Vista workshop – Vienna – 23 October 2017 – airspace-research@westminster.ac.uk
  • Performance Work Forum – SJU premises – 07 February 2018
Thank you