POEM
Passenger-Oriented Enhanced Metrics

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Overview

• Background and objectives
• Importance of passenger context
• Progress so far
  – model & scenarios
  – data & cleaning
  – metrics
  – recent results
• Conclusions
Background and objectives
Background and objectives

• Building an integrated simulation model for flights and passengers, which will:
  – include a range of new performance metrics we have designed:
    - passenger-centric and propagation-centric
  – operate under a range of flight prioritisation scenarios
• Two key analytical objectives – under these scenarios:
  – to explore trade-offs between various metric types
  – to characterise propagation of delay through network
• Design and data front-loaded
• Stakeholder consultation: workshops and case studies
Importance of passenger context
Importance of passenger context

• Policy-driven motivation
  – ultimate performance delivery to the passenger
  – Commission's new roadmap (2011) to a Single European Transport Area for 2050: pax mobility & network resilience
  – extension of passenger rights (e.g. review of Regulation 261)
  – ACARE Strategic Research & Innovation Agenda (Sep. 2012)

• More compelling still: the technical imperative
  – dominate AO delay costs and therefore strongly influence AO behaviour in the network (strategically and tactically)
  – currently only using flight-centric metrics (Europe & US), although flight delay ≠ pax delay (factor of 1.6 – 1.7)
  – from the context of fully understanding network behaviour ...
Importance of passenger context
Progress so far
- model & scenarios
<table>
<thead>
<tr>
<th>Type, and level</th>
<th>Designator</th>
<th>Summary description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common, 0</td>
<td>C₀</td>
<td>Level ‘0’ - common baseline, reproduces historical operations</td>
</tr>
<tr>
<td>ANSP, 1</td>
<td>N₁</td>
<td>Prioritisation of inbound flights, based on simple passenger numbers</td>
</tr>
<tr>
<td>ANSP, 2</td>
<td>N₂</td>
<td>Inbound flights arriving more than 15 minutes late are prioritised based on the number of onward flights delayed by inbound connecting passengers</td>
</tr>
<tr>
<td>AO, 1</td>
<td>A₁</td>
<td>Departure slots allocated based on delay costs – if ATFM delays are not severe, implement wait rules for premium passengers, long-haul passengers and minimum passenger load</td>
</tr>
<tr>
<td>AO, 2</td>
<td>A₂</td>
<td>Departure slots and arrival sequences based on delay costs – A₁ is implemented and flights are (independently) arrival-managed based on delay cost</td>
</tr>
<tr>
<td>Policy, 1</td>
<td>P₁</td>
<td>Passengers are reaccommodated based on prioritisation by arrival delay, instead of by ticket type, but preserving interlining hierarchies</td>
</tr>
<tr>
<td>Policy, 2</td>
<td>P₂</td>
<td>Passengers are reaccommodated based on prioritisation by arrival delay, regardless of ticket type, and also relaxing all interlining hierarchies</td>
</tr>
</tbody>
</table>
Progress so far
- data & cleaning
Data and cleaning

• Unique combination of PaxIS and PRISME data
• Two stages of testing pax allocation
  – early: ‘difficult’ airport pair (anonymous, 5 AOs; OAG, CAA, …)
  – recently: 460 000 pax & connections for 500 routes (17SEP10)
  – assign 4 AO types; use a/c configurations and load factors (rules)
• Airports in final model (ACI Europe, Eurostat, …)
  – August & September, 2009 & 2010 (busiest holiday & non-holiday)
  – 200 ECAC airports (97% pax, 93% traffic, 2010)
  – 50 external airports based on pax flows in/out Europe
• Selection of days
  – Tuesdays and Fridays, excluding high strike/ATFM & bad weather
  – bad weather day as reserve
Data and cleaning

- **Logic checks**
  - exclude by operator / aircraft type:
    - cargo, helicopters, military, air taxi operators, corporate, private
  - resolve discrepancies:
    - aircraft type (about 10%), WTCs, registrations (sequences)
    - circular flights (slot-retaining, maintenance, training)

- **Range checks**
  - outliers and variances (e.g. delays by phase of flight)
  - ratios (e.g. filed over actual route lengths, durations and speeds)
  - absolute speeds (some a/c & route sensitivity)

- **Removal (11%) c.f. ‘demotion’ (80); 17SEP10 final = 26 170**
Data and cleaning
Progress so far
- metrics
Metrics

classical metrics

derived complexity

non-classical metrics
<table>
<thead>
<tr>
<th>Metric family</th>
<th>Type</th>
<th>Primarily drives delay or propagation metrics</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>delayed departures</td>
<td>count</td>
<td>d</td>
<td></td>
</tr>
<tr>
<td>delayed arrivals</td>
<td>count</td>
<td>d</td>
<td></td>
</tr>
<tr>
<td>departure delay</td>
<td>duration(s)</td>
<td>d</td>
<td>to specifically include % above certain thresholds</td>
</tr>
<tr>
<td>arrival delay</td>
<td>duration(s)</td>
<td>d</td>
<td>to specifically include % above certain thresholds</td>
</tr>
<tr>
<td>cancelled flights</td>
<td>count</td>
<td>p</td>
<td></td>
</tr>
<tr>
<td>extra flight time</td>
<td>duration(s)</td>
<td>d</td>
<td></td>
</tr>
<tr>
<td>extra gate time</td>
<td>duration(s)</td>
<td>p</td>
<td>analogue of the pax ‘missed connections’ metric</td>
</tr>
<tr>
<td>reactionary minutes</td>
<td>duration(s)</td>
<td>p</td>
<td>reactionary delay mins caused by primary delay</td>
</tr>
<tr>
<td>back-propagation</td>
<td>ratio</td>
<td>p</td>
<td>ratio of reactionary delay from an airport that later propagates back to the same airport</td>
</tr>
<tr>
<td>reactionary depth †</td>
<td>count</td>
<td>p</td>
<td>number of disrupted flights in the longest path in the propagation tree*</td>
</tr>
<tr>
<td>reactionary disruptions †</td>
<td>count</td>
<td>p</td>
<td>number of disrupted flights*</td>
</tr>
<tr>
<td>reactionary depth / disruptions †</td>
<td>ratio of nodes/flight</td>
<td>p</td>
<td>-</td>
</tr>
<tr>
<td>reactionary / primary delay ratio †</td>
<td>ratio of durations</td>
<td>p</td>
<td>value is 0.85 for whole European network (2010)</td>
</tr>
</tbody>
</table>

* Excluding the causal flight.
† These metrics may be expected to be lower at hub airports than for other stations.
Progress so far
- recent results
Recent results

- First run of model – 200 baselines, 87 million cells
- Delay matrix, $M_d$, characterisation of delay propagation:
  - Factor analysis
    - PCA, eigenvalues > 1, oblique (promax) rotation
    - 5 components gave good differentiation
- Percolation approach & centralities
  - link density, degree assortativity, clustering coefficient, efficiency
  - quite widely distributed backbone, many isolated nodes

- Compared with ‘classical’ – degree of subjectivity
- Association rather than causality (Granger causality)
- $w_d C_d - w_f C_f = C''$
Recent results
Conclusions
Conclusions

• Early results of analyses
  – comparative & complementary approach; further depth; causality

• Secondary & tertiary effects in network behaviour

• Building a simulation model (partly) using PRISME data
  – extensive cleaning and calibration
  – by individual phase of flight
  – taxi-out unreliable; taxi-in missing; IOBT c.f. schedule
  – distribution of metrics important

• Full prioritisation scenario trade-offs in May 2013
  – for now, we seem to have more questions than we started with!
Thank you