‘POEM’ Outstanding Project Award
Cook, A.J.

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FROM INNOVATION TO SOLUTION

‘POEM’
OUTSTANDING PROJECT AWARD

Dr Andrew Cook (University of Westminster, London) & on behalf of Innaxis (Madrid)
Overview

• What is POEM about and why did we bother?

• The simulations in a nutshell

• How does complexity science fit in?

• A sample of key results

• Where next?
What is POEM about and why did we bother?

• Passenger-Oriented Enhanced Metrics
  – putting the passenger at the centre of service delivery
  – exploring new prioritisation strategies using new metrics

• Political motivation re. pax mobility, e.g. Commission:
  – roadmap to a Single European Transport Area for 2050 (2011)
  – ‘Flightpath 2050’, HLG on Aviation Research (2011)
    … 4 hour door-to-door target for 90% of passengers
  – on-going reviews to Regulation 261/2004 (2016?)

• Operational motivation
  – pax direct costs often dominate AO cost of delay (& behaviour)
  – even in pure G2G context, passenger delay > flight delay
The simulations in a nutshell

• Evaluate flight and pax prioritisation strategies
  – currently 3 major scenario types (pax numbers, costs, policies)

• Use new metrics to measure performance trade-offs
  – classical (e.g. pax delay) and complexity (e.g. centralities)

• Investigate delay propagation through network

• First full-scale European simulation with explicit pax
  – captures full AO delay costs (pax, fuel, crew, maint.); 4 types
  – busiest 200 ECAC airports + 50 airports outside Europe
  – unexceptional, busy day in 2010 (17SEP10)
  – detailed decision-making rules (workshops; Reg. 261; IATA)

• Combined PaxIS (2.5m) and PRISME (30k) data
  – 150k distinct routings (itineraries)
  – respects MCTs, LFs, seat configurations
A look inside one second ...

[...] (17-Sep-2010 12:25:00) 47 out of 49 of pax (95.92 pct.) of DLH_EDDLEGGBB02:15877 were ready, flight over 80 pct. occupancy, no more delay added

(17-Sep-2010 12:25:00) Total cost of flight DLH_EDDLEGGBB02:15877 departing at 17-Sep-2010 12:25:00 now estimated at 127.15 euros

(17-Sep-2010 12:25:00) No further pax delay will be introduced, thus flight DLH_EDDLEGGBB02:15877 is now pushback ready, reaccommodating connecting pax

(17-Sep-2010 12:25:00) Pax group DLH1815:37550 of 2 inflex pax coming from DLH_EDDHEDDL06:12246 to EGBB did not make it to DLH_EDDLEGGBB02:15877 (no more connections afterwards) and need to be reaccommodated

(17-Sep-2010 12:25:00) 2 inflex pax of group DLH1815:37550 of DLH_EDDHEDDL06:12246 that missed DLH_EDDLEGGBB02:15877 were successfully reaccommodated in DLH_EDDLEGGBB03:23396 same alliance, DLH1815/1:145607 Arrival: 17-Sep-2010 17:50:00 delay: 04:00'00" (airport wait 03:01'51")

(17-Sep-2010 12:25:00) Trying to reaccommodate the 80 pax waiting at EDDL:10 (DUS)

(17-Sep-2010 12:25:00) A total of 2 pax of DLH_EDDLEGGBB02:15877 were left behind and all of them were successfully reaccommodated

(17-Sep-2010 12:25:00) Flight SAS_ENKBENGM03:15843 loading 67 pax and all of the 67 pax are not coming from a previous flight. There are NO connecting pax

(17-Sep-2010 12:25:00) There are 29 pax groups in SAS_ENKBENGM03:15843 connecting with another flight afterwards (SAS3310:87574, SAS3311:87575, SAS3312:87576, SAS3313:87577, SAS3314, [..]) (KSU-OSL)
How does complexity science fit in?

• Not one theory; system of systems – usually a network
  – multiple components, non-linear dynamics: can’t predict
  – non-analytical models, e.g. agent-based
  – usually need to take uncertainty into account
• Emergent behaviour, e.g. delay propagation
• ATM = complex socio-technical system
• How can complexity science contribute?
  – user-defined nodes in topological networks
  – existing metrics such as centralities (causality)
  – existing methods such as community detection & percolation
• Complementary approach
A sample of key results

- Cost-minimising aircraft wait rules (scenario A₁):
  - ↓ €39 avg. cost / flight
  - ↓ 9.8 mins avg. arr. / dlyd pax
  - ↑ 2% reactionary (focus)

- All scenarios: no statistically significant changes in current flight-centric metrics

- Persistence of delay
  - hub back-propagation
  - role of smaller airports

- Delay topologies for A₁:
  - smaller communities
  - more susceptible
Where next?

• Live model, on-going developments such as:
  – fidelity of various rules (flexible, event-driven; + CO$_2$?)
  – 2014 traffic with new costs; GDS integration; D2D context

• Exploring further use of valuable new metrics
  – passenger-centric; in context SES RP3 (2020 – 2024)?
  – increased focus on cost resilience

• Policy evaluation
  – e.g. Regulation 261; ‘exploratory’ policies

• Increased AO-level focus and software integration
  – strategic planning, trending context (e.g. a/c sizes & LFs)
Thank you
Stand-bys
## Summary of scenarios

<table>
<thead>
<tr>
<th>Type, level</th>
<th>Designator</th>
<th>Summary description</th>
</tr>
</thead>
<tbody>
<tr>
<td>No-scenario, 0</td>
<td>S₀</td>
<td>No-scenario baselines: reproducing 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 prioritised based on number of onward flights delayed by inbound connecting passengers</td>
</tr>
<tr>
<td>AO, 1</td>
<td>A₁</td>
<td>Wait times and associated departure slots estimated on cost minimisation basis; longer wait times potentially forced during periods of heavy air traffic flow management (ATFM) delay</td>
</tr>
<tr>
<td>AO, 2</td>
<td>A₂</td>
<td>Departure times 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 reaccommodated based on prioritisation by final arrival delay, instead of by ticket type; preserves interlining hierarchies</td>
</tr>
<tr>
<td>Policy, 2</td>
<td>P₂</td>
<td>As P₁, now also relaxing all interlining hierarchies</td>
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### New Metrics

<table>
<thead>
<tr>
<th>Core Metric</th>
<th>Units</th>
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<tbody>
<tr>
<td>Flight departure delay</td>
<td>mins / flight</td>
</tr>
<tr>
<td>Flight arrival delay</td>
<td>mins / flight</td>
</tr>
<tr>
<td>Departure delay of departure-delayed flights</td>
<td>mins / flight</td>
</tr>
<tr>
<td>Arrival delay of arrival-delayed flights</td>
<td>mins / flight</td>
</tr>
<tr>
<td>Pax departure delay</td>
<td>mins / pax</td>
</tr>
<tr>
<td>Pax arrival delay</td>
<td>mins / pax</td>
</tr>
<tr>
<td>Departure delay of departure-delayed pax</td>
<td>mins / pax</td>
</tr>
<tr>
<td>Arrival delay of arrival-delayed pax</td>
<td>mins / pax</td>
</tr>
<tr>
<td>Passenger value of time</td>
<td>Euros / pax</td>
</tr>
<tr>
<td>Non-passenger costs</td>
<td>Euros / flight</td>
</tr>
<tr>
<td>Per-flight pax hard cost</td>
<td>Euros / flight</td>
</tr>
<tr>
<td>Per-flight pax soft cost</td>
<td>Euros / flight</td>
</tr>
<tr>
<td>Total flight cost</td>
<td>Euros / flight</td>
</tr>
<tr>
<td>Total flight cost per minute of departure delay</td>
<td>Euros / min</td>
</tr>
<tr>
<td>Reactionary delay ratio</td>
<td>ratio</td>
</tr>
</tbody>
</table>

### Comparison

<table>
<thead>
<tr>
<th>N&lt;sub&gt;1&lt;/sub&gt; &amp; N&lt;sub&gt;2&lt;/sub&gt;</th>
<th>P&lt;sub&gt;1&lt;/sub&gt;</th>
<th>P&lt;sub&gt;2&lt;/sub&gt;</th>
<th>A&lt;sub&gt;1&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inbound prioritisation based on simple pax numbers, or on onward flights delayed</td>
<td>Passenger reaccommodated based on delay at final destination ... preserving interlining hierarchies</td>
<td>... relaxing interlining hierarchies</td>
<td>Departs times based on cost minimisation (and consideration of ATFM delay)</td>
</tr>
</tbody>
</table>

- **Flight-Centric**
- no significant changes in current flight-centric metrics: stresses need for passenger-centric metrics

- **New Metrics**

  - revised passenger rebooking rules produce only weak improvements whilst current airline interlining rules are preserved. c.f. →

  - Total flight cost per minute of departure delay
    - N: 26 Euros/min
    - P: -40 Euros/min
    - A: -39 Euros/min
  - Reactionary delay ratio
    - N: 49%
    - P: 51%