Evaluation of Integrated Demand Management looking into Strategic & Tactical Flow Management

Presented by Christoph Moehlenbrink

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Integrated Demand Management

Motivation and Objective

Improving Demand Management & looking into the challenges of demand/capacity matching

– Work on more integrated operations and tools
– Leveraging existing systems
– Exploring existing NextGen capabilities
– if indicated... suggesting new automation tools

... exemplified on Newark Liberty Airport (EWR)
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Strategic and Tactical Flow Management

Traffic Flow Mang. System (TFMS)
- Command Center
- Traffic Man. Initiative
- CTOP
- Flow Constraint Area

Time-Based Flow Mang. (TBFM)
- en/ar scheduling
- Speed/vectoring
- Meterfix
- Extended Metering

Harmonize
→ Overlay control structures for procedural integration
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San Francisco (SFO) to Newark (EWR) Flight

Trajectory-Based Flight Operations

CTOP Departure
Depart SFO on CTOP-assigned EDCT time.

CTOP RTA to an FEA
Manage speeds to meet crossing time at a waypoint near FEA W.

Transition
Pass RTA waypoint & FEA W, then cross TBFM freeze horizon.

TBFM to meter fix
Follow ATC clearances for STA compliance.

* !
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Motivation and Objective

1. Traffic Flow Management System (TFMS) with CTOP

   *CTOP: Collaborative Trajectory Option Program

2. Time-Based Flow Management (TBFM)

3. IDM Concept and IDM Operations Types
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Objective of the study

To explore whether IDM is **beneficial** to deliver traffic more efficiently

Testing IDM types in a real time quasi simulation setup

1 IDM type: “EDCT only”

2 IDM type: “EDCT and RTAs”

3 compared to a Baseline
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Conditions

- **Baseline**
  ‘miles-in-trail’ to regulate traffic into TBFM

- **IDM type: “EDCT only”**
  CTOP with EDCTs to replace MIT

- **IDM type: “EDCT and RTAs**
  CTOP with EDCTs and RTA assignment when airborne to improve ‘pre-conditioning’ accuracy
Integrated Demand Management Method

- **traffic scenario:** 5 hour runtime
- **runs:** n=10
- **this presentation:** 4*1 factor (CONDITION, SCENARIO='distributed')

<table>
<thead>
<tr>
<th>Experimental Design</th>
<th>Baseline</th>
<th>Integrated Demand Management</th>
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<tbody>
<tr>
<td>CONDITION</td>
<td>BL Off</td>
<td>BL ON !</td>
</tr>
<tr>
<td>Distributed</td>
<td>Check Box OFF</td>
<td>Check Box ON</td>
</tr>
<tr>
<td>Gaggle</td>
<td>Check Box OFF</td>
<td>Check Box ON</td>
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</tbody>
</table>
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Method

- **Independent variables:**
  - Baseline Checkbox off/on
  - EDCT only
  - EDCT + RTA
- **Dependent variables:**
  - throughput
  - airborne delay
  - ground delay
  - total delay

The simulation environment (MACS ERAM Planning Station & nCTOP)

MACS FMS simulation (B757/HW BL emulation)
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Airborne delay regions

- meterfix versus extended metering

Ground delay assignment

- CTOP assigned (strategic) versus TBFM (tactical)
- hours prior to take Off versus last-minute (right before take Off)

‘Short-haul flights’ or ‘Internal Departures’
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Research Questions

- What is the target **throughput rate** of the IDM conditions in comparison to the Baseline condition?

- What effect on **airborne delay** in the TBFM region, is caused by forcing **short-haul aircraft** into the arrival stream?

- What is the distribution of strategic (**CTOP assigned**) versus tactical (**TBFM assigned**) ground delay in the IDM conditions (versus Baseline)?

- What is the ratio of airborne and ground delay, as well as the **total delay** under different conditions?
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Results: Throughput
## Integrated Demand Management

### Results: Throughput

<table>
<thead>
<tr>
<th>Condition</th>
<th>Scenario</th>
<th>Flights Landed in 4 hours (90-330 min)</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline (Checkbox OFF)</td>
<td>Distributed</td>
<td>177</td>
<td>44.25</td>
</tr>
<tr>
<td>Baseline (Checkbox ON)</td>
<td>Distributed</td>
<td>183</td>
<td>45.75</td>
</tr>
<tr>
<td>EDCT Only</td>
<td>Distributed</td>
<td>176</td>
<td>44</td>
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<tr>
<td>EDCT+RTA</td>
<td>Distributed</td>
<td>174</td>
<td>43.5</td>
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</table>
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Results: Throughput

- Throughput

  ‘Comparable’
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Results: Airborne Delay
Integrated Demand Management

Results: Airborne Delay

Total Airborne Delay Distribution
R1 Distributed, Baseline, Ckbx OFF

Total Airborne Delay Distribution
R8 Distributed, EDCT+RTA

Delay Totals by Condition

Base On  |  Base Off  |  EDCT Only  |  EDCT+RTA
---------|------------|-------------|------------
29.23    | 15.22      | 7.89        | 6.44       

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Results: Airborne Delay
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Results: Airborne Delay

**Table II. Extended Metering Region Airborne Delay, in Minutes**

<table>
<thead>
<tr>
<th>Condition</th>
<th>‘acceptable’ [-5,0)</th>
<th>‘marginal’ [0, 5)</th>
<th>‘unacceptable’ [5,10)</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline CB Off</td>
<td>7</td>
<td>126</td>
<td>32</td>
<td>9</td>
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<tr>
<td>Baseline</td>
<td>3</td>
<td>68</td>
<td>65</td>
<td>38</td>
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<tr>
<td>EDCT</td>
<td>19</td>
<td>150</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>EDCT+RTA</td>
<td>17</td>
<td>157</td>
<td>0</td>
<td>0</td>
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</tbody>
</table>

**Table III. Meter Fix Region Assigned Airborne Delay, in Minutes**

<table>
<thead>
<tr>
<th>Condition</th>
<th>‘acceptable’ [-2, 0)</th>
<th>‘marginal’ [0, 2)</th>
<th>‘unacceptable’ [2, 4)</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline CB Off</td>
<td>11</td>
<td>78</td>
<td>62</td>
<td>42</td>
</tr>
<tr>
<td>Baseline</td>
<td>11</td>
<td>45</td>
<td>62</td>
<td>74</td>
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<tr>
<td>EDCT</td>
<td>7</td>
<td>93</td>
<td>70</td>
<td>22</td>
</tr>
<tr>
<td>EDCT+RTA</td>
<td>12</td>
<td>112</td>
<td>61</td>
<td>7</td>
</tr>
</tbody>
</table>
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Results: Airborne Delay

- Throughput
  - ‘Comparable’

- Airborne Delay & Prioritizing Short-Haul Flights
  - ‘IDM conditions: less unacceptable airborne delays’
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Results: Ground Delay Distribution
TFMS and TBFM Ground Delay (All flights)

1. **Distributed Baseline Checkbox ON: MIT and TBFM Ground Delay**
   - TBFM Ground Delay
   - MIT Ground Delay

2. **Distributed Baseline CkBx OFF: CTOP and TBFM Ground Delay**
   - TBFM Ground Delay
   - TFMS Ground Delay

3. **Distributed EDCT Only: CTOP and TBFM Ground Delay**
   - TBFM Ground Delay
   - TFMS Ground Delay

4. **Distributed EDCT+RTA: CTOP and TBFM Ground Delay**
   - TBFM Ground Delay
   - CTOP Ground Delay
TBFM and TFMS (Miles-in-trail or CTOP) Ground Delay
"INTERNAL" DEPARTURES ONLY

Baseline, Checkbox ON

Baseline, Checkbox OFF

EDCT Only

EDCT+RTA

Runway Crossing Sequence
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Results: Ground Delay

- Throughput
  ‘Comparable’

- Airborne Delay & Prioritizing Short-Haul Flights
  ‘IDM conditions: less unacceptable airborne Delays’

- Ground Delay and Minimizing Tactical Delay
  ‘IDM conditions: minimizing tactical delay works’
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Results: Total Delay
Results: Total Airborne and Total Ground Delay per flight

Baseline, Checkbox OFF

Baseline, Checkbox ON

EDCT Only

EDCT+RTA
Results: Total Delay

![Radar Chart]

- Sum Ratios, log10
- Base On
- Base Off
- EDCT Only
- EDCT+RTA
- Airborne Sum ratios
- Ground Sum ratios
- Total sum ratio
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Results: Total Delay

- Throughput
  - ‘Comparable’

- Airborne Delay & Prioritizing Short-Haul Flights
  - ‘IDM conditions: less unacceptable airborne Delays’

- Ground Delay and Minimizing Tactical Delay
  - ‘IDM conditions: minimizing tactical delay works’

- Shift of Airborne to Ground Delay under the Umbrella of Total Delay
  - ‘IDM conditions: less airborne delay + more ground delay’
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Summary & Conclusion

- Throughput
  - ‘Comparable’

- Airborne Delay & Prioritizing Short-Haul Flights
  - ‘IDM conditions: less unacceptable airborne Delays’

- Ground Delay and Minimizing Tactical Delay
  - ‘IDM conditions: minimizing tactical delay works’

- Shift Airborne to Ground Delay under the Umbrella of Total Delay
  - ‘IDM conditions: less airborne delay + more ground delay’
Discussion

Additional interests:

- Uncertainties (Dep Error and Wind Forecast Error)
- EDCT vs. EDCT+RTA
- Quasi Real Time Simulation Approach
Conclusion & Outlook

- Study demonstrated that IDM is beneficial: with respect to delivering traffic more efficiently
  - Delays can be shifted from airborne to ground delay for RTA and non-RTA conditions while a target throughput rate can be satisfied
  - Under good predictability of airport capacity last minute tactical TBFM delay can be minimized

Future Work

- IDM benefits looking into demand/capacity imbalances e.g. to weather
Acknowledgments

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Thank you!

Email:
christoph.p.moehlenbrink@nasa.gov
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