Runway Pressure Research

*The effect of en-route delay absorption on the runway throughput*

by

Wouter Vermeersch
Agenda

- Introduction and background
- Goals of the research
- Simulation set-up
- Results
- Conclusions & recommendations
Introduction

Cross Border Arrival Management (XMAN)
- Trials started in 2014 for London Heathrow
- Deployment expected for Paris Charles de Gaulle, Frankfurt, Munich and Amsterdam Schiphol airport

- Shift delay absorption from approach to cruise phase
- Reduce waiting time in holding and lower airspace
- Benefits: decreased fuel consumption and lower emissions
Introduction

The XMAN Heathrow trials: the delay sharing strategy between London Terminal (LATC), London ACC (LACC) and Reims UAC (En-route)

Delays generated to slow down aircraft are not counted as ATFCM delays.

Source: DSNA/NATS XMAN folder – March 2015
Introduction

What if aircraft arrive too late at the Initial Approach Fix (IAF)?

- Gaps in the landing interval
- Less landings per hour
- Decreased runway efficiency

Source: AIRE trial document
Introduction

Solution:
Maintain a minimum amount of delay for APP controller to absorb **Runway Pressure**

“*The Runway Pressure is defined by the amount of delay that shall be left for the approach controller to be absorbed.*”

This is to guarantee an optimum use of the runway and avoiding ‘holes’ in the sequence. This value may vary with *physical* parameters such as IAF, Runways in use, Type of Aircraft, Wind, etc.

However: No research performed on this topic
Goals of the Research

Main research question:
“What is the effect on the actual runway throughput of an airport if the delay in the TMA is shifted towards the en-route phase?”
Simulation set-up

AirTOp software: license provided by To70
Simulation set-up

1. Design simulation environment
2. Verification/validation of the model with actual flight data
3. Create simulation scenarios to answer research question(s)
4. En-Route Delay Absorption (ERDA) algorithm
Simulation set-up
Design simulation environment

Implement significant rules and approach procedures
• Approach paths, altitude and speed ranges
• Time based separation matrix
• Runway maximum arrival rate (34 landings per hour)

Create traffic flight plans
• Various aircraft types and fleet mix (Medium, Heavy, Super)
• Aircraft perf: BADA files
• Reference time at the IAF (± 30 s)
Simulation set-up
Verification of the model

- Data from actual traffic radar tracks (28-05-2014)
- Used ATO @ IAF as reference time flight plan
- Compare TMA flight time and delay
Simulation set-up
Verification of the model

Verification AirTOp model with max RWY arrival rate
TMA flight time and delay for SUGOL and RIVER to 18R

RIVER flight time
Flight time
Delay

Time [h:mm:ss]

Call sign

simulated flight time
real flight time AAA
delay sim
delay real
Simulation set-up
Variables for scenarios

- Fleet mix based on actual inbound peaks
  - Morning peak: 7 heavy, 25 medium jet and 2 turboprop per hour
  - Evening peak: only medium jets + 2 turboprop per hour
  - Future: 1 super (A380) per hour, no turboprop

- 2 approach scenarios in TMA
  - 1 IAF to 1 runway
  - 2 IAFs merge to 1 runway

- 3 demand profiles: 68 aircraft per inbound peak of 2 hours

<table>
<thead>
<tr>
<th>Time period [H:MM]</th>
<th>0:20</th>
<th>0:40</th>
<th>1:00</th>
<th>1:20</th>
<th>1:40</th>
<th>2:00</th>
<th>2:20</th>
</tr>
</thead>
<tbody>
<tr>
<td>High demand</td>
<td>10</td>
<td>11</td>
<td>13</td>
<td>12</td>
<td>11</td>
<td>11</td>
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<td>11</td>
<td>11</td>
<td>12</td>
<td>12</td>
<td>11</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Low demand</td>
<td>10</td>
<td>10</td>
<td>11</td>
<td>11</td>
<td>10</td>
<td>10</td>
<td>6</td>
</tr>
</tbody>
</table>
Simulation set-up
Variables for scenarios

Demand for landing for future inbound peak fleet mix
Simulation set-up
En-route delay absorption

Simulate En-route delay absorption

How?
Modify the reference time at the IAF (CTO) to get the required interval at the IAF that matches runway capacity
Simulation set-up
En-route delay absorption

<table>
<thead>
<tr>
<th>Sequence nr.</th>
<th>WTC</th>
<th>IAF</th>
<th>Initial ETA</th>
<th>Separation</th>
<th>Required separation</th>
<th>Difference</th>
<th>New ETA</th>
<th>New CTO IAF</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>SuperHeavy</td>
<td>SUGOL</td>
<td>10:17:43</td>
<td></td>
<td></td>
<td></td>
<td>10:17:43</td>
<td>10:07:10</td>
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<tr>
<td>15</td>
<td>Medium</td>
<td>SUGOL</td>
<td>10:19:43</td>
<td>0:02:00</td>
<td>0:03:00</td>
<td>-0:01:00</td>
<td>10:20:43</td>
<td>10:10:10</td>
</tr>
<tr>
<td>16</td>
<td>Heavy</td>
<td>RIVER</td>
<td>10:21:43</td>
<td>0:01:00</td>
<td>0:01:45</td>
<td>-0:00:45</td>
<td>10:22:28</td>
<td>10:07:42</td>
</tr>
<tr>
<td>17</td>
<td>Medium</td>
<td>SUGOL</td>
<td>10:23:43</td>
<td>0:01:15</td>
<td>0:02:00</td>
<td>-0:00:45</td>
<td>10:24:28</td>
<td>10:13:55</td>
</tr>
<tr>
<td>18</td>
<td>Medium</td>
<td>SUGOL</td>
<td>10:25:43</td>
<td>0:01:15</td>
<td>0:01:45</td>
<td>-0:00:30</td>
<td>10:26:13</td>
<td>10:15:40</td>
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<tr>
<td>19</td>
<td>Medium</td>
<td>SUGOL</td>
<td>10:27:43</td>
<td>0:01:30</td>
<td>0:01:45</td>
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<td>10:27:58</td>
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<tr>
<td>20</td>
<td>Heavy</td>
<td>RIVER</td>
<td>10:29:43</td>
<td>0:01:45</td>
<td>0:01:45</td>
<td>-0:00:00</td>
<td>10:29:43</td>
<td>10:14:57</td>
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<tr>
<td>21</td>
<td>Heavy</td>
<td>RIVER</td>
<td>10:31:43</td>
<td>0:02:00</td>
<td>0:01:40</td>
<td>0:00:20</td>
<td>10:31:43</td>
<td>10:16:57</td>
</tr>
</tbody>
</table>
Simulation

Example
Results
1 IAF to 1 runway
Results
2 IAFs merging 1 runway
# Results

![Image](image.png)

## Throughput

<table>
<thead>
<tr>
<th>Throughput \ Time</th>
<th>1:40:00</th>
<th>2:00:00</th>
<th>2:20:00</th>
<th>2:40:00</th>
<th>3:00:00</th>
<th>3:20:00</th>
<th>3:40:00</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 min: No ERDA</td>
<td>4,0</td>
<td>10,0</td>
<td>11,0</td>
<td>11,0</td>
<td>11,0</td>
<td>11,0</td>
<td>10,0</td>
</tr>
<tr>
<td>20 min: ERDA</td>
<td>4,0</td>
<td>10,0</td>
<td>10,4</td>
<td>10,8</td>
<td>11,7</td>
<td>11,0</td>
<td>10,0</td>
</tr>
<tr>
<td>Rolling hour: No ERDA</td>
<td>25,0</td>
<td>32,0</td>
<td>33,0</td>
<td>33,0</td>
<td>32,0</td>
<td>24,4</td>
<td>31,3</td>
</tr>
<tr>
<td>Rolling hour: ERDA</td>
<td>24,4</td>
<td>31,3</td>
<td>33,0</td>
<td>33,0</td>
<td>32,7</td>
<td>25,7</td>
<td>32,5</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Throughput \ Time</th>
<th>5:40:00</th>
<th>6:00:00</th>
<th>6:20:00</th>
<th>6:40:00</th>
<th>7:00:00</th>
<th>7:20:00</th>
<th>7:40:00</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 min: No ERDA</td>
<td>4,2</td>
<td>10,8</td>
<td>11,0</td>
<td>11,0</td>
<td>11,0</td>
<td>9,0</td>
<td>9,0</td>
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<tr>
<td>20 min: ERDA</td>
<td>4,1</td>
<td>10,9</td>
<td>10,7</td>
<td>10,9</td>
<td>10,9</td>
<td>11,3</td>
<td>9,2</td>
</tr>
<tr>
<td>Rolling hour: No ERDA</td>
<td>26,0</td>
<td>32,8</td>
<td>33,0</td>
<td>33,0</td>
<td>33,0</td>
<td>31,0</td>
<td>31,0</td>
</tr>
<tr>
<td>Rolling hour: ERDA</td>
<td>25,7</td>
<td>32,5</td>
<td>32,5</td>
<td>32,5</td>
<td>33,1</td>
<td>31,4</td>
<td>31,4</td>
</tr>
</tbody>
</table>
Conclusions

- ERDA can sometimes cause a small decrease in runway throughput.
- TMA delay decreases significantly
- Inbound peak is extended in time by 30 to 90 seconds (1 arrival)
- A correct time based separation at the IAF is important:
  - Same required time interval at the threshold can be used
  - Difference in TMA flight time between aircraft can be important if long fixed approach paths are in use
Conclusions

**Runway Pressure?**

Always minimum delay remaining in TMA

- Caused by accuracy of ATO IAF => +/- 30 seconds
- Caused by difference in flight time (aircraft performance)

Benefit of decreased delay in TMA are clear, so should we absorb all expected delay en-route?

No, some factors not investigated:

- Workload of en-route airspace and ACC controllers
- Absorption capacity in those airspaces can be limited
Recommendations

For further research

- Simulate with a dynamic AMAN/flow control module
  - Time based separation with strong head wind at threshold
  - Missed approaches, pop-up flights, runway change, etc.
- Investigate effect on workload ATCOs (APP, ACC, MUAC)
- Investigate delay sharing strategy
- Effect of ERDA in continuous hub operations

For other students/researchers

- Perform good analysis of the ATM system before modeling
Thank you!

Luchtverkeersleiding Nederland
Air Traffic Control the Netherlands
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