Local TBS delay reduction effect on global network operations

Goce Nikolovski, Vincent Treve, Floris Herrema
ICRAT Castelldefels, Barcelona (Spain)
29.06.2018
Outline

1. Introduction
2. Background
3. Methodology
4. Results
5. Conclusion
Introduction

- Problematic – flight delay and propagation
- Forecast of air traffic and expected issues
- TBS – Time Based Separation

Objective
- Quantify and model a potential delay reduction tool on a network of airports in high-wind conditions

Sub-objectives of the paper
- Reveal the effect of the TBS implementation on delays
- Demonstrate the flight delay mitigation in the network – for one and two flight legs
- Rationalize the obtained results.
Background

*TBS – Time Based Separation*

Normal Landing Rate – Light Headwind

Reduced Landing Rate – Strong Headwind

Time Based Separation in Strong Headwind
Background
Concept DBS versus TBS

Strong Headwind

3.6 NM = 90 s

4 NM = 90 s

Low Headwind
**TBS at LHR – 24.03.2015**

**Benefits**

- 83% of the aircraft had smaller Arrival-Arrival separations (May-July 2015)
- 78 NM saved per day on final approach
- In strong wind conditions (>20kts) 178NM were saved on average per day
- In strong wind conditions - additional 2.9 movements per hour
- In all wind conditions - additional 1.2 movements per hour
Background
Flight delay

- Primary delay
- Reactionary delay / propagated delay
all-causes delay $\neq$ ATFM delay

ATFM delay: COBT-EOBT

Delay all causes: OUT-STD
Background

Reactionary delay illustration
Methodology
Delays used in the study

* All-cause departure delay
  * ACTUAL_OUT – STD
* Arrival delay
  * ACTUAL_IN – STA
**Methodology**

- **Data collection sources:**
  - CODA – Central Office of Delay Analysis
    - Flight records data – to match the given criteria in terms of time period and airports
  - PRISME - Pan-European Repository of Information Supporting the Management of EATM
    - Weather data for period before and after TBS
    - Airport network – to be as congested as possible
Methodology

Data analysis

* **Criteria**
  * 6 airports [ LHR, CDG, FRA, MUC, AMS, DUB ]
  * 15 windy days prior and post TBS
  * All-cause delay with less than 120 minutes

* **Scenarios**
  * All departures from London Heathrow with destination one of the 5 airports + arrivals in the network
  * Two flight legs pattern – flight delay propagation in a wider network
  * Data Mining – sequential pattern mining
Methodology

Weather data

Before TBS
After TBS

Wind speed (knots)
SCENARIO 1

All departures and arrivals at London Heathrow in the network
Acronyms

* DLY_1 – all-cause delay – minutes
  * DLY_1 = ACTUAL_OUT - STD
* DLY_2 – arrival delay – minutes
  * DLY_2 = ACTUAL_IN - STA
KPIs

* NDI – Number of Delays Indicator [e.g. 238]
* TDI – Total Delay Indicator in minutes [e.g. 23’846]
LHR departures – NDI

Number of Delays Indicator

<table>
<thead>
<tr>
<th></th>
<th>Number of departure delays</th>
<th>Number of arrival delays</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before TBS</td>
<td>889</td>
<td>860</td>
</tr>
<tr>
<td>After TBS</td>
<td>629</td>
<td>635</td>
</tr>
<tr>
<td>Improvement</td>
<td>29.25%</td>
<td>26.16%</td>
</tr>
</tbody>
</table>

All with DLY_1 > 0

All with DLY_2 > 0
LHR departures – TDI
Total Delay Indicator

Total delay in minutes

<table>
<thead>
<tr>
<th></th>
<th>departure delays</th>
<th>arrival delays</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before TBS</td>
<td>26950</td>
<td>24670</td>
</tr>
<tr>
<td>After TBS</td>
<td>16708</td>
<td>13663</td>
</tr>
<tr>
<td>Improvement</td>
<td>38.00%</td>
<td>44.62%</td>
</tr>
</tbody>
</table>

All with DLY_1 > 0

All with DLY_2 > 0
LHR arrivals – NDI
Number of Delays Indicator

Number of delayed flights

<table>
<thead>
<tr>
<th></th>
<th>Number of departure delays</th>
<th>Number of arrival delays</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before TBS</td>
<td>953</td>
<td>966</td>
</tr>
<tr>
<td>After TBS</td>
<td>838</td>
<td>806</td>
</tr>
<tr>
<td>Improvement</td>
<td>12.07%</td>
<td>16.56%</td>
</tr>
</tbody>
</table>

All with DLY_1 > 0

All with DLY_2 > 0
LHR arrivals – TDI
Total Delay Indicator

All with DLY_1 > 0 at the other airports

Total delay in minutes

<table>
<thead>
<tr>
<th></th>
<th>departure</th>
<th>arrival</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before TBS</td>
<td>28342</td>
</tr>
<tr>
<td></td>
<td>After TBS</td>
<td>21099</td>
</tr>
<tr>
<td>Improvement</td>
<td>25.56%</td>
<td></td>
</tr>
</tbody>
</table>

All with DLY_2 > 0 i.e. arrival delay at LHR
* NDI improvement - from 14% to 20% for departure delays. And for the arrival delays from 11.2% to 30.4% reduction.

* TDI improvement - in case of departures the reduction observed was between 9.8% and 40.8% and in case of arrivals 16.1% to 43.9%.
SCENARIO 2

Two flight leg pattern – propagation in a network of airports in ECAC
Acronyms

* DLY_1 – all-cause delay of first leg
* DLY_2 – arrival delay of first leg
* DLY_3 – all-cause delay of second leg
* DLY_4 – arrival delay of second leg
First flight leg’s KPIs
NDI – Number of Delays Indicator

Number of delayed flights (departures only)

All with $DLY_1 > 0$

All with $DLY_2 > 0$

<table>
<thead>
<tr>
<th></th>
<th>Number of departure delays</th>
<th>Number of arrival delays</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before TBS</td>
<td>243</td>
<td>204</td>
</tr>
<tr>
<td>After TBS</td>
<td>182</td>
<td>166</td>
</tr>
<tr>
<td>Improvement</td>
<td>25.1%</td>
<td>18.6%</td>
</tr>
</tbody>
</table>
First flight leg’s KPIs

**TDI – Total Delay Indicator**

Total delay in minutes (TDI) (departures only)

<table>
<thead>
<tr>
<th></th>
<th>Departure</th>
<th>Arrival</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before TBS</td>
<td>7053</td>
<td>5125</td>
</tr>
<tr>
<td>After TBS</td>
<td>4843</td>
<td>3386</td>
</tr>
<tr>
<td>Improvement</td>
<td>31.3%</td>
<td>33.9%</td>
</tr>
</tbody>
</table>
Second flight leg’s KPIs
NDI – Number of Delays Indicator

<table>
<thead>
<tr>
<th></th>
<th>Number of departure delays</th>
<th>Number of arrival delays</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before TBS</td>
<td>233</td>
<td>179</td>
</tr>
<tr>
<td>After TBS</td>
<td>199</td>
<td>132</td>
</tr>
<tr>
<td>Improvement</td>
<td>14.6%</td>
<td>26.3%</td>
</tr>
</tbody>
</table>
Second flight leg’s KPIs

TDI – Total Delay Indicator

Total delay in minutes (TDI) (departures only)

<table>
<thead>
<tr>
<th></th>
<th>minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>departure</td>
</tr>
<tr>
<td>Before TBS</td>
<td>4584</td>
</tr>
<tr>
<td>After TBS</td>
<td>3318</td>
</tr>
<tr>
<td>Improvement</td>
<td>27.6%</td>
</tr>
</tbody>
</table>

All with DLY_3 > 0

All with DLY_4 > 0
Double-delayed flights KPI
NDI – Number of Delays Indicator

Number of delayed flights

<table>
<thead>
<tr>
<th>Flights</th>
<th>Number of departure delays (first &amp; second leg)</th>
<th>Number of arrival delays (first leg)</th>
<th>Number of arrival delays (second leg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before TBS</td>
<td>72</td>
<td>68</td>
<td>68</td>
</tr>
<tr>
<td>After TBS</td>
<td>50</td>
<td>48</td>
<td>47</td>
</tr>
<tr>
<td>Improvement</td>
<td>30.6%</td>
<td>29.4%</td>
<td>30.9%</td>
</tr>
</tbody>
</table>
Double-delayed flights KPI

**TDI – Total Delay Indicator**

**Total delay in minutes**

<table>
<thead>
<tr>
<th></th>
<th>Before TBS</th>
<th>After TBS</th>
<th>Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>departure delay first leg</td>
<td>3110</td>
<td>2363</td>
<td>24.0%</td>
</tr>
<tr>
<td>arrival delay first leg</td>
<td>2938</td>
<td>2454</td>
<td>16.5%</td>
</tr>
<tr>
<td>departure delay second leg</td>
<td>2122</td>
<td>1384</td>
<td>34.8%</td>
</tr>
<tr>
<td>arrival delay second leg</td>
<td>2190</td>
<td>1809</td>
<td>17.4%</td>
</tr>
</tbody>
</table>
Conclusion

- Significant improvements
- Future high expectations in delay reduction
- Better traffic flow and capacity
- Hopefully this research will stimulate further RTE concept studies, especially the TBS
Recommendations for further work

- Expand the network
- More days with strong headwinds
- Annual analysis
- Analysis on different types of delays
- Comparison between different types of delays
- Analysis on cancellations
Thank you for your attention.

Questions?

g_nikolovski@hotmail.com
www.pinwheelaerospace.com