Time Based concept and validation
EUROCONTROL development

WakeNet Europe 2015

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21 April 2015
Time based separation concept

- Strong headwind increases time separation for constant distance applied
- Reduced separations support constant time between 2 landings in strong headwind conditions
Preliminary analysis of the traffic and MET database

- Database from October 2012 and July 2013
- Wind measured by anemometer and SODAR
- Traffic analysed during the morning peak
- Approach on single Runway
Preliminary analysis of the traffic and MET database

01/07/2013 - Maximum throughput = 42 - Headwind = 4kt

Throughput [-] (1h sliding window) vs. Hour of the day
Preliminary analysis of the traffic and MET database

Low wind
Preliminary analysis of the traffic and MET database

Low wind

Strong wind
reduced capa
Preliminary analysis of the traffic and MET database

01/07/2013 - Maximum throughput = 42 - Headwind = 4kt

Throughput [-] (1h sliding window)

Hour of the day
Preliminary analysis of the traffic and MET database

11/06/2013 - Maximum throughput = 36 - Headwind = 19kt
Preliminary analysis of the traffic and MET database

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<thead>
<tr>
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<tr>
<td>Throughput</td>
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<tr>
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<td>3</td>
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</tr>
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<td>Average_coeff_to_ICAO</td>
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Preliminary analysis of the traffic and MET database

Low wind

Strong wind
reduced capa
Preliminary analysis of the traffic and MET database

2012 and 2013 traffic and SODAR data
Preliminary analysis of the traffic and MET database

06/07/2013 - Maximum throughput = 41 - Headwind = 16kt
## Preliminary analysis of the traffic and MET database

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Time based validation

- Demonstrate TBS separations are safe in fault free and faulted operations
- Demonstrate the application of the reduced separation by ATCO is acceptably safe

Low Headwind

5.0 Nm = 122 s

Strong Headwind

4.6 Nm = 122 s
Time based validation

- Demonstrate TBS separations are safe in fault free and faulted operations.
- Demonstrate the application of the reduced separation by ATCO is acceptably safe.

- Low Headwind
  - 5.0 Nm = 122s

- Strong Headwind
  - 4.6 Nm = 122 s
TBS separations are safe in fault free operations

- Using EGLL-1 database, the application of TBS is verified to be safe in terms of wake vortex encounter hazard
  - In case of headwind, reduced separations lead to encounter younger vortices
  - However, wind enhances the wake decay in ground proximity
  - The reduction of vortex age is seen to be mitigated by the headwind effect on wake decay

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CatB: p50, Δ w=2 kts

- HW < 5 kts
- HW = 5 kts
- HW = 10 kts
- HW = 15 kts
TBS separations are safe in faulted operations

- Error on separation computation leads to error on delivered time separations

  Origins of the error:
  - Unexpected windspeed profile variation
  - Unexpected shift in wind direction

  Consequence of the error:
  - The time separation between two aircraft can then be reduced compared to time observed in DBS mode

- Hence, the wake encounter risk is increased compared to the “nominal” (safe) TBS operation
TBS separations are safe in faulted operations

- This increasing risk should be mitigated using either:
  
  a) Mitigation 1: Add a time buffer ($\Delta t$) on all time separations in the used TBS matrix
  
  b) Mitigation 2: Only apply TBS when the total wind is above a certain total wind threshold ($TW_{\text{Thres}}$)

- The value of the required $\Delta t$ or $TW_{\text{Thres}}$ depends on the performance of the wind and airspeed forecasting / nowcasting

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<th>Safety buffer to be added</th>
<th>Wind threshold for mitigating the error</th>
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<tr>
<td>5 s</td>
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<td>6 kts</td>
</tr>
<tr>
<td>10 s</td>
<td>10 s</td>
<td>7 kts</td>
</tr>
<tr>
<td>15 s</td>
<td>15 s</td>
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</tr>
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TBS separations are safe in faulted operations

- In extreme case of 30s error on the delivered time separation
  a) Mitigation 1: Add 30 s to all time separations
  b) Mitigation 2: Use $TW_{\text{Thres}} = 10$ kts

**Diagram:**

- **DBS low wind**
- TBS - 30 s with $TW_{\text{Thres}} = 6$ kts
- Provisional results
Mitigation of error on the separation indicator

Example

- In extreme case of 30s error on the delivered time separation
  
  a) Mitigation 1: Add 30 s to all time separations
  
  b) Mitigation 2: Use $ TW_{\text{Thres}} = 10 \text{ kts} $
Mitigation of error on the separation indicator

Example

- In extreme case of 30s error on the delivered time separation
  
  a) Mitigation 1: Add 30 s to all time separations
  
  b) Mitigation 2: Use $TW_{\text{Thres}} = 10$ kts

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Provisional results
Time based validation

- Demonstrate TBS separations are safe in fault free and faulted operations
- Demonstrate the application of the reduced separation by ATCO is acceptably safe
Time based validation

- Demonstrate TBS separations are safe in fault free and faulted operations
- Demonstrate the application of the reduced separation by ATCO is acceptably safe
THALIN 1 Real Time Simulation

- Need to include Human in the Loop assessment during validation.
- Main aim of THALIN 1 was to assess the acceptability and feasibility of using the Optimised Runway Delivery tool to support controllers in delivering separation at runway threshold.
- Assessed both Tower and Final Approach.
- Used operational Charles De Gaulle controllers.
Simulation Objectives

Objectives aim to contribute to these questions:

Safety
- Can the controller safely deliver aircraft separations at threshold?

Human Performance
- Does the controller find the tool acceptable to use?
- Does it impact controller workload and situational awareness?

Runway Throughput
- How is the runway throughput impacted?
Separation Conformance at 1Nm from Threshold

- Results indicate that separation conformance is not degraded comparing Time Based PWS with DBS.
- There is a smaller separation buffer comparing DBS with TDIs and DBS without TDIs.

Note - there was not sufficient data to prove statistical significance.
Human Performance

- Workload shown to improve when comparing TBS with DBS during strong winds.
- No clear change in situational awareness.
- Controller found the Optimised Runway Delivery tool acceptable to use but suggested improvement in arrival sequence stability.
Runway Throughput

- Runway throughput is partially recovered during strong wind conditions comparing DBS with Time Based PWS.

![Runway Throughput Comparing DBS and Time Based PWS](chart.png)

- DBS Low Wind
- DBS Strong wind
- Time Based PWS Strong Wind (FTD)
- Time Based PWS Strong Wind (ITD/FTD)

Lost capacity
Recovered capacity
Preliminary analysis of the traffic and MET database
TBS measured effect

- Day1_run01_Low_DBS: 39.0 ac/h
- Day1_run02_Low_DBS: 38.9 ac/h
- Day5_run17_Low_DBS: 38.4 ac/h

- Day1_run03_Strong_DBS: 29.6 ac/h
- Day4_run15_Strong_DBS: 34.3 ac/h

- Day2_run04_Strong_TBS_FTD_ITD: 34.8 ac/h
- Day2_run06_Strong_TBS_FTD: 34.6 ac/h
- Day3_run09_Strong_TBS_FTD: 37.6 ac/h
- Day4_run14_Strong_TBS_FTD_ITD: 33.8 ac/h

39 ac/h with 15% under spaced
32 ac/h with 33% under spaced
35 ac/h with 21% under spaced

-18% equivalent to the -16% observed in data

Under spaced pairs also result from the limited training in that simulation environment
Under spaced were filtered for computing the provided throughputs
Preliminary analysis of the traffic and MET database
Runway Throughput

- Runway throughput is improved during DBS operations in a challenging wind when using TDIs.
Delivery tool measured effect

- Day1_run01_Low_DBS: 39.0 ac/h
- Day1_run02_Low_DBS: 38.9 ac/h
- Day5_run17_Low_DBS: 38.4 ac/h

- Day2_run05_Adverse_DBS: 37.7 ac/h
- Day3_run10_Adverse_DBS: 37.7 ac/h

- Day2_runXX_Adverse_TBS_FTD_ITD: 41.6 ac/h
- Day3_runXX_Adverse_TBS_FTD_ITD: 39.5 ac/h

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<td>39 ac/h with 15% under spaced</td>
<td>40.5 ac/h with 10% under spaced</td>
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-3% +4% = +1%

Adverse wind conditions are 15kt tail wind at 3000ft and 15kt headwind at the ground

*Under spaced pairs also result from the limited training in that simulation environment*

*Under spaced were filtered for computing the provided throughputs*
Summary

- Time Based reduced Separation are acceptably safe in fault-free operations

- Mitigations for faulted operations have been analysed and need now to be translated into requirement for MET office (ongoing)

- Results from THALIN-1 are promising
  - Headwind delay recovery observed are in line with expectations
  - The HMI is well accepted by the ATCO
  - Industrial prototype is stable and performed as expected

- More data will be needed for being statistically conclusive (THALIN-2)