Technical feasibility and impacts of Reducing Standard Separation Minima in final approach

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Agenda

- Introduction to SESAR PJ02 EARTH
- Problem Description
- Technical Study
- Simulation Environment
- Results
- Future work
PJ-02 Enhanced Runway Throughput

Solution List

- PJ02-01: Wake turbulence separation optimization
- PJ02-02: Enhanced arrival procedures
- **PJ02-03: Minimum-Pair separations based on RSP**
- PJ02-05: Independent Rotorcraft IFR operations at the Airport
- PJ02-06: Improved access into secondary airports in low visibility conditions
- PJ02-08: Traffic optimisation on single and multiple runway airports
- PJ02-11: Enhanced Terminal Area for efficient curved operations
PJ02.01 Runway Throughput Enhancement Solution

- **RECAT & TBS** are available for deployment, and can be operated independently or in combination.
LORD: an ATC concept for optimised runway delivery at APP and TWR
How to validate the reduction to 2NM separation

- **Technical Constraints**
  
  => Technical Studies including major European industrials

- **Operational Constraints**
  
  => Workshops, Fast time and Real time simulations

  - Safety Assessment report
  - Security Assessment report
  - Human Performance Assessment report
  - Performance Assessment report
PJ02-03 Solution overview

- Investigate the surveillance technology (e.g. Primary and Secondary Surveillance Radar, GNSS/GBAS, WAM) which have the potential to meet the Required Surveillance Performance (RSP) requirements
- Standard ICAO MP arrival separation – 3NM
- In specific conditions and equipment – 2.5NM
- Sol3 to reduce MRS to 2NM with RSP conditions
reducing the Minimal-Pair separations

<table>
<thead>
<tr>
<th>Leader</th>
<th>Arrivals</th>
<th>Follower</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>J</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>J</td>
<td>A</td>
<td>3.0</td>
</tr>
<tr>
<td>H</td>
<td>B</td>
<td>SM</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>SM</td>
</tr>
<tr>
<td>M</td>
<td>D</td>
<td>SM</td>
</tr>
<tr>
<td></td>
<td>E</td>
<td>SM</td>
</tr>
<tr>
<td>L</td>
<td>F</td>
<td>SM</td>
</tr>
</tbody>
</table>
Separation Minimum Structure

Forbidden Zone
- Collision cross section

Surveillance Uncertainty
- A/C surveillance & RNP
- Ground/Satellite systems surveillance

Intervention Buffer
- Detection, reaction...
- A/C performance
- Human performance
- Communication
- Environment & others

Wake Turbulence Zone
- Considered by other SM Standards

Surveillance Uncertainty

Wake Turbulence Zone

Intervention Buffer

Forbidden Zone
Surveillance Uncertainty

- The surveillance uncertainty on the exact positioning of the aircraft at each positioning report,
- The additional uncertainty due to missing information between 2 discrete positioning reports (positioning is not available in a continuous way),
- The possibility of system failure in the reporting of the aircraft positioning (missing reports).
- The display accuracy on the controller screen.
**Required Surveillance Performance**

- RSP is the set of system performance parameters that are required for a surveillance system to support a surveillance application.
- System performance parameters impacted:
  - accuracy,
  - availability,
  - integrity,
  - latency
  - and refresh rate
RSP Requirements

The following requirements linearly extrapolated (5Nm-3Nm) to create an initial specification for the 2Nm were revised as following:

- The longitudinal position update interval shall be less than or equal to 3.5 sec. => through discussion with ATCOs 4s update rate is sufficient, more validation with ATCO on the loop shall be conducted.

- The pressure altitude update interval shall be less than or equal to 3.5 sec. => indicated altitude shall be used in APP instead of pressure: indicated altitude update interval of 4 sec shall be sufficient.

- The aircraft identity update interval shall be less than or equal to 3.5 sec. => 4 sec shall be sufficient.
The probability of the longitudinal position update shall be greater than or equal to 97%. => ac are flying in the same direction and similar speed profile

The ratio of missed 3D positions involved in long gaps shall be less than or equal to 0.5%. => be less than or equal to 0.25

The longitudinal positional RMS error shall be less than or equal to 200 meters per flight.

The ratio of longitudinal position target reports involved in series of at least 3 consecutive errors larger than 0.5 NM shall be less than or equal to 0.003%.

Probability of update of indicted altitude with correct value shall be greater than or equal to 96%

The average data age of the forwarded pressure altitude shall be less than or equal to 1.75 sec. => The average data age of the forwarded indicated altitude shall be less than or equal to 2 sec
Results of the Survey

Three surveillance technologies fulfill the required surveillance performance:

- PSR
- SSR
- ADS-B

Increasing the radar rotation speed will have an impact in the mechanical structure.
Simulation environment

- Based on Vienna RWY34
- Mixed mode runway operations
- There are two working positions:
  - **Executive Final Approach** - Arrival spacing managed by final director.
    - Final Approach inserts gaps in arrival traffic flow when necessary via LORD sequence list: gap size and required co-ordination will vary depending on arrival-departure procedure applied
  - **TWR RWY** controller – manages arrivals and departures for RWY 34
  - Planner Final Approach position is an automated feed sector
  - Ground position is fully automated
Real Time Simulation Plateform
Optimised Runway Delivery (LORD) Tool

Red chevron – Final Target Distance (FTD) indicator: Separation to be delivered
Optimised Runway Delivery (LORD) Tool

Black Chevron – Initial Target Distance Indicator (ITD): Compression buffer

Red chevron-Final Target Distance Indicator (FTD): Separation to be delivered
Optimised Runway Delivery (LORD) Tool

**Only** black ITD Chevron is used by approach controller

Black Chevron – Initial Target Distance Indicator (ITD): Compression buffer

Red chevron-Final Target Distance Indicator (FTD): Separation to be delivered

Red FTD is provided in the APP if the buffer is infringed
Optimised Runway Delivery (LORD) Tool

Only black ITD Chevron is used by approach controller

Black Chevron – Initial Target Distance Indicator (ITD): Compression buffer

Red chevron-Final Target Distance Indicator (FTD): Separation to be delivered
Optimised Runway Delivery (LORD) Tool

Black Chevron – Initial Target Distance Indicator (ITD): Compression buffer

Red chevron-Final Target Distance Indicator (FTD): Separation to be delivered

Only RED FTD chevron is displayed in the TWR
LORD target distance indicators

**Approach HMI:** Initial Target Distance indicators (ITD) / compression:

- $C = WT / MRS$
- $I = ROT$ (Runway Occupancy Time)
- $[ = Gap$ (inserted by APP)

**Tower HMI:** Final Target Distance indicators (FTD) / Separation:

- $C = WT / MRS$ separation
- $I = ROT$ (Runway Occupancy Time)
- $[ = Gap$ (inserted by APP)
LORD separations (e.g. to manage compression management) are based on aircraft speed modelling and wind data

- Model is based on years of Radar and Wind data
- **local** parametrisation
Sequencing list / tool

<table>
<thead>
<tr>
<th>LORD (T) - 34L</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LORD Hold</strong></td>
<td></td>
</tr>
<tr>
<td>1  BAW9257</td>
<td>H</td>
</tr>
<tr>
<td>2  ETH724</td>
<td>H T</td>
</tr>
<tr>
<td>3  LGL8851</td>
<td>M T</td>
</tr>
<tr>
<td>4  EZY81NW</td>
<td>M T</td>
</tr>
<tr>
<td>5  AUA128L</td>
<td>M T</td>
</tr>
<tr>
<td>6  DLH99X</td>
<td>M T</td>
</tr>
<tr>
<td>7  UPS274</td>
<td>H T</td>
</tr>
<tr>
<td>8  AUA9066</td>
<td>M T</td>
</tr>
<tr>
<td>9  UAE127</td>
<td>J T</td>
</tr>
</tbody>
</table>

SEQUENCE NUMBER IN LABEL

LORD SEQUENCE LIST
Alerts

**Automatic FTD pop up** – FTD is automatically displayed if ITD is infringed OR if difference between leader’s FTD and ITD is less than 0.3NM (little compression), and the a/c is 0.3NM from leader’s ITD
Alerts

**Sequence alert** – appears when the actual aircraft sequence (calculated by system based on distance from a specific point on glide) is different from the a/c sequence displayed in the sequence list and a/c label.
Alerts

**Catch-up alert** – triggered when the speed difference between follower and ITD is greater than 12Kts and if in the next 60 seconds the ITD will be infringed.
Alerts

**Speed alert** – triggered when there is 20Kts difference between the aircraft speed and the 160Kts reference speed used by the LORD tool within the last 10NM from the threshold
Under RECAT PWS separations are defined as a function of aircraft types:

- Under current ICAO wake separation scheme, aircraft are categorised into one of four wake categories.

- Separation minima based on ICAO wake scheme can be over conservative as they are designed to protect lightest follower aircraft from the heaviest leader aircraft.
RECAT PairWise Separations – separation defined per pair of aircraft types

Under a PairWise separation scheme, separations are adapted as a function of leader and follower aircraft type characteristics.

Separations are designed for the top 96 most frequent aircraft as a function of leader and follower characteristics (extract for most frequent Heavy and Upper-Lower Medium)

Pair Wise Separations currently under EASA review
### RECAT PairWise Separations – separation defined per pair of aircraft types

- Under a PairWise separation scheme, **separations are adapted as a function of leader and follower aircraft type characteristics**

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**RECAT PairWise Separations – separation defined per pair of aircraft types**

- Under a PairWise separation scheme, separations are adapted as a function of leader and follower aircraft type characteristics.

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<table>
<thead>
<tr>
<th>Aircraft Type</th>
<th>Separation (Nm)</th>
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</thead>
<tbody>
<tr>
<td>A388</td>
<td>4.5</td>
</tr>
<tr>
<td>B77L</td>
<td>3.5</td>
</tr>
<tr>
<td>B77W</td>
<td>3.5</td>
</tr>
<tr>
<td>A351</td>
<td>3.5</td>
</tr>
<tr>
<td>A359</td>
<td>3.5</td>
</tr>
<tr>
<td>A358</td>
<td>3.5</td>
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<td>B744</td>
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</tr>
<tr>
<td>A346</td>
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<td>A345</td>
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<td>B773</td>
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<td>A306</td>
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<td>A30B</td>
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<td>A310</td>
<td>2.5</td>
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<tr>
<td>B752</td>
<td>1.5</td>
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<tr>
<td>B753</td>
<td>1.5</td>
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</table>

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Separations are designed for the top 96 most frequent aircraft as a function of leader and follower characteristics.

(extract for most frequent Heavy and Upper-Lower Medium)
RECAT PairWise Separations – separation defined per pair of aircraft types

- Under a PairWise separation scheme, **separations are adapted as a function of leader and follower aircraft type characteristics**

---

### Pair Wise Separations currently under EASA review

Separations are designed for the top 96 most frequent aircraft as a function of leader and follower characteristics

*(extract for most frequent Heavy and Upper-Lower Medium)*
Performance assessment – methods & measures

Operational feasibility/acceptability and performance in terms of human performance, safety and capacity/resilience will be assessed using a number of different methods and measures:

- **System performance data**
  - Number of separation infringements (arrivals and departures),
  - number of go-arounds,
  - accuracy of a/c delivery,
  - runway throughput (arrivals/departures) / number of aircraft handled per unit time (APP and TWR);
  - % RT occupancy,
  - number /duration of telephone calls (TWR/APP),
  - number of aircraft on frequency,
  - number and type of instructions

- **ISA workload ratings**
- **Observations**
- **Post exercise questionnaires (workload and situation awareness)**
- **Post exercise debriefs**
- **Post simulation (usability of tools, concepts, trust, safety)**
- **Post simulation debrief**
# Traffic Sample

<table>
<thead>
<tr>
<th>ICAO WTC</th>
<th>Arr</th>
<th>Dep</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>A380-800</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Heavy</td>
<td>5</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>Medium</td>
<td>25</td>
<td>14</td>
<td>39</td>
</tr>
<tr>
<td>Light</td>
<td>2</td>
<td>0</td>
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## Run description

<table>
<thead>
<tr>
<th>Run #</th>
<th>MRS value [NM]</th>
<th>LORD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.0</td>
<td>Yes</td>
</tr>
<tr>
<td>2</td>
<td>2.0</td>
<td>No</td>
</tr>
<tr>
<td>3</td>
<td>2.5</td>
<td>No</td>
</tr>
<tr>
<td>4</td>
<td>2.0</td>
<td>No</td>
</tr>
</tbody>
</table>
Initial results

- The number of consecutive arrivals with MRS separation ($N_{A-A_{MRS}}$)
- The number of go-arounds performed by the follower of two consecutive arrivals for which MRS was the applicable separation ($N_{GA\ A-A_{MRS}}$).

<table>
<thead>
<tr>
<th>Run #</th>
<th>$N\ A-AMRS$</th>
<th>$N\ GA\ A-AMRS$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>13</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>16</td>
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<tr>
<td>3</td>
<td>18</td>
<td>1</td>
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<tr>
<td>4</td>
<td>17</td>
<td>0</td>
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</table>
Initial results

<table>
<thead>
<tr>
<th>run #</th>
<th>$T_{P_{\text{pairs, noGA}}}^{\text{ac/h}}$</th>
<th>$N_{\text{pairs, A-A, no GA}}$</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>42.8</td>
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</tr>
<tr>
<td>2</td>
<td>42.2</td>
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<tr>
<td>3</td>
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<tr>
<td>4</td>
<td>41.1</td>
<td>17</td>
</tr>
</tbody>
</table>
Conclusion

- Technical study shows that PSR, SSR and ADS-B technologies are ready for the separation reduction.
- The controllers are observed to be able to successfully operate with MRS set at 2.0NM with and without separation delivery support tool.
- When applying a 2.0NM MRS without support tool, the controllers add more separation buffers compared to 2.5NM MRS => the objective to increase the throughput is reached.
- The tool brings more confidence to the ATCO to apply the 2.0NM.
- Need for more RTS to confirm initial results with different configurations varying:
  - Wind
  - Runway Occupancy Time (ROT)
Questions?