Contextual note – SESAR Solution PJ.02-08-03 "Reduced separation based on local Runway Occupancy Time characterisation"

Purpose:

This contextual note introduces the SESAR Solution PJ.02-08-03 (for which maturity has been assessed as sufficient to support a decision for industrialization) with a summary of the results stemming from R&D activities contributing to deliver it. It provides to any interested reader (external and internal to the SESAR programme) an introduction to the SESAR Solution in terms of scope, main operational and performance benefits, relevant system impacts as well as additional activities to be conducted during the industrialization phase or as part of deployment. This contextual note complements the technical data pack comprising the SESAR deliverables required for further industrialization/deployment. It has been enhanced with information from PJ37 ITARO (WP2) and VLD3 SORT (WP2).

Improvements in Air Traffic Management (ATM)

This Contextual Note is focusing on solution PJ.02-08-03 "Reduced separation based on local Runway Occupancy Time characterisation".

The Increased Runway Throughput based on local ROT characterization is a concept that intends to reduce the in-trail separation on final approach with the aim of increasing runway throughput by taking into account the Runway Occupancy Time (ROT). The most constraining factor for the reduction of the separation is, together with the wake turbulence, the ROT; and therefore a new separation minimum could be computed based on the prediction of the ROT, the MRS and the wake categorization separation

The operational application can be based either per aircraft type or per aircraft ROT-based category (ROCAT).

ROCAT defines separation sub-categories based on runway occupancy time, wake minima from RECAT and reduced radar separation based on ICAO approved minima. The solution can increase runway throughput by up to 12% where the aircraft traffic mix is predominantly medium aircraft, and the constraint for separation between medium aircraft is the ROT rather than the Minimum Wake Separation (MWS). Rather than making the same assumption on ROT for all aircraft (which would necessarily need to consider as a constraint the highest observed ROT values and result in higher separation minima), the enhanced ROT prediction based on local Runway Occupancy Time characterisation allows that different ROT assumptions for different aircraft be made, so that for leading aircraft with lower ROT the separation minima can be lower.

The solution consists on developing the runway occupancy minima through big data analytics to identify a runway occupancy time per aircraft type using machine learning techniques and historical data.

The separation minima can be delivered by ATC through a change in the separation minima used by controllers separating aircraft on final approach through a controller decision support tool called ORD (Optimised Runway Delivery).

Operational Improvement Steps (OIs) & Enablers

For this concept, the coverage of the following OI is full:

- AO-0337: Increased Runway Throughput based on local ROT characterization Applicable Integrated Roadmap Dataset is DS21.

The following enablers are required for solution PJ.02-08-03:

- AERODROME-ATC-55: Aerodrome ATC System to support Optimised Runway Delivery on Final Approach based on Aircraft ROT categorization
- APP ATC 169: Approach ATC System to support Optimised Runway Delivery on Approach based on Aircraft ROT categorization
- STD 094: EUROCONTROL Guidelines for reduced aircraft separation based on runway occupancy time.

The solution PJ.02-08-03 “Reduced separation based on local Runway Occupancy Time characterisation” targets High density Final approach and very large airport, the reduction of the separation based on ROT supposes that the airport is equipped with an A-SMGCS system.

Background and validation process

PJ.02 EARTH:

The SESAR Solution has been validated through a Real Time Simulation (RTS) using a Very Large Airport focusing on a range of objectives such as the operational feasibility, the acceptability of the tool by ATCOs, safety, human performance and the capacity.
The RTS Assessed the Enhanced Prediction of Runway Occupancy Time based on aircraft type integrated in a separation delivery function (the ORD tool) using Very Large airport and high-density approach environment.
The objective was to assess the benefits brought by the enhanced prediction of the ROT in various contexts with RECAT-EU and Time Based Separation-Pair Wise Separation and reducing Minimum Radar Separation to 2.5 NM.

PJ37 ITARO:

The PJ37-W3-01A ITARO Arrivals Solution track builds on previous work conducted in SESAR 2020 PJ.01 EAD and PJ.02 EARTH, respectively for Solutions PJ.01-05 and PJ.02-01-01, PJ.02-01-04 and PJ.02-08-03. These SESAR solutions were combined for a first time and it is this combination of SESAR Solutions that was demonstrated mainly through Real Time Simulations (RTS) in preparation of a future VLD. It achieved TRL7-ongoing.

- **EXE-PJ.37-W3-001** related to RTS1 for PJ.37-W3-01A and aimed to test the combined SESAR solutions within PJ.37-W3-01A for the Schiphol Terminal Manoeuvring Area

(TMA). The RTS was performed on NLR's Air traffic management Real-time SIMulator (NARSIM).

- **EXE-PJ.37-W3-002** related to RTS2 for PJ.37-W3-01A. This exercise was based on EXE-PJ.37-W3-001 with improvements incorporated based on the findings of EXE-PJ.37-W3-001 and air traffic controller feedback. The aim of the exercise was to test the combined SESAR solutions within PJ.37-W3-01A for the Schiphol TMA. In addition, the evaluated solution scenarios were extended to more complex operational scenarios (e.g. IM mixed-mode operation and disruptions). The RTS was performed on NARSIM.

VLD3 SORT:

The VLD3 WP2 activity demonstrated at TRL7 feasibility and benefits of implementing together the concepts of Pairwise TBS, reduced MRS and improved ROT management in an RTS pre-deployment trial for London Terminal Control Centre.

Results and performance achievements

PJ.02 EARTH:

The validation showed that the use of the ORD tool with the solution (based on ROCAT) and a wake vortex pairwise separation scheme (per aircraft type) was operationally feasible and acceptable in segregated runway operations.

In addition to the following benefits:

- Arrival runway throughput increased by between 10-14% with compared to a baseline scenario of current Zurich operations (Zurich 5 category wake scheme, 3NM MRS and no tool support), and
- Safety benefits were observed as controller performance improved with fewer separation infringements and missed approaches.
- Controller workload was reduced (even though more aircraft were handled by the controllers per hour).

PJ37-ITARO:

The results below are based on the demonstrations of combined solutions PJ.02-01-01, PJ.02-01-04, PJ.02-08-03 and PJ.01-05.

For Safety, the real time simulations have not shown that the new combination of tools increases the number of controller-instructed go-arounds or the number of losses of separation. However, there are a few issues regarding interoperability of the different tools in the combination, and the controllers involved had some issues with the perceived controllability of the traffic situation. Another conclusion is that the nature of the real time

simulations did not allow a complete safety assessment, and recommendations for further work have been formulated.

From a Human Performance perspective, the real time simulations revealed that the concept is acceptable to the controllers. Furthermore, the controllers were successful in achieving the tasks. An important finding was that the controllers had the feeling not to have sufficient time for monitoring the traffic that is turning in for final and being able to instruct interventions when necessary.

It was demonstrated that combining the SESAR solutions under investigation does not have a negative impact, that is no gaps were identified, on airspace capacity, runway throughput, predictability, CO2 emissions and noise profiles.

The integration of the Solutions did not reveal major issues, but a few topics could benefit from further refinements. Note that none of these refinements directly impact PJ.02-08-03. However, the transition from 3 NM MRS in the TMA to lower values on the final approach track may also impact PJ.02-08-03.

- IM spacing goal – ORD tool – Arrival Manager (AMAN). The spacing goal was based on the minimum separation between aircraft pairs from the ORD tool as well as the arrival planning information from the AMAN), to not only increase runway capacity by setting the spacing goals to the minimum separation, but also considering operations in accordance with the planning. This however resulted in front-loading behaviour, the airspeeds beyond the merge point, being the Achieve-by Point, and in particular on the final approach track were found to be high.

- Combination of the fixed route presentation with the distance-based merge tool and IM operations has been received positively by the controllers. However, it should be explored whether the IM clearance could be given by ACC as the arrival sequence is known before entering the TMA. It was questioned whether in real-life the merge tool should already be presented so early, the ghost blip was already presented on the long approach transitions when the aircraft was still under control of ACC, also for a significant amount of time.

- Transition from MRS 3 NM in the TMA to MRS 2.5 NM (or 2.0) NM on final approach track. The presentation of the Target Distance Indicator (TDI) would gradually reduce the separation to the applicable separation distance, while also taking into account the compression effect on final. Though when the 3 NM is the most stringent requirement, the TDI on short final may still indicate a value slightly above 2.5NM (or 2.0NM). Overall, the operation was perceived positively, however, one could also think of a more abrupt change in TDI presentation once both aircraft are established on the extended centreline.

- The integrated solutions could handle high traffic loads very efficiently for nominal operations and single aircraft events/disturbances. The use of fixed routes with a very

high traffic load and therefore high pressure on the ATM system, may need additional measures (e.g., tools or working methods) to create a gap in case of challenging (e.g., multi aircraft) disturbances/events, a level of flexibility is needed.

VLD3 SORT:

- All participants agreed that the defined procedures are acceptable, as defined in the MOps. Comments from controllers suggest that the alignment of new procedures with those pre-established in eTBS operations increases their acceptability.
- The concept is acceptable to controllers across operational configurations, including different runway configurations and wind conditions;
- Across a range of operational contexts, controllers found HMI and indicator support acceptable. Controllers generally found the system and HMI intuitive and understood system behaviours;
- All participants agreed that the defined procedures are acceptable, as defined in the MOps. Comments from controllers suggest that the alignment of new procedures with those pre-established in eTBS operations increases their acceptability;
- The Pairwise concept supports an increase in arrival throughput in the Heathrow environment. This benefit is heavily influenced by the wind conditions and the individual controller's delivery relative to the displayed indicator;

For the combined demonstration activity, which included PJ.02-01-01, PJ.02-01-04, PJ.02-03 and PJ.02-08-03, the following results were achieved:

- Depending on the wind profile and runway direction, a segregated runway capacity impact of -0.2 to 3.4 movements/hour (-0.44-8.11%) was identified. Note: values in red indicate a performance reduction.
- In the exercise, an average of 14 seconds of holding per flight was saved, which corresponds to 14.84Kg of fuel saving per flight, or 46.73kg of CO_2 saving per flight.

Recommendations and Additional activities

PJ.02 EARTH

The following recommendation are made concerning the implementation solution PJ.02-08-03 "Reduced separation based on local Runway Occupancy Time characterisation" i.e. V4 / V5 activities:

- The validation used wind characterisation that did not include a wind parameter, and therefore correspond to a ROT prediction based on a study of the distribution across all wind conditions. In the V4 phase, it is recommended that a study be conducted to identify if there are certain wind conditions (outliars) in which the ROT may increase so as to require an extra buffer to be added to the ROT value in order to reduce the risk of go-arounds due to runway not vacated.

- The validations of the solution considered an environment where MRS was 2.5NM; however, SESAR PJ02 validated in parallel a solution allowing MRS on final approach to be reduced to 2NM (solution PJ.02-03). The solution is equally applicable in an environment where 2NM is the MRS; moreover, with a lower MRS, there are higher chances that the ROT is the constraining factor, and therefore the solution can be expected to produce more benefits.
- The ROT concept has been validated with ATCOs having the Optimised Runway Delivery (ORD) tool, which supports them in the accuracy for delivering aircraft to the minimum applicable separation on final approach. This tool (solution PJ.02-01-01) has been validated in parallel to the solution PJ.02-08-03; for more information about this tool, the reader should refer to the PJ.02-01 data pack.
- It is recommended that in the V4 phase the colour-coding of the ORD indicators be investigated; different colours would be used to display different constraints: the ROT, WT or MRS to support the ATCO situational awareness (applicable to FTD and ITD/ORD tools).
- To be able to work with the tool confidently and comfortably controllers need to have sufficient training and time to familiarise themselves with the tool and the changes in working methods that result from working with both the FTD and ITD/ORD tool, prior to implementation.
- To increase the confidence in the results obtained with the TB PWS for arrival concept with ITD/ORD with PJ.02-08-03 it is recommended to conduct alternative studies. Further studies could consider different traffic samples / increase the variety of aircraft pairs or different runway configurations. Additionally use of different validation techniques such as fast time simulation is also recommended to increase the reliability of the results.
- Finally, the legal aspect of responsibility in case of a loss of separation due to the FTD and /or ITD/ORD tool miscalculation needs to be addressed prior to implementation. The legal framework describing clearly the roles and responsibilities between controllers, air traffic service providers and tool developers need to be produced before the implementation into an operational environment.

PJ37-W3-ITARO

If the solutions PJ.02-01-01, PJ.02-01-04, PJ.02-08-03 and PJ.01-05 will be implemented together and in combination with RNP-RNAV + CDO trajectory based operations in the Terminal Airspace operational environment, the main recommendations to consider during the industrialisation and deployment phases are as follows:

- REC-37-W3-SAF-R1.1: For a more accurate representation of the safety objectives being studied, incorporate a runway controller in future simulations to manage traffic on the final approach segment and collaborate with the arrival (ARR) controller in instances that may result in go-arounds.

- REC-37-W3-SAF-R4.3: The objectives studied looked at safety up to the level of potential for loss of separation, limited by the nature of real time simulations. In order to assess the risk of a mid-air collision and the risk of wake turbulence related accidents, as is required in SESAR safety reference material (SRM), in a follow on project it is recommended to use Dynamic Risk Modelling to assess the safety benefits of the combination of tools more accurately.

- REC-37-W3-SAF-R3.2: Consider expanding the coverage of the FIM system to include the ACC airspace, in addition to the TMA airspace. This could provide more time and space for the system to maintain appropriate spacing between aircraft and to create gaps in case an aircraft needs to re-sequenced.

- REC-37-W3-SAF-R3.3: Enhance the realism of future simulations or demonstrations by incorporating more realistic speed profiles of aircraft. Refining the FIM algorithms and ensuring seamless transitions between them may be necessary to achieve this.

VLD3 SORT

- The functionality of the Status Spacing Window interface is recommended to reviewed prior to the final validation of the concept to ensure that the presented information reliably gains the controller's attention, when needed.

- Tool behaviour in any unusual/edge-case scenarios are highlighted in controller training and in the CONOPs.

- SESAR should consider investigating the effectiveness of humans as fallbacks when technology systems fail.

- A review of aircraft speed performance modelling inside 4DME in the simulator is recommended to ensure that it is consistent with operational data.

Actors impacted by the SESAR Solution

Tower and TMA Controllers.

Impact on Aircraft System

No Impact

Impact on Ground Systems

The solution considers the use of a support tool for the controller to display Indicators for separation; the tool can be enhanced by a precise wind nowcast.

Regulatory Framework Considerations

The local safety regulator would need to define what reduced separations are safe / acceptable for the environment where the solution will be implemented.

Standardization Framework Considerations

EUROCONTROL is working on specification document for the solution, the document is to be considered as a first step toward the standardisation for reduced aircraft separation based on runway occupancy time.

Considerations of Regulatory Oversight and Certification Activities

A safety case will be required in order for the National Authorities to approve the use of PJ.02-08-03; the safety case will need to be based on the ROT data collected for each specific runway. Given that the solution allows a reduction of separation minima based on the distribution of observed ROTs, it can be expected that the regulatory approval will require that a process be set up to monitor ROT values after implementation.

No certification activities are required.

Solution Data pack

The solution is integrated in the PJ.02-08 V3 data pack (SPR-INTEROP/OSED, TS/IRS and VALR) covering solutions PJ.02-08-01, PJ.02-08-02 and PJ.02-08-03. Note that the solution datapack refers to a previous version of solution PJ.02-08-03 (and AO-0337) that was limited to ROCAT (aircraft category based) while the content is valid also to aircraft type based. These definitions will be updated in DS21.

Solution PJ.02-08-03 is also covered by the integrated demonstrations of PJ.37-W3-ITARO, reported in the following DEMOR document:

- SESAR 2020, PJ37-W3-ITARO deliverable D1.5, PJ.37-W3-DEMOR, Parts I, II (SAR), III (HPAR), IV (ENVAR) and V (PAR), Edition 01.00.00, 25th May 2023.

VLD3 delivered the DEMOR:

- D1.4 – DEMOR-VLD3-W2, edition 00.03.00, 24th May 2023