Contextual note – PJ.02-01-01 “Optimised Runway Delivery on Final Approach” (V3) Description Form for Deployment Planning

1. Purpose

This contextual note describes SESAR solution PJ.02-01-01 “Optimised Runway Delivery on Final Approach” with a summary of the results stemming from R&D activities contributing to deliver it. It provides (to both those external and internal to the SESAR programme) an overview of PJ.02-01-01 in terms of scope, main operational and performance benefits, relevant system impacts and recommends additional activities that should be conducted during the industrialisation phase or as part of deployment.

This contextual note complements the solution Data Pack comprising the SESAR deliverables required for industrialisation and deployment. The PJ02 CN has been updated with the PJ.37 ITARO and VLD3 SORT info.

2. Improvements in Air Traffic Management (ATM)

Solution PJ.02-01-01 “Optimised Runway Delivery on Final Approach” enables safe, consistent and efficient delivery of the required separation or spacing between arrival pairs on final approach to the runway landing threshold. It is supported by the Optimised Runway Delivery (ORD) tool. The ORD tool can be used to support the application of Distance Based and Time Based wake separation rules e.g. ICAO, RECAT-EU, PWS-A and WDS-A wake separation schemes, and aims at consistently and efficiently managing the spacing compression that occurs on short final from the lead aircraft crossing the deceleration fix.

The solution can be deployed in different operational environments either independently or as an enabler of other SESAR solutions (and OI steps) developed and validated in SESAR that aim at increasing runway throughput.

Based on the validations performed in Wave 1, the solution can be considered an optional or required operational support tool for other SESAR solutions depending on the complexity of the targeted operational environment. In case of SESAR solutions where the use of the ORD tool is optional, particular attention must be paid when assessing traffic demand, expected benefits and scalability of the proposed solutions. The CBA supporting the different SESAR solutions will support this analysis.

The solution targets capacity constrained runways during high intensity runway operations and applies to very large, large and possibly medium airports.

Note that solution PJ.02-01-01 is an ATM solution even if the SPR-INTEROP/OSED is not always explicit about this.

Relevant Operational Environments

OEs	Sub Operating Environments	Definition
Airport (capacity constrained)	Very Large Airport	Airports with more than 250k movements per year
	Large Airport	Airports with more or equal than 150k and less or equal than 250k movements per year
	Medium Airport	Airports with more or equal than 40k and less than 150k movements per year

Note: The investment on this solution may be only justified only in large and very large airports.

3. Operational Improvement Steps (OIs) & Enablers

Applicable OI Step:

AO-0328 — Optimised Runway Delivery on Final Approach.

Required enablers:

AERODROME-ATC-68 – ATC System to support Optimised Runway Delivery on Final Approach;

APP ATC 120 – ATC System to support Optimised Runway Delivery on Final Approach;

STD-093 – EUROCONTROL Guidelines for Optimised Runway Delivery;

APP ATC 99 – ATC System to use Real-Time Meteo Information Received From Met Systems[1];

Optional enablers:

A/C-47 – On-board management of meteorological data from on-board sensors for sharing and use by MET service providers

AERODROME-ATC-55 – Airport ATC tool for Aircraft ROT categorisation;

AERODROME-ATC-17 - Airport ATC tool to Support Time-Based Separation in Final Approach;

APP ATC 169 – Approach ATC tool for Aircraft ROT categorisation (compute + display);

APP ATC 156 - ATC System to Support Time-Based Separation in Final Approach;

SWIM-APS-07a - Stakeholder systems consumption of Meteorological Information services for Step 1.

Applicable Integrated Roadmap Dataset is DS23 draft.

4. Background and Validation Process

Significant validation and development work was performed on Pairwise separation and TBS throughout SESAR 1:

- **SESAR1 P06.08.01:** Flexible and Dynamic Use of Wake Turbulence Separations.

PJ.02 EARTH built on this work and performed both real-time and fast-time simulation activities:

[1] Enabler developed under the scope of solution PJ.02-01-05 (AO-0310).

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- **RTS1:** Validation to assess Weather Dependent Separations on the arrival approach (WDS-A) with Optimised Runway Delivery (ORD) tool in a dual approach environment with segregated runway operations;
- **RTS2:** Validation to assess Static Pairwise Separations on the arrival approach (S-PWS-A) with Optimised Runway Delivery (ORD) tool under segregated runway operations**;**
- **RTS3a:** Validation to assess Static Pairwise Separations on the arrival approach (S-PWS-A) with Optimised Runway Delivery (ORD) tool plus Static Pairwise Separations for departures (S-PWS-D) with Optimised Separation Delivery (OSD) tool under mixed runway operations;
- **RTS3b:** Validation to assess ICAO Time Based Separation (TBS) with Optimised Runway Delivery (ORD) tool in a PBN approach environment with segregated runway operations.
- **RTS4a:** Validation to assess Static Pairwise Separations on the arrival approach (S-PWS-A) with Optimised Runway Delivery (ORD) tool plus Static Pairwise Separations for departures (S-PWS-D) with Optimised Separation Delivery (OSD) tool under mixed mode runway operations;
- **RTS4b:** Validation to assess Static Pairwise Separations on the arrival approach (S-PWS-A) with Optimised Separation Delivery (OSD) tool plus Static Pairwise Separations for departures (S-PWS-D) with Optimised Separation Delivery (OSD) tool in a dual approach environment with CSPR under segregated and partially segregated runway operations;
- **FTS9:** Fast time simulations of ORD, S-PWS and WDS concepts for different airports to support the CBA.

PJ.37 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.

- The PJ.01-05 solution is the use of the airborne surveillance application Flight-deck Interval Management (FIM) aimed to sustain or increase runway throughput in a PBN-based terminal airspace environment, in which aircraft fly fixed approach routes from defined TMA entry fixes down to the landing runway. The solution is combined with a form of optimised descent operations, namely fixed profile descents.

- The PJ.02-01-01 solution is an ATC support tool to enable safe, consistent and efficient delivery of the required separation or spacing between arrival pairs on final approach to the runway threshold.

- The PJ.02-01-04 solution consists of the efficient aircraft type pairwise wake separation rules for final approach. It consists of both the 103x103 aircraft type-based wake separation minima (for the most common aircraft in ECAC area) and the 20 wake category (20-CAT) based wake separation minima for arrival pairs involving all the remaining aircraft types.

- The PJ.02-08-03 solution 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).

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.

- **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. It reached TRL7-ongoing.

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.

5. Results and Performance Achievements

PJ.02 EARTH

The results show that the use of the Optimised Runway Delivery tool to support separations and spacing delivery (either time or distance based) is operationally feasible and acceptable in both segregated and mixed mode runway operations in a high complexity TMA and large airport environment in low wind and strong wind conditions.

The solution can be used in the mixed mode single runway operations to support the delivery of large gap spacings in the arrival flow to allow for several departures in a peak departure traffic flow.

Furthermore, it was shown that the tool could be used on the final approach in a PBN approach environment with no negative impact on the approach and / or final approach controllers' work.

Overall the accuracy of separation delivery was found to improve with the ORD tool. The controllers reported that the ORD tool was necessary for TBS procedures to be applied accurately and consistently. Runway throughput capacity gains can be achieved compared to current operations with no support tool.

There is a positive impact on resilience, as the capacity loss was found to be smaller with TBS and the ORD tool under strong headwind and crosswind conditions. Also the number of go-arounds stays the same or is reduced up to 1%, in adverse headwind condition; depending on the current wake vortex separation scheme applied at the airport.

The workload of the Final Approach and runway tower controllers was not negatively impacted with the ORD tool compared to current operations in mixed mode runway operations. No changes in competence requirements were identified

Changes to tasks, procedures and working methods when working with TBS and the ORD tool in mixed mode procedures were clear, acceptable and usable for the ATCOs. However, controllers did express concern that while working with the ORD tool, a controller might become less aware about the aircraft distances on the final approach and consequently have a lower level of situational awareness. Although not a problem when the ORD was available, this could be an issue if the ORD was not available such as in degraded modes of operations i.e. tool not operative.

PJ37-W3-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 only the transition from 3 NM MRS in the TMA to lower values on the final approach track may impact PJ.02-01-01.

- 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

- The pairwise 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.

6. Recommendations and Additional activities

PJ.02 EARTH

The following recommendations should be taken into consideration during the industrialisation and deployment phases.

- The reliability of the ORD must be improved and assured prior to implementation;
- The ORD would need to be further tuned for the local approach and tower environment e.g. smaller buffers in the tool to ensure runway throughput is optimised (the buffers required to optimise capacity whilst maintaining safety would have be determined in the local safety assessment). The industrialised version of the ORD tool will need to be developed using a methodology appropriate to the software assurance level required in the local deployment environment;
- Issues related to potential loss of controllers situational awareness need to be investigated further in industrialization and deployment phases. Training is considered essential to prevent any skill decay and ensure controllers were fully familiar and at ease with any contingency procedures developed relating to the ORD tool;
- The ORD tool requires a stricter more rigid speed control profile on the final approach. An information campaign should be conducted with airlines to ensure pilots adhere to the controllers speed instructions.

Future development of the ORD tool could include:

- The integration of ORD tool within the CWP;

- The integration the ORD with the AMAN / DMAN;

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.

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- 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.

7. Actors Impacted by the SESAR Solution

The following actors are impacted by the solution PJ.02-01-01:

- Air Traffic Controllers;
- Flight Crew;
- ANSPs;
- Airlines /airspace Users;
- Airport Operators;
- Regulatory Authorities.

8. Impact on Aircraft System

No impact on aircraft system.

9. Impact on Ground Systems

ORD tool has to be integrated in CWP and current TBS system (if present). The solution is based on existing MET capabilities and information to measure or forecast the wind on the final approach path along the section applicable for calculating separations and spacing indicators.

The TS/IRS and the SPR-INTEROP/OSED refer to a new MET service (METForWTS service) that has been developed by solution PJ.18-04b. This service has achieved TRL2 in Wave 1 and it may be an option for this solution if further developed and validated in future R&D activities.

10. Regulatory Framework Considerations

EC 2017/373 IR for Change Management and Assessment is applicable. It requires the development of a Local Safety Case.

11. Standardisation Framework Considerations

STD-93 “EUROCONTROL Guidelines for Optimised Runway Delivery “

12. Solution Data pack

Solution PJ.02-01-01 is covered by PJ.02-01 Data Pack that includes the following documents:

- D1.1.01 – PJ02-01 OSED-SPR-INTEROP (Final) Parts I 00.01.02, II, IV and V – 01.02.01 (31/01/2020);
- D1.1.02 – PJ02-01 TS/IRS (Final) – 00.03.04 (06/03/2020)[2];
- D1.1.04 – PJ02-01 VALR (Final) – 00.01.01 (31/01/2020);
- D1.1.05 – PJ02-01 CBA – 00.01.01 (31/01/2020)[3].

VLD3 delivered the DEMOR:

[2] The final version of the TS/IRS MS Word document still contains many requirements that are “in progress” status while they have been actually validated. The status of these requirements is properly updated and documented in the SE-DMF that represents the reference for the list of validated requirements.

[3] Note that PJ.02-01-01 can be independently deployed even if the CBA does not consider the solution and a standalone one explicitly.

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

Solution PJ.02-01-01 is also covered by the integrated demonstrations of PJ.37-W3-ITARO, reported in the following 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, 25 May 2023.