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SESAR Solution PJ.02-01-04 Contextual Note for V3 and TRL7

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00.02.00	14/06/2023	Final	NATS & NLR	Updated with PJ.37-W3-ITARO and VLD3-W2-SORT TRL7 info

*silent approval

Copyright Statement

PJ.02-W2 AART[1] / PJ.37-W3-ITARO[2] and VLD3-W2-SORT[3]

1: AIRPORT, AIRSIDE & RUNWAY THROUGHPUT / 2: INTEGRATED TMA, AIRPORT AND RUNWAY OPERATIONS /3: SAFELY OPTIMISED RUNWAY THROUGHPUT

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Abstract

This contextual note describes PJ.02-01 OI step AO-0306 (Wake Turbulence Separations (for Arrivals) based on Static Aircraft Characteristics) 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 AO-0306 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.

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1 Purpose

This contextual note (CN) describes PJ.02-01 OI step AO-0306 (Wake Turbulence Separations (for Arrivals) based on Static Aircraft Characteristics) 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 AO-0306 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 AART-based CN info has been updated with PJ.37-ITARO and VLD3-SORT info.

2 Improvements in Air Traffic Management (ATM)

Significant work was performed by EUROCONTROL and ANSPs (NATS, DSNA, and AUSTROCONTROL) on Pairwise Wake Separation (PWS) and TBS throughout SESAR 1. Solution PJ.02-01 builds on this work to further optimise wake turbulence separation rules. The solution targets capacity constrained runways during high intensity runway operations and applies to very large, large and possibly medium airports.

PWS-A is the efficient aircraft type pairwise wake separation rules for final approach consisting of both the aircraft type based wake separation minima and the twenty wake category (20-CAT) based wake separation minima for arrival pairs involving all the remaining aircraft types. The PWS matrix originally developed in Wave 1 included 96 of the most common aircraft in ECAC area. In Wave 2, the methodology for integrating additional / new aircraft types was refined and the pairwise matrix has been expanded to include 103 of the most common aircraft types in ECAC area.

The Distance based pairwise wake separation scheme was used to derive a TBS variant, which was employed in five validation exercises to assess benefits and operational feasibility when used in combination with the ORD tool, a controller tool developed in SESAR 2020 Wave 1 to support the accurate and safe delivery of more complex separation schemes such as TBS and PWS. Both real-time and fast-time simulation activities were carried out to validate this concept.

For pairwise separation for arrivals, a regulatory change as per the RECAT-PWS-EU Safety Case Ed. 2.1 has been submitted to EASA and is under review. Pairwise separation is expected to become an EASA AMC to Req. ATS.TR.220 Application of wake turbulence separation from Reg. EC 2017/373 Annex IV Part-ATS.

2.1 Relevant Operational Environments

SESAR Solution PJ.02-01-04 aims to optimise wake separations for arrivals in Very Large, Large and Medium Airports and Very High and High Terminal and Medium complexity Airspace sub-operating environments. These operating environments are defined in PJ.19-W2 Validation Targets (2021) and extracted below.

OEs	Sub-Operating Environment	Definition
Airport	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
	Terminal Very High Complexity	Very High complexity ATC operational unit mainly providing Approach Control Services in a part of the

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Terminal Airspace		airspace under control has a complexity score of equal or more than 10
	Terminal High Complexity	High complexity ATC operational unit mainly providing Approach Control Services in a part of the airspace under control has a complexity score of equal or greater than 6 and less than 10
	Terminal Medium Complexity	High complexity ATC operational unit mainly providing Approach Control Services in a part of the airspace under control has a complexity score of between 2 and 6

2.2 Expected Benefits

The following KPAs were expected to be benefitted through PWS-A:

- **Resilience** (additional resilience to cases of perturbation);
- **Environment** (decrease in fuel burn from aircraft holding/reduced flying time);
- **Predictability** (less variability between planned and actual arrival time);
- **Cost efficiency** (ORD tool can be integrated in existing TBS systems);
- **Capacity** (increased throughput due to reduced wake separation between aircraft)

For **Safety,** it should be noted that by bringing the aircraft closer together, the frequency of wake turbulence encounters at lower severity level may increase. However, the pairwise wake turbulence risk will be aligned to what is considered as acceptable today on the basis of proven current operations experience at ICAO minima for reference aircraft pairs. In addition the use of the ORD tool improves the accuracy of separation delivery and reduces the number of unmanaged under-separations.

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3 Operational Improvement Steps (OIs) & Enablers

Applicable OI Step:

AO-0306 — Wake Turbulence Separations (for Arrivals) based on Static Aircraft Characteristics

Required Enablers:

AERODROME-ATC-42a - Airport ATC tool to support static pair-wise wake separation (S-PWS) in final approach;

APP ATC 118 – ATC System to support static pair-wise wake separation (S-PWS) on approach;

REG-0523 – Regulatory provisions (AMC) for static pair-wise wake separation minima (S-PWS).

Optional Enablers:

AERODROME-ATC-60 – Airport ATC system to monitor wake turbulence risk using ground-based LIDAR/Radar;

AIRPORT-08 - Decay Enhancing Devices.

Dependent OI Step:

AO-0328 —Optimised Runway Delivery on Final Approach (predecessor).

Applicable Integrated Roadmap Dataset is DS23

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4 Background and validation process

SESAR1 Validation:

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

SESAR2020 Wave 1 Validation:

- **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;
- **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 Runway Delivery (ORD) 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.

SESAR2020 Wave 3- PJ37-W3-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. This activity 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.

SESAR2020 Wave 2- VLD3-W2- 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

Consolidated Wave 1 Results

The findings show that use of Pairwise Separation for Arrivals with the Optimised Runway Delivery tool in both segregated and mixed mode operations is operationally feasible and acceptable to controllers in a high complexity approach environment and a large airport environment. Fast time simulation and RTS activity show significant benefits for this OI.

Wave 2

New aircraft types were included in the pairwise matrix and the wake separation scheme extended from 96 aircraft types to 103 aircraft types.

PJ.37 ITARO

The results below are based on demonstrations of the 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.02-01-04. However, the transition from 3 NM MRS in the TMA to lower wake values on the final approach track (e.g. 2.0 or 2.5 NM) may also impact PJ.02-01-04.

- 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.

SORT VLD3

- 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;
- The reduction of MRS on final approach from 2.5NM to 2NM, and an earlier reduction from 3NM to 2.5NM in the RMA is assessed as acceptable. All responses from controllers were positive, with participants agreeing this this support is acceptable for operations;
- 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 is acceptable to controllers in cases of broken off approaches, speed non-conformance and missing wake category scenarios;
- Controllers agreed that Early Line Zero is acceptable. The ELZ is seen as a benefit to the operation and useful as information to support the controller which improves predictability.

- 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. Larger data sets are required to provide a full understanding of the long-term capacity benefits;

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

No additional activities recommended to complete V3.

PJ.37 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.

SORT VLD3

- The participant suggestion to avoid 2.5 MRS losses by introducing a standardised drop to a higher altitude than used in the current operation to give the final approach controller the option to use vertical separation should be explored by the concept team to determine the potential inclusion of this procedure in the ConOps.
- 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.

- The next phase of development should review the relevance of the spacing information displayed for dependant aircraft pairs and of the indicator HMI and display for aircraft outside 20 miles from the threshold.

7 Actors impacted by the SESAR Solution

The following actors are impacted by S-PWS-A (AO-0306):

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

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8 Impact on Aircraft System

No impact on aircraft systems is currently foreseen.

9 Impact on Ground Systems

S-PWS-A requires the ORD tool to be integrated in CWP and current TBS system (if present). Meteo services are needed for measuring and forecast the wind on the final approach path.

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10 Regulatory Framework Considerations

A regulatory change as per the RECAT-PWS-EU Safety Case Ed. 2.1 has been submitted to EASA and is under review. Pairwise separation is expected to become an EASA AMC to Req. ATS.TR.220 Application of wake turbulence separation from Reg. EC 2017/373 Annex IV Part-ATS.

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11 Standardization Framework Considerations

No change to the standardisation framework is currently foreseen.

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12 Solution Data pack

The SESAR 2020 Wave 1 PJ.02-01Data Pack includes the following documents, that includes PJ.02-01-04:

- D1.1.01 – PJ02-01 OSED-SPR-INTEROP (Final) Parts I, II, IV and V – 01.00.00 (31/01/2020);
- D1.1.02 – PJ02-01 TS/IRS (Final) – 01.00.00 (31/01/2020);
- D1.1.04 – PJ02-01 VALR (Final) – 01.00.00 (31/01/2020);
- D1.1.05 – PJ02-01 CBA – 01.00.00 (31/01/2020).

The SESAR 2020 Wave 2 PJ.02-01-04 Data Pack (D4.10) includes the following documents:

- D4.15.01 – PJ02-01-04 OSED-SPR-INTEROP (Final) Parts I, II, IV and V – 00.02.01 (02/11/2022);
- D4.15.06 – PJ02-01-04 VALR (Final) – 01.00.00 (30/09/2022);
- D4.15.08 – PJ02-01-04 TS/IRS (Final) – 01.00.00 (30/09/2022).

VLD3 delivered the DEMOR:

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

Solution PJ.02-01-04 is also covered by the integrated demonstrations of PJ.37- 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, 25th May 2023.

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