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SESAR Solution PJ.02-01-06 SPR/INTEROP-OSED for V3 - Part V - Performance Assessment Report (PAR)

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PJ.02-W2 AART

AIRPORT, AIRSIDE AND RUNWAY THROUGHPUT

This Performance Assessment Report is part of a project that has received funding from the SESAR3 Joint Undertaking under grant agreement No 874477 under European Union's Horizon 2020 research and innovation programme.

Abstract

This document contains the Performance Assessment Report for the SESAR 2020 Wave 1 SESAR Solution PJ.02-01 (WTS for Departures) which consists of the extrapolation to ECAC wide level of the performance assessment results conducted according at V3 level of maturity for the concepts in PJ.02-01 and the process applied to obtain the results. Report covers the concepts that contribute to WTS (for Departures):

- AO-0329: Optimised Separation Delivery for Departure (OSD);
- AO-0323: Wake Turbulence Separations (for departures) based on Static Aircraft Characteristics (PWS-D);
- AO-0304: Weather-dependent reductions of Wake Turbulence Separations for Departure (WDS-D).

No updates to the SESAR 2020 Wave 1 PJ02-01 PAR have been made in SESAR 2020 Wave 2 PJ.02-01-06, as the validation activities conducted in SESAR 2020 Wave2 PJ.02-01-06 did not impact the PAR results.

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1 Executive Summary

This document provides the Performance Assessment Report (PAR) for SESAR 2020 Wave 1 Solution PJ.02-01 (WTS (for Departures). No updates to the SESAR 2020 Wave 1 PJ02-01 PAR have been made in SESAR 2020 Wave 2 PJ.02-01-06, as the validation activities conducted in SESAR 2020 Wave2 PJ.02-01-06 did not impact the PAR results

The PAR is consolidating Solution performance validation results addressing KPIs/PIs and metrics from the SESAR2020 Performance Framework [2].

This Performance Assessment Report provides the results for the three concepts of the SESAR Solution PJ.02-01.

- AO-0329: Optimised Separation Delivery for Departure (OSD);
- AO-0323: Wake Turbulence Separations (for departures) based on Static Aircraft Characteristics (PWS-D);
- AO-0304: Weather-dependent reductions of Wake Turbulence Separations for Departure (WDS-D).

Definition of Solution Scenarios:

Throughout the document, the departures tools solutions will be referred to in simplified forms for convenience to the reader. These are:

- **OSD** (A0-0329);
- **PWS-D** – TB PWS-D (A0-0323) with OSD (AO-0329) tool support;
- **WDS-D** – WDS-D (A0-0304) in the context of TB PWS-D (A0-0323) with OSD (AO-0329) tool support.

Assessment Results Summary:

The following tables summarise the assessment outcomes per KPI (Table 1) and mandatory PI (Table 2) against Validation Targets in case of KPI from PJ.19 [7]. The impact of a Solution on the performances is described in the Benefit and Impact Mechanisms. All the KPIs and mandatory PIs from the Benefit Mechanisms expected to be impacted by the solution have been assessed via validation activities (RTS, FTS, expert judgment etc.).

There are three cases:

1. An assessment result of 0 with confidence level High, Medium or Low indicates that the Solution is expected to impact in a marginal way the KPI or mandatory PI;
2. An assessment result (positive or negative) different than 0 with confidence level High, Medium or Low indicates that the Solution is expected to impact the KPI or mandatory PI;
3. An assessment result of N/A (Not Applicable) with confidence level N/A indicates that the Solution is not expected to impact at all the KPI or mandatory PI consistently with the Benefit Mechanism.

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KPI	Validation Targets – Network Level (ECAC Wide)	Performance Benefits at Network Level (ECAC Wide or Local depending on the KPI)	Confidence in Results
FEFF1: Fuel Efficiency - Actual average fuel burn per flight	26.7 kg	Flights Impacted = 9850000 (flights/year) x 59.5% (high density airports contributions) x 50% (departures contribution) = 2931038 flights OSD (AO-0329) tool support for RECAT-EU TBS = 1.79 kg reduction in fuel consumption per flight at ECAC level, compared to RECAT-EU TBS without OSD tool support, with a Heathrow traffic mix. PWS-D (AO-0323): - 10.53kg reduction in fuel consumption per flight at ECAC level, compared to ICAO without OSD tool support, with a Barcelona traffic mix; - 2.28kg reduction in fuel consumption per flight at ECAC level, compared to RECAT-EU without OSD tool support, with a Heathrow traffic mix. WDS-D (AO-0304) in the context of PWS-D (AO-0323) = 2.23 kg	Low[2]

[2] Confidence in the results was impacted by anomalies in the measures across comparative exercise runs.

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		reduction[1] in fuel consumption per flight at ECAC level, compared to RECAT-EU without OSD tool support, with a Heathrow traffic mix.	
CAP3: Airport Capacity – Peak Runway Throughput (Mixed mode).	2.6%	OSD (AO-0329) – 1.0% increase in departure movements/hour, compared to RECAT-EU without OSD tools support, with a Heathrow traffic mix. PWS-D (AO-0323): - 8.65% increase in departure movements/hour, compared to ICAO without OSD tool support, with a Barcelona traffic mix; - 2.41% increase in departure movements/hour, compared to RECAT-EU without OSD tool support, with a Heathrow traffic mix. WDS-D (AO-0304) in the context of PWS-D (AO-0323) – 0.1% increase in departure movements/hour[1], compared to RECAT-EU without OSD tool support, with a Heathrow traffic mix.	Low[2]

[1] This is an anomalous result as changes to the take-off order due to trying to induce WDS-D pairs resulted in a less efficient departure order and lost nearly all of the benefit gains of PWS-D. In theory, WDS-D in the context of PWS-D should be a delta increase to the benefits of PWS-D alone.

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PRD1: Variance of Difference in actual & Flight Plan or RBT durations	0.27% [3]	Number of flights impacts = 2931038 flights OSD (AO-0329) = 1.22mins^2 (2.5%) reduction in flight duration variability, compared to RECAT-EU without OSD tool support, with a Heathrow traffic mix. PWS-D (AO-0323): - 3.71mins^2 (7.57%) reduction in flight duration variability, compared to ICAO without OSD tool support, with a Barcelona traffic mix; - 0.92 mins^2 (1.87%) reduction in flight duration variability, compared to RECAT-EU without OSD tool support, with a Heathrow traffic mix. WDS-D (AO-0304) in the context of PWS-D (AO-0323) = 0.91 mins^2 (1.85%) reduction[1] In flight duration variability, compared to RECAT-EU without OSD tool support, with a Heathrow traffic mix. .	Low[2]

Table 1: KPI Assessment Results Summary

[3] In Validation Targets [18] the unit for PRD1 is % Reduction in variance of block-to-block flight time.

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Mandatory PI	Performance Benefits Expectations at Network Level (ECAC Wide or Local depending on the KPI)	Confidence in Results
FEFF2: CO2 Emissions.	OSD (AO-0329) = 5.62 kg reduction in CO2 emissions per flight at ECAC level, compared to RECAT-EU without OSD tool support, with a Heathrow traffic mix. PWS-D (AO-0323): - 33.18 kg reduction in CO2 emissions per flight at ECAC level, compared to ICAO without OSD tool support, with a Barcelona traffic mix; - 7.17 kg reduction in CO2 emissions per flight at ECAC level, compared to RECAT-EU without OSD tool support, with a Heathrow traffic mix. WDS-D (AO-0304) in the context of PWS-D (AO-0323) = 7.03 kg reduction[1] in CO2 emissions per flight at ECAC level, compared to RECAT-EU without OSD tool support, with a Heathrow traffic mix.	Low[2]
FEFF3: Reduction in average flight duration.	OSD (AO-0329) = 0.12 minutes reduction in flight duration (taxi-out time) per flight at ECAC level, compared to RECAT-EU without OSD tool support, with a Heathrow traffic mix. PWS-D (AO-0323): - 0.7 minutes reduction in flight duration (taxi-out time) per flight at ECAC level, compared to ICAO without OSD tool support, with a Barcelona traffic mix; - 0.3 minutes reduction in flight duration (taxi-out time) per flight at ECAC level, compared to RECAT-EU without OSD tool	Low[2]

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	support, with a Heathrow traffic mix. WDS-D (AO-0304) in the context of PWS-D (AO-0323) = 0.15 minutes reduction[1] in flight duration (taxi-out time) per flight at ECAC level, compared to RECAT-EU without OSD tool support, with a Heathrow traffic mix.	
CAP3.1: Peak Departure throughput per hour (Segregated mode)	OSD (AO-0329) – 0.6 increase in departure movements/hour, compared to RECAT-EU without OSD tool support, with a Heathrow traffic mix. PWS-D (AO-0323): - 3.92 increase in departure movements/hour, compared to ICAO without OSD tool support, with a Barcelona traffic mix; - 1.2 increase in departure movements/hour, compared to RECAT-EU without OSD tool support, with a Heathrow traffic mix. WDS-D (AO-0304) in the context of PWS-D (AO-0323) – 0.05 increase[1] in departure movements/hour, compared to RECAT-EU without OSD tool support, with a Heathrow traffic mix.	Low[2]
CAP4: Un-accommodated traffic reduction	OSD (AO-0329) - 0.6 reduction in un-accommodated departures/hour, compared to RECAT-EU without OSD tool support, with a Heathrow traffic mix. PWS-D (AO-0323) – 1.1 reduction in un-accommodated departures/hour, compared to RECAT-EU without OSD tool	Low[2]

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	support, with a Heathrow traffic mix. WDS-D (AO-0304) in the context of PWS-D (AO-0323) – 0.05 reduction[1] in un-accommodated departures/hour, compared to RECAT-EU without OSD tool support, with a Heathrow traffic mix.	
RES1: Loss of Airport Capacity Avoided	OSD (AO-0329) – 0.6 departure movements per hour loss of capacity avoided, compared to RECAT-EU without OSD tools support, with a Heathrow traffic mix. PWS-D (AO-0323) – 1.1 departure movements per hour loss of capacity avoided, compared to RECAT-EU without OSD tools support, with a Heathrow traffic mix. WDS-D (AO-0304) in the context of PWS-D (AO-0323) – 0.05 departure movements[1] per hour loss of capacity avoided, compared to RECAT-EU without OSD tools support, with a Heathrow traffic mix.	Low[2]
HP1: Consistency of human role with respect to human capabilities and limitations	See Section 4.7.	N/A
HP2: Suitability of technical system in supporting the tasks of human actors	See Section 4.7.	N/A
HP3: Adequacy of team structure and team communication in supporting the human actors	See Section 4.7.	N/A
HP4: Feasibility with regard to HP-related transition factors	See Section 4.7.	N/A

Table 2 Mandatory PIs Assessment Summary

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2 Introduction

2.1 Purpose of the document

The Performance Assessment[4] covers the Key Performance Areas (KPAs) defined in the SESAR2020 Performance Framework [2]. The Key Performance Indicators (KPIs) and the mandatory Performance Indicators (PIs) are assessed, but also additional PIs as needed to capture the performance impacts of the Solution. It considers the guidance document on KPIs/PIs [2] for practical considerations, on metrics for example.

The purpose of this document is to present the performance assessment results from the validation exercises at SESAR Solution level. The KPA performance results are used for the performance assessment at strategy level and provide inputs to the SESAR Joint Undertaking (SJU) for decisions on the SESAR2020 Programme.

In addition to the results, this document presents the assumptions and mechanisms (how the validation exercises results have been consolidated) used to achieve this performance assessment result.

One Performance Assessment Report shall be produced or iterated per Solution.

2.2 Intended readership

In general, this document provides the ATM stakeholders (e.g. airspace users, ANSPs, airports, airspace industry) and SJU performance data for the Solution addressed.

Produced by the Solution project, the main recipient in the SESAR performance management process is PJ.19, which will aggregate all the performance assessment results from the SESAR2020 solution projects PJ.01-PJ.18 and provide the data to PJ.20 for considering the performance data for the European ATM Master Plan. The aggregation will be done at higher levels suitable for use at Master Planning Level, such as deployment scenarios. Additionally, the consolidation process will be carried out annually, based on the SESAR Solution's available inputs.

In addition, other intended readership are the SESAR Solution PJ.02-01-06 project members, the other solutions in SESAR Project PJ.02 Increased Runway and Airport Throughput, the related solutions in SESAR Project PJ.01 Enhanced Arrivals and Departures, the related solutions in SESAR Project PJ.04 Total Airport Management and the related solutions in SESAR Project PJ.09 Advanced Demand & Capacity Balancing.

2.3 Inputs from other projects

[4] The opinions expressed herein reflect the authors view only. Under no circumstances shall the SESAR Joint Undertaking be responsible for any use that may be made of the information contained herein.

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The document includes information from the following SESAR 1 projects:

- B.05 D72 [2]: SESAR 1 Final Performance Assessment, where are described the principles used in SESAR1 for producing the performance assessment report.

PJ.19 will manage and provide:

- PJ.19.04.01 D4.1 [3]: Performance Framework (2018), guidance on KPIs and Data collection supports.
- PJ.19.04.03 D4.0.1: S2020 Common assumptions, used to aggregate results obtained during validation exercises (and captured into validation reports) into KPIs at the ECAC level, which will in turn be captured in Performance Assessment Reports and used as inputs to the CBAs produced by the Solution projects. Where are also included performance aggregation assumptions, with traffic data items.
- For guidance and support PJ.19 have put in place the Community of Practice (CoP)[5] within STELLAR, gathering experts and providing best practices.

2.4 Glossary of terms

See the AIRM Glossary [1] for a comprehensive glossary of terms.

2.5 Acronyms and Terminology

Term	Definition
AIM	Accident Incident Model
AIRM	ATM Information Reference Model
ANS	Air Navigation Service
ANSP	Air Navigation Service Provider
APP	Approach
APT	Airport
ARES	Airspace REServation
ATC	Air Traffic Control

5 https://stellar.sesarju.eu/?link=true&domainName=saas&redirectUrl=%2Fjsp%2Fproject%2Fproject.jsp%3FobjId%3Dxrn%3Aview%3Axrn%3Adatabase%3Aondb%2Ftable%2F59_anonymous%402333834.13%403834139.13

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Term	Definition
ATCO	Air Traffic Control Officer
ATFM	Air Traffic Flow Management
ATM	Air Traffic Management
BAD	Benefits Assessment Date
BAER	Benefit Assessment Equipment Rate
BIM	Benefit Impact Mechanism
CAP	Capacity
CBA	Cost Benefit Analysis
CDG	Charles De Gaulle
CFIT	Controlled Flight into Terrain
CREDOS	Crosswind Reduced Separations for Departure Operations
CRT	Criteria
CSPR	Closely Spaced Parallel Runway Operations
CWP	Controller Working Position
DB	Deployment Baseline
DBS	Distance-Based Separation
DOD	Detailed Operational Description
E-ATMS	European Air Traffic Management System
E-OCVM	European Operational Concept Validation Methodology
EARTH	Increased runway and airport throughput
EASA	European Aviation Safety Agency
EATMA	European ATM Architecture
ECAC	European Civil Aviation Conference
ECTL	EUROCONTROL
FEFF	Fuel Efficiency
FTS	Fast Time Simulation

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Term	Definition
GBAS	Ground Based Augmentation System
HMI	Human-Machine Interface
IAF	Initial Approach Fix
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
ISRM	Information Services Reference Model
ITD	Integrated Technology Demonstrators
ITM	Intermediate Approach controller
KPA	Key Performance Area
KPI	Key Performance Indicator
LVP	Low-Visibility Procedures
MAC	Mid-Air Collision
MET	Meteorological services for air navigation
MRS	Minimum Radar Separation
N/A	Not Applicable
OBJ	Objective
ORD	Optimised Runway Delivery
OI	Operational Improvement
OSD	Optimised Separation Delivery
OSED	Operational Service and Environment Definition
PAR	Performance Assessment Report
PBN	Performance Based Navigation
PI	Performance Indicator
PRD	Predictability
PRU	Performance Review Unit
PWS	Pair Wise Separation(s)

Term	Definition
QoS	Quality of Service
RBT	Reference Business / Mission Trajectory
RECAT	Re-categorisation of Wake Turbulence Separation Minima
RES	Resilience
RIMCAS	Runway Incursion Monitoring and Conflict Alert System
ROT	Runway Occupancy Time
RSP	Required Surveillance Performance
RTS	Real-Time Simulation
RWY	Runway
SAC	Safety Criteria
SAF	SAFety
SAR	Safety Assessment Report
SESAR	Single European Sky ATM Research Programme
SESAR2020 Programme	The programme which defines the Research and Development activities and Projects for the SJU.
SID	Standard Instrument Departure
SJU	SESAR Joint Undertaking
SPR	Safety and Performance Requirements
SRM	Safety Reference Material
STATFOR	EUROCONTROL Statistics and Forecasts Service
SWIM	System-Wide Information Management
TBS	Time-Based Separation
TEAM	Tactically-Enhanced Arrivals Mode
TMA	Tactical Manoeuvring Area
TWR	Tower
TWY	TaxiWaY
VALP	Validation Plan

Term	Definition
VALR	Validation Report
VALS	Validation Strategy
WDS	Weather-Dependant Separation
WTA	Wake Turbulence-induced Accident
WTC	Wake Turbulence Category

Table 3: Acronyms and terminology

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3 Solution Scope

3.1 Detailed Description of the Solution

The departures concepts solutions consist of Wake Turbulence Separations for Departure based on Static Aircraft Characteristics (PWS-D), Optimised Separation Delivery for Departure (OSD) and Weather-Dependent Reductions of Wake Turbulence Separation for Departure (WDS-D).

OSD is the ATC support tool to enable consistent and efficient delivery of the required separation or spacing between departure pairs on the initial departure path.

PWS-D is the efficient aircraft type pairwise wake separation rules for departure operations currently consist of the time-based seven wake category (7-CAT) based wake separation minima, or the distance-based 96 x 96 aircraft type based pairwise wake separation minima in conjunction with the twenty wake category (20-CAT) based wake separation minima for departure pairs involving other aircraft types.

Planned for SESAR 2020 Wave 2 is an activity to develop the aircraft type pairwise time-based wake separation minima for departures and the refined wake category time-based wake separation minima. This is subject to having sufficient departure aircraft data for carrying out the wake risk analysis for the supporting safety case. In SESAR 2020 Wave 1 draft aircraft type pairwise time-based wake separation minima and refined wake category time-based wake separation minima were established and employed in the validation exercises in order to support assessment of the Human Performance, Safety and Performance validation objectives.

WDS-D is the conditional reduction or suspension of the wake separation minima for departure operations, applicable under pre-defined wind conditions so as to enable a runway throughput increase compared to the applicable standard weather independent wake separation minima. This is on the basis that under the pre-defined wind conditions the wake turbulence generated by the lead aircraft is either crosswind transported out of the path of the follower aircraft on the initial departure path or has decayed sufficiently to be acceptable to be encountered by the follower aircraft on the initial departure path.

The wake separation minima on the initial departure path are defined as both distance-based minima and time-based minima, and so may be applied as either distance-based minima or time-based minima.

OSD, PWS-D and WDS-D will increase departure runway capacity, and improve the efficiency, predictability and resilience of departure operations, while maintaining safety.

3.2 Detailed Description of relationship with other Solutions

The figure below shows types of relationship that can exist between Solutions:

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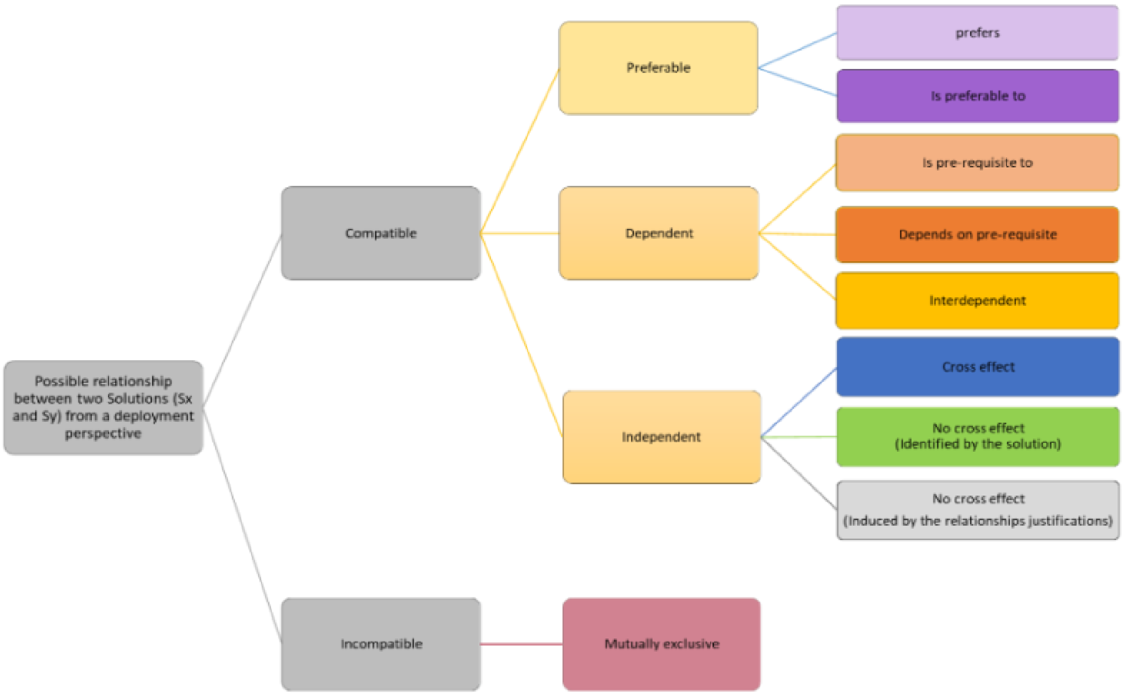

Figure 1: Possible relationships between two solutions from a deployment perspective

Solution Number	Solution Title	Relationship	Rational for the relationship
PJ.02-08	Traffic optimisation on single and multiple runway airports	Compatible, Independent, cross effect	Solution 8 provides enhanced prediction of Runway Occupancy Time to be integrated in the ATCO support tool to compute the separations to apply for optimizing runway throughput. Solution 8 provides integrated arrival and departure sequence that can support PJ.02-01-06 concepts. PJ.02-01-06 can provide wake separation requirements to be considered in the refinement of the (more stable) integrated arrival and departure sequence.
PJ.02-03	Minimum-Pair separations based on RSP	Compatible - independent - cross effect	Solution 3 is focused on the Required Surveillance Performance (RSP) for a 2 NM Minimum Radar Separation (MRS) on final approach. It has provided the expected requirements and specifications for the RSP such as the MRS update rate of 4s to be

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			used in the RTS. The ECTL RTS for PJ.02.01/PJ.02.03 has considered PWS-A at both the current 2.5 NM MRS and at a future 2 NM MRS.
PJ.02-02	Enhanced arrival procedures	Compatible - independent - cross effect	Solution 2 look at procedures that could provide noise and capacity benefits. This procedure may need additional separation buffer. Solution 2 will provide requirements, specifications and procedures for GBAS operations that are expected for the validation activities. Solution 1 provides requirements for wake separation based on pair. The results of Solution 1 simulations will be an input for Solution 2. The decrease/increase of separations can be defined at the granularity of aircraft type, but since the separation reductions are always bigger than the separation increases, cross benefits are expected in terms of APT capacity when the solutions for arrivals are combined.
PJ.01-07	Approach Improvement through Assisted Visual Separation	Compatible - independent - cross effect	PJ.02-01-06 and PJ.01-07 coordination to provide PJ.01-07 with needed expertise on wake turbulence issues. PJ.02-01-06 look at the wake turbulence monitoring on airborne cockpit point of view. No impact on APT CAP (as airborne only enhancement for wake monitoring). Cross effect as may improve situation awareness of the pilot and therefore may improve SAF and HP.
PJ.18-04b	MET information	Compatible – preferable - prefers	PJ.18-04b: PJ.02-01-06 prefers PJ.18-04b as better wind conditions

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			have a positive effect, although this can be difficult to quantify.

Table 4: Relationships with other Solutions

4 Solution Performance Assessment

4.1 Assessment Sources and Summary of Validation Exercise Performance Results

No previous Validation Exercises (pre-SESAR2020, etc.) relevant for this assessment have been identified.

SESAR Validation Exercises of this Solution are listed below:

Exercise ID	Exercise Title	Release	Maturity	Status
RTS3a	PWS-A with ORD for Arrivals, and PWS-D with OSD for Departures, on single RWY in mixed mode, for Vienna airport	9	V3	Completed
RTS4a	ORD for Arrivals, and PWS-D with OSD for Departures, on a single RWY in mixed mode, for Vienna airport	9	V3	Completed
RTS4b	PWS-A with ORD for Arrivals on CSPR runways, and PWS-D with OSD for Departures, on partially segregated runway, for Paris CDG airport	9	V3	Completed
RTS5	PWS-D and WDS-D with OSD for Departures, on dependent parallel RWYs in segregated mode, with a small number of arrivals landing on the departure runway under tactically enhanced arrival management, and encompassing transition in case of degraded mode, for London Heathrow airport	9	V3	Completed
RTS6	RTS conducted by ENAIRE to evaluate the feasibility of WDS-A for Arrivals, and PWS-D with OSD for Departures on parallel RWYs operating in segregated mode for Barcelona airport	9	V3	Completed

Table 5: SESAR2020 Validation Exercises

The following table provides a summary of information collected from available performance outcomes:

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Exercise	OI Step	Exercise scenario & scope	Performance Results
RTS3a	AO-0328 (ORD) AO-0306 (PWS-A)	PWS-A with ORD for Arrivals, and PWS-D with OSD for Departures, on single RWY in mixed mode, for Vienna airport	SAF: TB PWS-A with ORD tool is operationally feasible in mixed mode runway operations and controllers are able to safely and successfully deliver the aircraft under Time Based PWS-A on the final approach using the ORD tool. HP: Controllers provide feedback that TB PWS-A separation scheme with the ORD tool is operationally acceptable in single runway mixed mode environment. CAP: ORD (AO-0328) – 7.9% increase in movements/hour with ORD and mixed mode procedures of single consecutive arrivals and departures PWS-A (AO-0306) – 0.01% increase in movements/hour with ORD and mixed mode procedures of single consecutive arrivals and departures.
RTS4a	AO-0328 (ORD) AO-0306 (PWS-A) AO-0329 (OSD) AO-0323 (PWS-D)	PWS-A with ORD for Arrivals, and PWS-D with OSD for Departures, on a single RWY in mixed mode, for Vienna airport	HP: Controllers provide feedback that is operationally feasible to use the ORD tool in the mixed mode single runway operations to support the delivery of gap spacings in the arrival flow to allow for departures. Pair wise separations for departures using the OSD tool in mixed mode runway operations in the low wind conditions tested were reported to be operationally feasible. SAF: Safe working practices were observed during the simulation and the controllers reported that PWS with OSD tool did not increase the risk of human error in any way.
RTS4b	AO-0328 (ORD) AO-0306 (PWS-A) AO-0329 (OSD) AO-0323 (PWS-D)	PWS-A with ORD for Arrivals on CSPR runways, and PWS-D with OSD for Departures, on partially segregated runway, for Paris CDG airport	CAP: increase of 4.7 ac/h on departures with PWS-D and OSD when compared to reference scenario (ICAO separation). Increase of 2.5 ac/hour on arrivals with PWS-A and ORD when compared to reference scenario (RECAT-EU separation). HP: the ORD tool with PWS – A concept in CSPR at CDG airport is operationally feasible in approach environment only. OSD with PWS-D in CSPR are considered to be operationally feasible by providing additional functionalities to support the mixed mode runway operations. SAF: approach controllers were observed to apply safe standard practices during TB-PWS-A with ORD in CSPR for Arrivals operations.

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RTS5	AO-0329 (OSD) AO-0323 (PWS-D) AO-0304 (WDS-D)	RTS assessed OSD, PWS-D and WDS-D in segregated mode operations in the London Heathrow Very Large Airport Operational Environment.	Runway Capacity results showed a 1.0%, 2.0% and 0.1%[1] increase in runway throughput in the OSD, PWS-D and WDS-D solution scenarios compared to the reference scenario. Mean Taxi-out time reduced by 0.4minutes, 0.7minutes and 0.5minutes[1] in the OSD, PWS-D and WDS-D solution scenarios compared to the reference scenario. Predictability (variability in taxi-out time) reduced by 11.1%, 11.1% and 8.1%[1] in the OSD, PWS-D and WDS-D solution scenarios compared to the reference scenario.
RTS6	AO-0310 (WDS-A) AO-0329 (OSD) AO-0323 (PWS-D)	RTS conducted by ENAIRE to evaluate the feasibility of WDS-A for Arrivals, and PWS-D with OSD for Departures on parallel RWYs operating in segregated mode for Barcelona airport.	Runway Capacity results showed an 8.65% increase in runway throughput compared to ICAO separations and a 2.81% increase compared to RECAT-EU separations. Mean Taxi-out time reduced by 2.36 minutes compared to ICAO separations and 0.32 minutes compared to RECAT-EU separations. Predictability (variability in taxi-out time) reduced by 39.7% compared to ICAO separations and 5.3% compared to RECAT-EU

Table 6: Summary of Validation Results.

Note: The common assumption values were not used in the calculation of FTS KPA benefits in all cases. Instead, individual input values were used for each of the utilised traffic mixes. This is to provide more representative and detailed results, which would be lost through the use of single values.

4.2 Conditions / Assumptions for Applicability

The following Table 7 summarises the applicable operating environments.

OE	Applicable sub-OE	Special characteristics
TMA	TMA Very High Complexity	Very 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 more than 10
	TMA 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 between 6 and 10
	TMA Medium Complexity	Medium 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
Network	Network	Contribution of the network to ATM performance
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 movements per year

Table 7: Applicable Operating Environments.

The following Table 8 summarises the essential deployment details:

BAD	Specific geographical and/or stakeholder deployment
31-08-2026	Very Large Airports, Large Airports, Medium Airports environment operating at capacity constrained levels.

Table 8: Deployment details.

Equipage details and how equipage influences benefits in the ramp-up phase is given in Table 9:

Min flight equipage rate	Opt flight equipage rate	BAER	AUs that need to equip	Start of flight equipage	End of flight equipage
N/A	N/A	N/A	N/A	N/A	N/A

Table 9: Influence of Equipage on benefits.

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4.3 Safety

4.3.1 Safety Design drivers and Performance Mechanism

The following (amended) SAC[6] (Table 10) apply to all departure concepts[7]:

SAC Ref	SAC	Associated Hazard Ref	Associated Hazard
SAC#D1	There shall be no increase of imminent wake infringement on departure induced by ATC (or the crew of the 1st aircraft), when the 2nd aircraft **is not yet** airborne, in the wake turbulence scheme under consideration, compared to current operations' wake turbulence scheme (e.g. ICAO, RECAT-EU or UK 5-Cat) Precursor: WE8.a.1, WE8.1.2 leading to WE8.a	**Hp#D1**	Wake Turbulence-induced Accident (WTA) on Initial Common Departure Path
SAC#D2	There shall be no increase of imminent wake infringement on departure induced by ATC (or the crew of the 1st or 2nd aircraft), when the 2nd aircraft **is** airborne, in the wake turbulence scheme under consideration, compared to current operations' wake turbulence scheme (e.g. ICAO, RECAT-EU or UK 5-Cat) Precursor: WE8.b.1 leading to WE8.b	**Hp#D1**	Wake Turbulence-induced Accident (WTA) on Initial Common Departure Path
SAC#D3	There shall be no increase in imminent infringement of separation (non-wake) on departure induced by ATC	**Hp#D2**	Situation in which the intended 4-dimensional (4D) trajectories of two or more airborne aircraft are in conflict- Initial Common Departure Path"
SAC#D4	There shall be no increase in imminent wake infringement on departure due to incorrect design of the rule Precursor: WE7S	**Hp#D1**	Wake Turbulence-induced Accident (WTA) on Initial Common Departure Path. (Situation where wake separation on departure is eroded by catch-up scenario)

[6] SACs amended following revision of the Departure Wake AIM

[7] D-TB-WDS-Tw, D-TB-WDS-Xw, D-PWS-EU

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SAC#D5	There shall be no increase of ATC tactical conflicts	**Hp#D2**	Situation in which the intended 4-dimensional (4D) trajectories of two or more airborne aircraft are in conflict- Initial Common Departure Path
SAC#D6[8]	There shall be no increase in ATC induced Runway Incursion(s) (related to line-up/take-off) Precursor: RP3.2B	**Hp#D3**	The preceding landing/departing aircraft are not clear of the runway-in-use
SAC#D7	The probability of wake turbulence encounter (in the wake turbulence scheme under consideration), of a given severity for a given traffic pair on the initial common departure path, shall not increase compared to current operations' wake turbulence scheme (e.g. ICAO, RECAT-EU or UK 5-Cat) in reasonable worst-case conditions. Pre-cursor: WE7S1	**Hp#D1**	Wake Turbulence-induced Accident (WTA) on Initial Common Departure Path

Table 10 - Safety Criteria for the Departures Concepts

The following are the Performance Mechanisms associated with Safety.

OSD (AO-0329): With the OSD system support, the accuracy of the spacing delivered between departure aircraft can be improved compared to what is achieved today. Improving spacing delivery accuracy can enable the consistent separation delivery to the wake separation rules, with a reduced level of 'under separation delivery' compared to what is achieved today which links to Safety. Controller reliance on the OSD system support should have no impact on Task Performance (i.e. Workload, Situational Awareness and User Acceptance). Overall workload should not increase. It is expected that any workload increase for some tasks will be offset as a result of the OSD system support and reduce workload in other areas, so no changes are anticipated to Safety. Situational Awareness is not expected to be impacted and thus no changes are anticipated on Safety.

PWS-D (AO-0323) and the support of OSD (AO-0329): With the OSD system support, the accuracy of the spacing delivered between departure aircraft can be improved compared to what is achieved today. Improved spacing delivery accuracy with the OSD system support can enable the improved separation delivery to the PWS-D rules, reducing the level of 'under separation delivery' compared to what is achieved today, thus enabling a safe reduction in the overall amount of wake separation that is required to be delivered, which links to Safety. Controller reliance on the OSD system support should have no impact on Task Performance (i.e. Workload, Situational Awareness and User Acceptance). Overall workload should not increase. It is expected that any workload increase for some tasks will be offset as a result of the OSD system support and reduce workload in other areas, so no changes are

[8] RWY Collision risk model V2.0 08/04/2019

anticipated to Safety. Situational Awareness is not expected to be impacted and thus no changes are anticipated on Safety. Using PWS-D will not increase the frequency of potential WV encounters for a given wind and a given traffic pair compared to reference traffic pair at current standard operations in reasonable worst-case conditions. No increase in the frequency of potential WVEs compared to reference traffic pair at current standard operations in reasonable worst-case conditions, will not impact Safety Performance – links to Safety.

WDS-D (AO-0304) in the context of PWS-D (AO-0323) and the support of OSD (AO-0329): With the OSD system support, the accuracy of the spacing delivered between departure aircraft can be improved compared to what is achieved today. Improving spacing delivery accuracy with the OSD system support can enable the improved separation delivery to the WDS-D rules, reducing the level of 'under separation delivery' compared to what is achieved today, thus enabling a safe reduction in the overall amount of wake separation that is required to be delivered, which links to Safety. Controller reliance on the OSD system support should have no impact on Task Performance (i.e. Workload, Situational Awareness and User Acceptance). Overall workload should not increase. It is expected that any workload increase for some tasks will be offset as a result of the OSD system support and reduce workload in other areas, so no changes are anticipated to Safety. Situational Awareness is not expected to be impacted and thus no changes are anticipated on Safety. Using WDS-D will not increase the frequency of potential WV encounters for a given wind and a given traffic pair compared to reference traffic pair at current standard operations in reasonable worst-case conditions. No increase in the frequency of potential WVEs compared to reference traffic pair at current standard operations in reasonable worst-case conditions, will not impact Safety Performance – links to Safety.

4.3.2 Data collection and Assessment

The analysis conducted was as a result of RTS and hazard identification discussion along with end user workshops.

Functionality requirements have been identified along with high level integrity requirements. No shadow or live trials have been performed. Reference has been made to CREDOS[26] and whilst the requirements from that project are mentioned, they are included only for reference and it is recommended that they are referred to if local implementation is considered.

The safety assessment report does not replace any requirement for ANSPs to conduct bespoke safety cases when implementing the concept at local level.

Exercise ID, Name, Objective	Exercise Validation objective	Success criterion	Safety Criteria coverage	Validation results & Level of safety evidence
RTS04b - Conducted by EUROCONTROL to assess the operational feasibility of the static PairWise Separations departure concept (S-PWS) – wake turbulence	**OBJ-PJ2.02-V3-VALP-SA5** To assess the impact of PWS-D with OSD on operational safety compared to current operations	**CRT-PJ2.01-V3-VALP-SA5-001** Check that safe standard controller working practices are employed for managing departures under PWS-D with OSD	D-SAC#F2, D-SAC#F4, D-SAC#F5,	No unsafe controller working practices were seen to be introduced by the OSD tool alone. However, due to the fact that the OSD tool was not taking into account the arrivals on RWY28L, which could increase the

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separations for departing aircraft based on static aircraft characteristics (AO-0323) with Optimised Separation Delivery (OSD – AO-0329) for departure aircraft under partially segregated runway departure operations. RTS4b was conducted using the Paris CDG airport and approach environment.	applying current wake vortex separation scheme for departures without OSD tool in partially segregated runway operations under nominal conditions.	tool in partially segregated runway operations. Controllers' feedback and observations based on expert judgement indicate there is no increase in the potential for human error with safety implication due to the introduction of time based PWS-D with OSD tool for managing departures in partially segregated runway operations e.g. either in terms of the severity of existing possible human errors or introduction of new potential causes for human errors.	D-SAC#R3	potential for human error with safety implications, PWS-D with OSD in partially segregated runway operations is considered as <u>not</u> acceptable. The OSD tool needs to be developed further for partially segregated and mixed mode runway operations, to indicate to the TWR ATCO that the runway is in use by an arrival, which would stop the TWR ATCO from clearing a departure for line-up.
		CRT-PJ2.01-V3-VALP-SA5-002 The number* of minor under-separated aircraft on the Initial departure in operations is not higher under time based PWS-D with OSD tool to the reference scenario in partially segregated	D-SAC#F1, D-SAC#F2, D-SAC#F4	The number of minor and major under-separated aircraft on the initial departure path is not higher under time based PWS-D with OSD compared to the Solution 1 scenario (TB ICAO no OSD).

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		runway operations. *The number will be expressed as a percentage of the traffic sample of each exercise, for normalization needs. The number of major under-separated aircraft (to be defined) on the initial departure in partially segregated runway operations is reduced under time based PWS-D with OSD tool compared to the reference scenario.		
		CRT-PJ2.01-V3-VALP-SA5-003 The number* of Departure-related Runway incursions in partially segregated runway operations is not higher under time based PWS-D with OSD compared to the reference scenario. *The number will be expressed as a percentage of the number of Departures (only	D-SAC#R3	There were no RWY incursions observed in the runs where PWS-D with the OSD tool was applied (i.e. Solution 2).

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		occurrences involving conflicts with Departures will be counted).		
RTS5 – Conducted by NATS to assess the operational feasibility of the static PairWise Separations departure concept (S-PWS) – wake turbulence separations for departing aircraft based on static aircraft characteristics (AO-0323) with Optimised Separation Delivery (OSD – AO-0329) for departure aircraft under partially segregated runway departure operations. RTS5 also assessed Weather-dependent separations for departures (WDS-D – AO-0304). RTS5 was conducted using the London Heathrow airport and approach environment.	To assess the impact of the use of OSD tool with RECAT-EU 6-CAT wake time separations on operational safety compared to current operations with no OSD tool	There is evidence that the level of safety is maintained and not negatively impacted in solution scenario versus reference scenario in terms of: -Safe controller working procedures and practices are employed for managing RECAT-EU 6-CAT wake time separations with OSD tool -Positive feedback from controllers on the safety level of the employed working procedures and practices -Potential for Human errors with safety implications are not increased -ATCOs do not issue take-off clearances such that following ac become airborne prior to the required SID departure separation time	SAC#D1 SAC#D2 SAC#D3 SAC#D5 SAC#D7	ATCOs provided positive feedback by either agreeing or strongly agreeing with the statement that the working procedures/practises under the OSD scenario are safe. No controller disagreed with the statement that the potential for human error is the same (low) as current operations in the OSD scenario. Some controllers highlighted the potential risk of over-relying on the tool as well as the risk of being mislead with the use of the word “NONE” on the NBAT even when a SID separation still applies. The OSD scenario runs show a minor change in the proportion of under-separated SID pairs compared to the matched reference scenario runs. However, there were still instances of SID under-separation during the OSD scenario.

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		There is evidence that OSD tool in the context of RECAT-EU 6-CAT wake time separations for departures does not increase the number of minor under-separations and decreases the number of large under-separations (i.e. those with potential for severe wake encounters) compared to the reference scenarios in terms of: -Departure aircraft minor under-separations (= <10 s) are no more than in the solution scenarios versus the reference scenario -Departure aircraft major under-separations (>10 s) are less than in the solution scenarios versus the reference scenario -Number of aborted take-off -Number of go-around for arrival aircraft landing on the departure runway -ATCOs do not issue line up clearances such	SAC#D1 SAC#D2 SAC#D3 SAC#D5 SAC#D7	The OSD scenario runs show a reduction in the proportion of minor under-separated wake pairs compared to the matched reference scenario runs. The number of large under-separated wake pairs in the OSD scenario runs was comparable to the matched reference scenario runs. There were no occurrences of aborted take-offs or go-arounds in any of the matched runs. During 09R runs, no TEAM arrivals were observed to be constrained in the OSD scenario runs. There were instances of under-separated wake pairs indicating the take-off clearance was issued such that the follower ac became airborne prior to the NBAT. The OSD scenario runs show negligible change in the proportion of under-separated SID pairs compared to the matched reference scenario runs. However, there were still instances of under-separated SID pairs indicating the take-off clearance was issued such that the follower ac became airborne prior to the SID separation time.

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		that during TEAM arriving aircraft approaches are constrained -ATCOs do not issue take-off clearances such that following ac become airborne prior to the NBAT		
		There is evidence that in OSD solution scenario with RECAT-EU 6-CAT wake time separations the probability of Departure-related Runway incursions is not higher than the reference scenario in terms of: -Departure aircraft minor under-separations (= <10 s) are no more than in the solution scenarios versus the reference scenario -Departure aircraft major under-separations (>10 s) are less than in the solution scenarios versus the reference scenario -Number of aborted take-off -Number of go-around for arrival aircraft landing on		Same as above

		the departure runway -ATCOs do not issue line up clearances such that during TEAM arriving aircraft approaches are constrained -ATCOs do not issue take-off clearances such that following ac become airborne prior to the NBAT -ATCOs do not issue take-off clearances such that following ac become airborne prior to the required SID departure separation time		
	To confirm the impact of PWS-D concept on operational safety compared to reference scenario	There is evidence that the level of safety is maintained and not negatively impacted in solution scenario versus reference scenario in terms of: -Safe controller working procedures and practices are employed for managing SPW-D -Positive feedback from controllers on the safety level of the employed working procedures and practices	SAC#D1 SAC#D2 SAC#D3 SAC#D5 SAC#D7	ATCOs provided positive feedback by either agreeing or strongly agreeing with the statement that the working procedures/practises under the PWS-D scenario are safe. No controller disagreed with the statement that the potential for human error is the same (low) as current operations in the PWS-D scenario. Some controllers highlighted the potential risk of over-relying on the tool as well as the risk of being mislead with the use of the word “NONE” on the NBAT even when a SID separation still applies.

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		-Potential for Human errors with safety implications are not increased -ATCOs do not issue take-off clearances such that following ac become airborne prior to the required SID departure separation time		The PWS-D scenario runs show a minor change in the proportion of under-separated SID pairs compared to the matched reference scenario runs. However, there were still instances of SID under-separation during the PWS-D scenario.
		There is evidence that PWS-D with OSD tool for departures does not increase the number of minor under-separations and decreases the number of large under-separations (i.e. those with potential for severe wake encounters) compared to the reference scenarios in terms of: -Departure aircraft minor under-separations (= <10 s) are no more than in the solution scenarios versus the reference scenario -Departure aircraft major under-separations (>10 s) are less than in the solution scenarios versus the	SAC#D1 SAC#D2 SAC#D3 SAC#D5 SAC#D7	The PWS-D scenario runs show a reduction in the proportion of minor under-separated wake pairs compared to the matched reference scenario runs. The number of large under-separated wake pairs in the PWS-D scenario runs was comparable to the matched reference scenario runs. There were no occurrences of aborted take-offs or go-arounds in any of the matched runs. During 09R runs, no TEAM arrivals were observed to be constrained in the PWS-D scenario runs. There were instances of under-separated wake pairs indicating the take-off clearance was issued such that the follower ac became airborne prior to the NBAT.

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		reference scenario -Number of aborted take-off -Number of go-around for arrival aircraft landing on the departure runway -ATCOs do not issue line up clearances such that during TEAM arriving aircraft approaches are constrained -ATCOs do not issue take-off clearances such that following ac become airborne prior to the NBAT		The PWS-D scenario runs show negligible change in the proportion of under-separated SID pairs compared to the matched reference scenario runs. However, there were still instances of under-separated SID pairs indicating the take-off clearance was issued such that the follower ac became airborne prior to the SID separation time.
		There is evidence that in PWS-D solution scenario the probability of Departure-related Runway incursions is not higher than the reference scenario in terms of: -Departure aircraft minor under-separations (= <10 s) are no more than in the solution scenarios versus the reference scenario -Departure aircraft major under-separations (>10 s) are less than in the solution scenarios		Same as above

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		versus the reference scenario -Number of aborted take-off -Number of go-around for arrival aircraft landing on the departure runway -ATCOs do not issue line up clearances such that during TEAM arriving aircraft approaches are constrained -ATCOs do not issue take-off clearances such that following ac become airborne prior to the NBAT -ATCOs do not issue take-off clearances such that following ac become airborne prior to the required SID departure separation time		
	To confirm the impact of WDS-D Crosswind concept on operational safety compared to current wake vortex separation scheme	There is evidence that the level of safety is maintained and not negatively impacted in solution scenario versus reference scenario in terms of: -Safe controller working procedures and practices are employed for managing WDS-D	SAC#D1 SAC#D2 SAC#D3 SAC#D5 SAC#D7	ATCOs provided positive feedback by either agreeing or strongly agreeing with the statement that the working procedures/practises under the WDS-D scenario are safe. No controller disagreed with the statement that the potential for human error is the same (low) as current operations in the WDS-D scenario. Some controllers highlighted

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		in solution scenario improving the level of safety respect to the reference scenarios -Positive feedback from controllers on the safety level of the employed working procedures and practices -Potential for Human errors with safety implications are not increased -ATCOs do not issue take-off clearances such that following ac become airborne prior to the required SID departure separation time		the potential risk of over-relying on the tool as well as the risk of being mislead with the use of the word “NONE” on the NBAT even when a SID separation still applies. The WDS-D scenario runs show a minor change in the proportion of under-separated SID pairs compared to the matched reference scenario runs. However, there were still instances of SID under-separation during the WDS-D scenario.
		There is evidence that WDS-D separations for departures does not increase the number of minor under-separations and decreases the number of large under-separations (i.e. those with potential for severe wake encounters) compared to the reference scenarios in terms of: -Departure aircraft minor	SAC#D1 SAC#D2 SAC#D3 SAC#D5 SAC#D7	The WDS-D scenario runs show a reduction in the proportion of minor under-separated wake pairs compared to the matched reference scenario runs. There were no large under-separated wake pairs in the WDS-D scenario runs. There were no occurrences of aborted take-offs or go-arounds in any of the matched runs. During 09R runs, no TEAM arrivals were observed to be

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		under-separations (= <10 s) are no more than in the solution scenarios versus the reference scenario -Departure aircraft major under-separations (>10 s) are less than in the solution scenarios versus the reference scenario -Number of aborted take-off -Number of go-around for arrival aircraft landing on the departure runway -ATCOs do not issue line up clearances such that during TEAM arriving aircraft approaches are constrained -ATCOs do not issue take-off clearances such that following ac become airborne prior to the NBAT		constrained in the WDS-D scenario runs. There were instances of under-separated wake pairs indicating the take-off clearance was issued such that the follower ac became airborne prior to the NBAT. The WDS-D scenario runs show negligible change in the proportion of under-separated SID pairs compared to the matched reference scenario runs. However, there were still instances of under-separated SID pairs indicating the take-off clearance was issued such that the follower ac became airborne prior to the SID separation time.
		There is evidence that in WDS-D solution scenario the probability of Departure-related Runway incursions is not higher than the reference scenario in terms of:		Same as above

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		-Departure aircraft minor under-separations (= <10 s) are no more than in the solution scenarios versus the reference scenario -Departure aircraft major under-separations (>10 s) are less than in the solution scenarios versus the reference scenario -Number of aborted take-off -Number of go-around for arrival aircraft landing on the departure runway -ATCOs do not issue line up clearances such that during TEAM arriving aircraft approaches are constrained -ATCOs do not issue take-off clearances such that following ac become airborne prior to the NBAT -ATCOs do not issue take-off clearances such that following ac become airborne prior to the required SID departure separation time		

RTS6 – Conducted by CRIDA/ENAIRE to assess AO-0323 Wake Turbulence Separations (for Departures) based on static Aircraft Characteristics (PWS-D) and AO-0329 Optimised separation delivery (OSD) for departures.	To assess the impact of static pairwise separations for departures on operational safety compared to current wake vortex separation scheme	There is evidence that the level of safety is maintained and not negatively impacted under static pairwise separations for departures compared to the current wake vortex separation scheme	SAC#D1 SAC#D2 SAC#D3 SAC#D5 SAC#D7	The level of perceived safety remained practically at the same level between reference and solution scenarios. Moreover the result of the analysis of the infringements go along the same line.

4.3.3 Extrapolation to ECAC wide

The results obtained from the validation activities are for the moment limited to a specific set of operational environments, in terms of runway layout and configuration as well as in terms of traffic.

These results could be extrapolated to similar aerodromes in ECAC, meaning that the level of safety would not be degraded when applying the PJ.02-01-06 Departures concepts (even if not all abnormal and degraded modes have been assessed) at these types of aerodromes.

However, not enough evidence is available to extrapolate this statement to the rest of the environments outside the scope of the PJ.02-01-06 validation activities. The number of aerodromes to which this Solution could be applied while ensuring the level of safety is maintained needs then to be defined.

4.3.4 Discussion of Assessment Result

N/A

4.3.5 Additional Comments and Notes

No additional comments.

4.4 Environment: Fuel Efficiency / CO2 emissions

Often fuel efficiency is improved through a reduction of flight or taxi time. This time benefit is also assessed, in this section, as it is additional input for the business case.

4.4.1 Performance Mechanism

OSD (AO-0329): Optimised delivery of departure aircraft separations can reduce the average ground delay per flight. As ground delay uses more fuel (e.g. in case of ground holding), a reduction in this delay will result in reduced fuel burn on the ground. This has a positive impact on Fuel Efficiency.

PWS-D (AO-0323) and the support of OSD (AO-0329): The use of PWS-D Reducing the wake departure aircraft separations will reduce the average ground delay per flight. As ground delay uses more fuel

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(e.g. in case of ground holding), a reduction in this delay will result in reduced fuel burn on the ground. This has a positive impact on Fuel Efficiency.

WDS-D (AO-0304) in the context of PWS-D (AO-0323) and the support of OSD (AO-0329): The use of WDS-D reducing the wake departure aircraft separations will reduce the average ground delay per flight. As ground delay uses more fuel (e.g. in case of ground holding), a reduction in this delay will result in reduced fuel burn on the ground. This has a positive impact on Fuel Efficiency.

4.4.2 Assessment Data (Exercises and Expectations)

The following results are taken from the RTS5 validation exercise (with a Heathrow traffic mix):

- AO-0329 (OSD) results showed an average 0.40 minutes reduction per flight in taxi-out time for RECAT-EU departure wake separations;
- AO-0323 (PWS-D) results showed an average 0.70 minutes reduction per flight in taxi-out time when compared to a reference scenario of RECAT-EU departure separation;
- AO-0304 (WDS-D) results in the context of PWS-D showed an average 0.50 minutes reduction1 per flight in taxi-out time when compared to a reference scenario of RECAT-EU departure wake separations.

The following results are taken from the RTS6 validation exercise (with a Barcelona traffic mix):

- AO-0323 (PWS-D) results showed on average:
  - 2.36 minutes reduction per flight in taxi-out time, when compared to a reference scenario of ICAO departure wake separations;
  - 0.32 minutes reduction per flight in taxi-out time, when compared to a reference scenario of RECAT-EU departure wake separations.

4.4.3 Extrapolation to ECAC wide

The following PJ.19 common assumptions have been used:

- Taxi Fuel burn rate = 900 kg/hour = 15kg/minute,
- Average fuel burn per flight = 4800kg,
- High density airports traffic contribution to total airport traffic = 59.5%
- Departures traffic contribution to total traffic = 50%
- CO_2/Fuel ratio = 3.15
- Average ECAC flight time = 1.5 hours = 90 minutes

The following methodology describes how the FEFF1, FEFF2 and FEFF3 metrics were obtained for AO-0329 (OSD):

1.) Taxi-time reduction per flight (RTS5 validation exercise result) = 0.40 minutes

2.) Flight time reduction (FEFF3) at ECAC level = 50% (departure traffic contribution) * 59.5% (high density airports traffic contribution) * 0.40 minutes (taxi-time reduction per flight) = 0.12 minutes

3.) Relative flight time reduction at ECAC level = 0.12 minutes (flight time reduction at ECAC level) * 90 minutes (average ECAC flight time) * 100 = 0.13%

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4.) Fuel consumption reduction per flight = 15 kg/minute (taxi fuel burn rate) *0.40 minutes (taxi time reduction per flight) = 6.00 kg

5.) Fuel consumption reduction (FEFF1) at ECAC level = 50% (departures traffic contribution) * 59.5% (high density airports traffic contribution) * 6.00 kg (fuel consumption reduction) = 1.79 kg

6.) Relative fuel consumption reduction at ECAC level = 1.79 kg (fuel consumption reduction at ECAC level) /4800 kg (average fuel burn per flight) * 100 = 0.04%

7.) CO_2 emission reduction (FEFF2) at ECAC level = 1.79 kg fuel consumption reduction at ECAC level * 3.15 (CO_2/Fuel ratio) = 5.62 kg

8.) Relative CO_2 consumption reduction at ECAC level = 5.62kg (CO_2 consumption reduction at ECAC level) / [4800 kg (average fuel burn per flight) * 3.15 (CO_2/Fuel ratio)] * 100 = 0.04%

The following methodology describes how the FEFF1, FEFF2 and FEFF3 metrics were obtained for AO-0323 (PWS-D), when compared to a reference scenario of ICAO departure wake separations:

1.) Taxi-time reduction per flight (RTS5 validation exercise result) = 2.36 minutes

2.) Flight time reduction (FEFF3) at ECAC level = 50% (departure traffic contribution) * 59.5% (high density airports traffic contribution) * 2.36 minutes (taxi-time reduction per flight) = 0.7 minutes

3.) Relative flight time reduction at ECAC level = 0.7 minutes (flight time reduction at ECAC level) * 90 minutes (average ECAC flight time) * 100 = 0.78%

4.) Fuel consumption reduction per flight = 15 kg/minute (taxi fuel burn rate) *2.36 minutes (taxi time reduction per flight) = 35.4 kg

5.) Fuel consumption reduction (FEFF1) at ECAC level = 50% (departures traffic contribution) * 59.5% (high density airports traffic contribution)*35.4 kg (fuel consumption reduction) = 10.53 kg

6.) Relative fuel consumption reduction at ECAC level = 10.53kg (fuel consumption reduction at ECAC level) /4800 kg (average fuel burn per flight) * 100 = 0.22%

7.) CO_2 emission reduction (FEFF2) at ECAC level = 10.53 kg fuel consumption reduction at ECAC level * 3.15 (CO_2/Fuel ratio) = 33.18 kg

8.) Relative CO_2 consumption reduction at ECAC level = 33.18kg (CO_2 consumption reduction at ECAC level) /[4800 kg (average fuel burn per flight)* 3.15 (CO_2/Fuel ratio)] * 100 = 0.22%

The following methodology describes how the FEFF1, FEFF2 and FEFF3 metrics were obtained for AO-0323 (PWS-D), when compared to a reference scenario of RECAT-EU departure wake separations:

Aggregation

1.) Taxi-time reduction per flight = 0.7 (RTS5) + 0.32 (RTS6)/2 = 0.51 minutes

Extrapolation of Aggregated results

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1.) Taxi-time reduction per flight = 0.51 minutes

2.) Flight time reduction (FEFF3) at ECAC level = 50% (departure traffic contribution) * 59.5% (high density airports traffic contribution) * 0.51 minutes (taxi-time reduction per flight) = 0.15 minutes

3.) Relative flight time reduction at ECAC level = 0.15 minutes (flight time reduction at ECAC level) * 90 minutes (average ECAC flight time) * 100 = 0.17%

4.) Fuel consumption reduction per flight = 15 kg/minute (taxi fuel burn rate) *0.51 minutes (taxi time reduction per flight) = 7.65kg

5.) Fuel consumption reduction (FEFF1) at ECAC level = 50% (departures traffic contribution) * 59.5% (high density airports traffic contribution) * 7.65 kg (fuel consumption reduction) = 2.28 kg

6.) Relative fuel consumption reduction at ECAC level = 2.28 kg (fuel consumption reduction at ECAC level) /4800 kg (average fuel burn per flight) * 100 = 0.05%

7.) CO_2 emission reduction (FEFF2) at ECAC level = 2.28 kg fuel consumption reduction at ECAC level * 3.15 (CO_2/Fuel ratio) = 7.17 kg

8.) Relative CO_2 consumption reduction at ECAC level = 7.17 kg (CO_2 consumption reduction at ECAC level) /[4800 kg (average fuel burn per flight)* 3.15 (CO_2/Fuel ratio)] * 100 = 0.05%

The following methodology describes how the FEFF1, FEFF2 and FEFF3 metrics were obtained for AO-0304 (WDS-D):

1.) Taxi-time reduction per flight (RTS5 validation exercise result) = 0.50 minutes

2.) Flight time reduction (FEFF3) at ECAC level = 50% (departure traffic contribution) * 59.5% (high density airports traffic contribution) * 0.50 minutes (taxi-time reduction per flight) = 0.15 minutes

3.) Relative flight time reduction at ECAC level = 0.15 minutes (flight time reduction at ECAC level) * 90 minutes (average ECAC flight time) * 100 = 0.17%

4.) Fuel consumption reduction per flight = 15 kg/minute (taxi fuel burn rate) *0.50 minutes (taxi time reduction per flight) = 7.50 kg

5.) Fuel consumption reduction (FEFF1) at ECAC level = 50% (departures traffic contribution) * 59.5% (high density airports traffic contribution) * 7.50 kg (fuel consumption reduction) = 2.23 kg

6.) Relative fuel consumption reduction at ECAC level = 2.23 kg (fuel consumption reduction at ECAC level) /4800 kg (average fuel burn per flight) * 100 = 0.05%

7.) CO_2 emission reduction (FEFF2) at ECAC level = 2.23 kg fuel consumption reduction at ECAC level * 3.15 (CO_2/Fuel ratio) = 7.03 kg

8.) Relative CO_2 consumption reduction at ECAC level = 7.03kg (CO_2 consumption reduction at ECAC level) / [4800 kg (average fuel burn per flight) * 3.15 (CO_2/Fuel ratio)] * 100 = 0.05%

The following table summarises the results for each OI step. Please provide validation results or initial estimation of the Solution's performance in SESAR2020 (horizon 2035, compared to 2012 extrapolated to ECAC wide). (Please use the metrics stated below)

KPIs / PIs	Unit	Calculation	Mandatory	Absolute expected performance benefit in SESAR2020	% expected performance benefit in SESAR2020
FEFF1 Actual Average fuel burn per flight	Kg fuel per movement	Total amount of actual fuel burn divided by the number of movements	YES	AO-0329 (OSD) = **1.79 kg reduction** in fuel consumption per flight at ECAC level, compared to RECAT-EU TBS without OSD tool support, with a Heathrow traffic mix. AO-0323 (PWS-D): - **10.53 kg reduction** in fuel consumption per flight at ECAC level, compared to ICAO without OSD tool support, with a Barcelona traffic mix; - **2.28 kg reduction** in fuel consumption per flight at ECAC level, compared to RECAT-EU without OSD tool support, with Heathrow and Barcelona traffic mixes. AO-0304 (WDS-D) in the context of PWS-D (AO-0323) = **2.23 kg reduction**[1] in fuel consumption per flight at ECAC level, compared to RECAT-EU without OSD tool	AO-0329 (OSD) = **0.04% reduction** in fuel consumption per flight at ECAC level, compared to RECAT-EU TBS without OSD tool support, with a Heathrow traffic mix. AO-0323 (PWS-D): - **0.22% reduction** in fuel consumption per flight at ECAC level, compared to ICAO without OSD tool support, with a Barcelona traffic mix; - **0.05% reduction** in fuel consumption per flight at ECAC level, compared to RECAT-EU without OSD tool support, with Heathrow and Barcelona traffic mixes. AO-0304 (WDS-D) in the context of PWS-D (AO-0323) = **0.05% reduction** in fuel consumption per flight at ECAC level, compared to RECAT-EU without OSD tool

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KPIs / PIs	Unit	Calculation	Mandatory	Absolute expected performance benefit in SESAR2020	% expected performance benefit in SESAR2020
				support, with a Heathrow traffic mix.	support, with a Heathrow traffic mix.
FEFF2 Actual Average CO_2 Emission per flight	Kg CO_2 per flight	Amount of fuel burn x 3.15 (CO_2 emission index) divided by the number of flights	YES	AO-0329 (OSD) = **5.62 kg reduction** in CO_2 emissions per flight at ECAC level, compared to RECAT-EU TBS without OSD tool support, with a Heathrow traffic mix. AO-0323 (PWS-D): - **33.18 kg reduction** in CO_2 emissions per flight at ECAC level, compared to ICAO without OSD tool support, with a Barcelona traffic mix; - **7.17 kg reduction** in CO_2 emissions per flight at ECAC level, compared to RECAT-EU without OSD tool support, with a Heathrow traffic mix. AO-0304 (WDS-D) in the context of PWS-D (AO-0323) = **7.03 kg reduction**[1] in CO_2 emissions per flight at ECAC level, compared to RECAT-EU without OSD tool support, with a Heathrow traffic mix.	AO-0329 (OSD) = **0.04% reduction** in in CO_2 emissions per flight at ECAC level, compared to RECAT-EU TBS without OSD tool support, with a Heathrow traffic mix. AO-0323 (PWS-D): - **0.22% reduction** in in CO_2 emissions per flight at ECAC level, compared to ICAO without OSD tool support, with a Barcelona traffic mix; - **0.05% reduction** in in CO_2 emissions per flight at ECAC level, compared to RECAT-EU without OSD tool support, with a Heathrow traffic mix. AO-0304 (WDS-D) in the context of PWS-D (AO-0323) = **0.05% reduction** in in CO_2 emissions per flight at ECAC level, compared to RECAT-EU without OSD tool support, with a Heathrow traffic mix.

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KPIs / PIs	Unit	Calculation	Mandatory	Absolute expected performance benefit in SESAR2020	% expected performance benefit in SESAR2020
FEFF3 Reduction in average flight duration	Minutes per flight	Average actual flight duration measured in the Reference Scenario – Average flight duration measured in the Solution Scenario	YES	AO-0329 (OSD) = **0.12 minutes reduction** in flight duration (taxi-out time) per flight at ECAC level, compared to RECAT-EU TBS without OSD tool support, with a Heathrow traffic mix. AO-0323 (PWS-D): - **0.7 minutes reduction** in flight duration (taxi-out time) per flight at ECAC level, compared to ICAO without OSD tool support, with a Barcelona traffic mix; - **0.3 minutes reduction** in flight duration (taxi-out time) per flight at ECAC level, compared to RECAT-EU without OSD tool support, with a Heathrow traffic mix. AO-0304 (WDS-D) in the context of PWS-D (AO-0323) = **0.15 minutes reduction**[1] in flight duration (taxi-out time) per flight at ECAC level, compared to RECAT-EU without OSD tool support, with a Heathrow traffic mix.	AO-0329 (OSD) = **0.13% reduction** in flight duration per flight at ECAC level, compared to RECAT-EU TBS without OSD tool support, with a Heathrow traffic mix. AO-0323 (PWS-D): - **0.78% reduction** in flight duration per flight at ECAC level, compared to ICAO without OSD tool support, with a Barcelona traffic mix; - **0.34% reduction** in flight duration per flight at ECAC level, compared to RECAT-EU without OSD tool support, with a Heathrow traffic mix. AO-0304 (WDS-D) in the context of PWS-D (AO-0323) = **0.17% reduction** 1in flight duration per flight at ECAC level, compared to RECAT-EU without OSD tool support, with a Heathrow traffic mix.

Table 11: Fuel burn and CO2 emissions saving for Mandatory KPIs /Pis

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	Taxi out	TMA departure	En-route	TMA arrival	Taxi in
FEFF1 Actual Average fuel burn per flight	AO-0329 (OSD) = 1.79 kg reduction in fuel consumption per flight at ECAC level compared to RECAT-EU TBS without OSD tool support, with a Heathrow traffic mix. AO-0323 (PWS-D): - 10.53kg reduction in fuel consumption per flight at ECAC level, compared to ICAO without OSD tool support, with a Barcelona traffic mix; - 2.28kg reduction in fuel consumption per flight at ECAC level, compared to RECAT-EU without OSD tool support, with a Heathrow traffic mix. AO-0304 (WDS-D) in the context of PWS-D = 2.23 kg reduction[1] in fuel consumption per flight at ECAC level, compared to RECAT-EU without OSD tool support, with a Heathrow traffic mix.	N/A	N/A	N/A	N/A
FEFF2 Actual Average CO_2 Emission per flight	AO-0329 (OSD) = 5.62 kg reduction in CO_2 emissions per flight at ECAC level, compared to RECAT-EU TBS without OSD tool support, with a Heathrow traffic mix, compared to RECAT-EU without OSD tool support. AO-0323 (PWS-D): - 33.18 kg reduction in CO_2 emissions per flight at ECAC level, compared to ICAO without OSD tool support, with a Barcelona traffic mix; - 7.17 kg reduction in CO_2 emissions per flight at ECAC level, compared to RECAT-EU without OSD tool support, with a Heathrow traffic mix. AO-0304 (WDS-D) in the context of PWS-D = 7.03 kg reduction[1] in CO_2 emissions per flight at ECAC level, compared to RECAT-EU without OSD tool support, with a Heathrow traffic mix.	N/A	N/A	N/A	N/A
FEFF3 Reduction in average flight duration	AO-0329 (OSD) = 0.12 minutes reduction in flight duration (taxi-out time) per flight at ECAC level, compared to RECAT-EU TBS without OSD tool support, with a Heathrow traffic mix. AO-0323 (PWS-D): - 0.7 minutes reduction in flight duration (taxi-out time) per flight at ECAC level, compared to ICAO without OSD tool support, with a Barcelona traffic mix; - 0.31 minutes reduction in flight duration (taxi-out time) per flight at ECAC level, compared to RECAT-EU without OSD tool support, with a Heathrow traffic mix. AO-0304 (WDS-D) in the context of PWS-D (AO-0323) = 0.15 minutes reduction[1] in flight duration (taxi-out time)	N/A	N/A	N/A	N/A

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	per flight at ECAC level, compared to RECAT-EU without OSD tool support, with a Heathrow traffic mix.				

Table 12: Fuel burn and CO2 emissions saving per flight phase.

4.4.4 Discussion of Assessment Result

The fuel efficiency results show a reduction in taxi-out time in each of the OI steps due to increased departure throughputs and hence reduced delays. There is low confidence in these results.

4.4.5 Additional Comments and Notes

No additional comments.

4.5 Airport Capacity (Runway Throughput Flights/Hour)

4.5.1 Performance Mechanism

OSD (AO-0329): With the OSD system support, the accuracy of the spacing delivered between departure aircraft can be improved compared to what is achieved today. Improving spacing delivery accuracy can reduce the level of ‘over spacing delivery’ compared to what is achieved today, thus enabling the efficient reduction of the overall amount of wake separation that is required to be delivered, which links to Capacity. . The use of OSD is expected to optimise the delivery of departure aircraft separations and thus increasing runway throughput. Optimised spacing delivery between departure aircraft has a positive impact on the runway throughput. The higher the departure aircraft throughput, the higher the number of departure aircraft movements, leading to a positive impact on Capacity.

PWS-D (AO-0323) and the support of OSD (AO-0329): The use of PWS-D is expected to reduce wake separation between departure aircraft. OSD is expected to optimise the accuracy of the spacing delivered between departure aircraft. The reduced wake separations and optimised spacing delivery increases the runway throughput. PWS-D reduces wake separation and OSD Optimised spacing delivery accuracy between departure aircraft has a positive impact on the runway throughput. The higher the departure aircraft throughput, the higher the number of departure aircraft movements, leading to a positive impact on Capacity. Improved spacing delivery accuracy with the OSD system support can enable the improved separation delivery to the PWS-D rules, reducing the level of ‘over spacing delivery’ compared to what is achieved today, thus enabling the efficient reduction of the overall amount of wake separation that is required to be delivered, which links to Capacity.

WDS-D (AO-0304) in the context of PWS-D (AO-0323) and the support of OSD (AO-0329): The use of WDS-D (e.g. for WDS based on crosswind when crosswind is above the activation threshold) is expected to reduce wake separation between departure aircraft. OSD is expected to optimise the accuracy of the spacing delivered between departure aircraft. The reduced wake separations and optimised spacing delivery increasing the runway throughput. WDS-D reduced wake separation and OSD optimised spacing delivery accuracy between departure aircraft has a positive impact on the runway throughput. The higher the departure aircraft throughput, the higher the number of departure aircraft movements, leading to a positive impact on Capacity. Improving spacing delivery accuracy with the OSD system support can enable the improved separation delivery to the WDS-D rules, reducing the level of ‘over spacing delivery’ compared to what is achieved today, thus enabling the

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efficient reduction of the overall amount of wake separation that is required to be delivered, which links to Capacity.

4.5.2 Assessment Data (Exercises and Expectations)

The following results were taken from the RTS5 validation exercise (with a Heathrow traffic mix) that assessed departure throughput in segregated mode operations:

- OSD (AO-0329) showed on average a 1.0% increase in departure throughput, which equates to a 0.6 increase in departure movements per hour, compared to RECAT-EU without OSD tools support;
- PWS-D (AO-0323) showed on average a 2.0% increase in departure throughput, which equates to a 1.1 increase in departure movements per hour, compared to RECAT-EU without OSD tools support;
- WDS-D (AO-0304) in the context of PWS-D (AO-0323) showed on average a 0.1% increase[1] in departure throughput, which equates to a 0.05 increase in departure movements per hour, compared to RECAT-EU without OSD tools support.

The following results were taken from the RTS6 validation exercise (with a Barcelona traffic mix) that assessed departure throughput in segregated mode operations:

- PWS-D (AO-0323) showed on average:
  - A 8.65% increase in departure throughput, which equates to a 3.9 increase in departure movements per hour, when compared to a reference of ICAO departure wake separations;
  - A 2.81% increase in departure throughput, which equates to a 1.3 increase in departure movements per hour, when compared to a reference of RECAT-EU departure wake separations.

Aggregation of Results for PWS-D

1.) **Peak Departure throughput per hour (Segregated mode) (CAP3.1) = 1.1 (RTS5) + 1.3 (RTS6)/2 = 1.2**

KPIs / Pis	Unit	Calculation	Mandatory	Absolute expected performance benefit in SESAR2020	% expected performance benefit in SESAR2020
CAP3 Peak Runway Throughput (Mixed mode)	% and Flight per hour	% and also total number of movements per one runway per one hour for specific traffic mix and density (in mixed mode RWY operations). The percentage change is measured against the maximum observed throughput during peak demand hours in the mixed-mode RWY operations airports group.	YES	Mixed Mode not assessed in RTS5/RTS6.	Mixed Mode not assessed in RTS5/RTS6.
CAP3.1 Peak Departure throughput per hour	% and Flight per hour	% and also total number of departures per one runway per one hour for specific traffic mix and density (in segregated mode of operations). The percentage change is	YES	OSD (AO-0329) – **0.6 increase** in departure movements per hour, compared	OSD (AO-0329) – **1.0% increase** in departure movements per hour, compared

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KPIs / Pis	Unit	Calculation	Mandatory	Absolute expected performance benefit in SESAR2020	% expected performance benefit in SESAR2020
(Segregated mode)		measured against the maximum observed throughput during peak demand hours in the segregated-mode RWY operations airports group.		to RECAT-EU TBS without OSD tool support, with a Heathrow traffic mix. PWS-D (AO-0323): - **3.92 increase** in departure movements per hour, compared to ICAO without OSD tools support, with a Barcelona traffic mix; - **1.2 increase** in departure movements per hour, compared to RECAT-EU without OSD tool support, with Heathrow and Barcelona traffic mixes. WDS-D (AO-0304) in the context of PWS-D (AO-0323) – **0.05 increase**[1] in departure movements per hour, compared to RECAT-EU without OSD tool support, with a Heathrow traffic mix.	to RECAT-EU TBS without OSD tool support, with a Heathrow traffic mix. PWS-D (AO-0323): - **8.65% increase** in departure movements per hour, compared to ICAO without OSD tools support, with a Barcelona traffic mix; - **2.41% increase** in departure movements per hour, compared to RECAT-EU without OSD tool support, with Heathrow and Barcelona traffic mixes. WDS-D (AO-0304) in the context of PWS-D (AO-0323) – **0.1% increase**[1] in departure movements per hour, compared to RECAT-EU without OSD tool support, with a Heathrow traffic mix.

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KPIs / Pis	Unit	Calculation	Mandatory	Absolute expected performance benefit in SESAR2020	% expected performance benefit in SESAR2020
CAP3.2 Peak Arrival throughput per hour (Segregated mode)	% and Flight per hour	% and also total number of arrivals per one runway per one hour for specific traffic mix and density (in segregated mode of operations). The percentage change is measured against the maximum observed throughput during peak demand hours in the segregated-mode RWY operations airports group.	YES	N/A	N/A
CAP4 Un-accommodated traffic reduction	Flights/year	Reduction in the number of un-accommodated flights i.e. a flight that would have been scheduled if there were available slots at the origin/destination airports. NB: Supports CBA Inputs. NB: Relates to Airport Capacity because this is STATFOR computation. CBA calculate this based on the assessment of the runway throughput we provide with and without the solutions and STATFOR data.	YES For CBA.	OSD (AO-0329) – **0.6 reduction** in un-accommodated departures per hour, compared to RECAT-EU TBS without OSD tool support, with a Heathrow traffic mix. PWS-D (AO-0323) – **1.1 reduction** in un-accommodated departures per hour, compared to RECAT-EU without OSD tool support, with a Heathrow traffic mix. WDS-D (AO-0304) in the context of PWS-D (AO-0323) – **0.05 reduction**[1] in un-accommodated departures per hour, compared to RECAT-EU without OSD tool support, with a Heathrow traffic mix.	OSD (AO-0329) – **1.0% reduction** in un-accommodated departures per hour, compared to RECAT-EU TBS without OSD tool support, with a Heathrow traffic mix. PWS-D (AO-0323) – **2.0% reduction** in un-accommodated departures per hour, compared to RECAT-EU without OSD tool support, with a Heathrow traffic mix. WDS-D (AO-0304) in the context of PWS-D (AO-0323) – **0.05 reduction**[1] in un-accommodated departures per hour, compared to RECAT-EU without OSD tool support, with a Heathrow traffic mix.

Table 13: Airport Capacity for Mandatory KPIs /Pis

4.5.3 Extrapolation to ECAC wide

There is no ECAC wide extrapolation required for this KPI.

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4.5.4 Discussion of Assessment Result

Varying performance between runs for some controllers led to unexpected departure throughput results. It was expected that AO-0329 (OSD) would bring negligible benefit due to keeping the wake separation scheme the same. AO-0304 (WDS-D) was expected to have a benefit in-line with AO-0323 (PWS-D) but it shows a smaller benefit. However, because of low departure throughput in the reference scenario the OSD and PWS-D throughputs are higher. Also, controllers noted during WDS-D runs that they were sequencing departures to try to achieve a reduced WDS-D separation, which may have not been the most optimal departure sequence. Hence, the WDS-D benefits showed a lower benefit than PWS-D. Therefore, it is recommended that validation exercises are conducted in the local environment to determine the benefits.

Following RTS5, consideration of 12 months' (April 2018-March 2019) worth of historical data was also used to investigate the potential benefits of PWS-D and WDS-D, local to London Heathrow[27]. In particular, this work intended to add insight to the RTS5 findings, to widen consideration via modelling and analysis of the Heathrow traffic beyond the four traffic samples deployed in RTS5.

Four cases were used in the analysis:

	SID pair constraint applied?	Crosswind constraint applied?
First Unconstrained Case	No	No
First Constrained Case	No	Yes
Second Unconstrained Case	Yes	No
Second Constrained Case	Yes	Yes

Table 14: Summary of differences between the cases for WDS-D in the context of PWS-D

Greater gains are anticipated with the introduction of PWS-D in the context of RECAT-EU, compared with the introduction of WDS-D in the context of PWS-D. Table 15 summarises the model results for each solution, and for the unconstrained and constrained cases.

	PWS-D in the context of RECAT-EU	WDS-D in the context of PWS-D
First Unconstrained Case	11m 52s	9m 23s
First Constrained Case	9m 50s	1m 58s
Second Unconstrained Case	Not applicable	2m 55s
Second Constrained Case	Not applicable	0m 36s

Table 15: Summary breakdown of potential gains by solution (gains measured in minutes and seconds per day) from additional capacity analysis

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For both solutions it is observed that the anticipated gains are not uniform through the day but are expected to be less at the beginning and end of the operational day, corresponding to hours when there are less wake pairs within the traffic mix. The pairing CAT-B – CAT-D, Heavy – Medium, is the category pairing expected to give rise to the greatest potential gain for both solutions.

The level of potential benefits with WDS-D is dependent on the weather conditions, as a sufficient crosswind on departure is required, and how often the reduced WDS-D wake separation would apply.

Further data is available in the full report[27].

4.5.5 Additional Comments and Notes

No additional comments.

4.5.6 Resilience (% Loss of Airport & Airspace Capacity Avoided)

4.5.6.1 Performance Mechanism

The increase in departure throughput discussed above may be used for resilience rather than extra capacity. The increase in departure throughput could help reduce the % loss of airport capacity and so result in improved resilience.

4.5.6.2 Assessment Data (Exercises and Expectations)

The loss of airport capacity avoided has been assumed to directly correspond to the increase in departure throughput results above.

The following results were taken from the RTS5 validation exercise (with a Heathrow traffic mix) which assessed departure throughput in segregated mode operations.

- OSD (AO-0329) showed a 1.0% increase in departure throughput compared to RECAT-EU without OSD tools support, which equates to a 0.6 increase in departure movements per hour;
- PWS-D (AO-0323) showed a 2.0% increase in departure throughput compared to RECAT-EU without OSD tools support, which equates to a 1.1 increase in departure movements per hour;
- WDS-D (AO-0304) in the context of PWS-D (AO-0323) showed a 0.1% increase[1] in departure throughput compared to RECAT-EU without OSD tools support, which equates to a 0.05 increase in departure movements per hour.

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PIs	Unit	Calculation	Mandatory	Benefit in SESAR1 (if applicable)	Absolute expected performance benefit in SESAR2020	% expected performance benefit in SESAR2020
RES1 Loss of Airport Capacity Avoided	% and Movements per hour	Loss of Airport Capacity with the concept divided by the loss of Airport Capacity without the concept.	YES	N/A	OSD (AO-0329) – **0.6 departure movements** per hour loss of capacity avoided, compared to RECAT-EU TBS without OSD tool support, with a Heathrow traffic mix. PWS-D (AO-0323) – **1.1 departure movements** per hour loss of capacity avoided, compared to RECAT-EU without OSD tool support, with a Heathrow traffic mix. WDS-D (AO-0304) in the context of PWS-D (AO-0323) – **0.05[1] departure movements** per hour loss of capacity avoided, compared to RECAT-EU without OSD tool support, with a Heathrow traffic mix.	OSD (AO-0329) – **1.0% departure movements** per hour loss of capacity avoided, compared to RECAT-EU TBS without OSD tool support, with a Heathrow traffic mix. PWS-D (AO-0323) – **2.0% departure movements** per hour loss of capacity avoided, compared to RECAT-EU without OSD tool support, with a Heathrow traffic mix. WDS-D (AO-0304) in the context of PWS-D (AO-0323) – **0.1%[1] departure movements** per hour loss of capacity avoided, compared to RECAT-EU without OSD tool support, with a Heathrow traffic mix.
RES 1.1 Airport time to recover from non-nominal to nominal condition	Minutes	Duration of Airport lost capacity from non-nominal to nominal condition.	YES for Airport OE Solutions	N/A	Not assessed in RTS5/RTS6.	Not assessed in RTS5/RTS6.
RES2 Loss of Airspace Capacity Avoided	% and Movements per hour	Loss of Airspace Capacity with the concept divided by the loss of Airspace Capacity without the concept	YES	N/A	N/A	N/A

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PIs	Unit	Calculation	Mandatory	Benefit in SESAR1 (if applicable)	Absolute expected performance benefit in SESAR2020	% expected performance benefit in SESAR2020
RES2.1 Airspace time to recover from non-nominal to nominal condition	Minutes	Duration of Airspace lost capacity compared to non-nominal to nominal condition.	YES for Airspace OE Solutions	N/A	N/A	N/A
RES4 Minutes of delays	Minutes	Impact on AUs measured through delays resulting from capacity degradation RES1 and RES2 KPIs drive this PI, though the PI may need to be measured on a condition-by-condition basis (e.g. fog, wind, system outage).	YES	N/A	Not assessed in RTS5/RTS6.	Not assessed in RTS5/RTS6.
RES5 Number of cancellations	Nb flights	Impact on AUs measured through Cancellations resulting from capacity degradation. RES1 and RES2 KPIs drive this PI, though the PI may need to be measured on a condition-by-condition basis (e.g. fog, wind, system outage).	YES	N/A	Not assessed in RTS5/RTS6.	Not assessed in RTS5/RTS6.

4.5.6.3 Extrapolation to ECAC wide

There is no ECAC wide extrapolation required for this KPI.

4.5.6.4 Discussion of Assessment Result

% loss in capacity avoided has been assumed to directly relate to the increase in departure throughput from each of the OI steps. It would be up to individual airports to decide whether to use the increase in throughput to increase airport capacity (schedule extra movements) or improve resilience (not schedule extra movements).

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4.5.6.5 Additional Comments and Notes

No additional comments.

4.6 Predictability

4.6.1 Performance Mechanism

AO-0329 (OSD) leads to optimised delivery of departure aircraft separations, and AO-0323 (PWS-D) and AO-0304 (WDS-D) leads to reduced wake departure aircraft separations, hence reducing the average ground delay per flight. This will result in less variability between the planned and actual departure time, and departures flying closer to their planned time which will improve on-time operations, and so improves predictability.

4.6.2 Assessment Data (Exercises and Expectations)

The following results are taken from the RTS5 validation exercise (with a Heathrow traffic mix).

- AO-0329 (OSD) results showed an average 11.1% reduction in taxi-out time variability compared to RECAT-EU without OSD tools support;
- AO-0323 (PWS-D) results showed an average 11.1% reduction in taxi-out time variability compared to RECAT-EU without OSD tool support.
- AO-0304 (WDS-D) in the context of PWS-D (AO-0323) results showed an average 8.1% reduction in taxi-out time variability compared to RECAT-EU without OSD tools support.

The following results are taken from the RTS6 validation exercise (with a Barcelona traffic mix):

- AO-0323 (PWS-D) results showed on average:
  - 39.7% reduction in taxi-out time variability, when compared to a reference scenario of ICAO departure wake separations;
  - 5.3% reduction in taxi-out time variability, when compared to a reference scenario of RECAT-EU departure wake separations.

4.6.3 Extrapolation to ECAC wide

The following PJ.19 common assumptions have been used:

- High density airports traffic contribution to total airport traffic = 59.5%
- Departures traffic contribution to total traffic = 50%
- B2B variance = 49.0 mins^2
- Taxi-out contribution to variability = 40%

The following methodology describes how the PRD1metric was obtained for AO-0329 (OSD):

1.) Current Taxi-Out time Variance = 49.0 min^2 (B2B variance) * 40% (taxi-out contribution to variability) = 19.60 mins^2

2.) Current Taxi-Out time Standard Deviation = sqrt (19.6 mins^2 (current taxi out time variance)) = 4.43 minutes

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3.) Improved Absolute Standard Deviation = 4.43 minutes (current taxi-out time variability) * (100-11.1% reduction in taxi-out variability) = 3.94 minutes

4.) Improved Absolute Variance = 4.43 minutes (current taxi out time variability) ^2 = 15.49 mins^2

5.) Absolute Difference in Variance = 15.49 mins^2 (improved absolute variance) – 19.6 mins^2 (current taxi-out time variance) = -4.11mins^2

6.) Absolute Predictability difference (PRD1) at ECAC level = -4.11 mins^2 (absolute difference in variance) * 50% (departures traffic contribution) * 59.5% (high density airports traffic contribution) = -1.22 mins^2

7.) Relative Predictability difference at ECAC level = -1.22 mins^2 (absolute predictability benefit at ECAC level) / 49.0 mins^2 (B2B variance) * 100 = -2.50%

The following methodology describes how the PRD1metric was obtained for AO-0323 (PWS-D), when compared to a reference scenario of ICAO departure wake separations:

1.) Current Taxi-Out time Variance = 49.0 min^2 (B2B variance) * 40% (taxi-out contribution to variability) = 19.60 mins^2

2.) Current Taxi-Out time Standard Deviation = sqrt (19.6 mins^2 (current taxi out time variance)) = 4.43 minutes

3.) Improved Absolute Standard Deviation = 4.43 minutes (current taxi-out time variability) * (100-39.7% reduction in taxi-out variability) = 2.67 minutes

4.) Improved Absolute Variance = minutes (current taxi out time variability) ^2 = 7.13 mins^2

5.) Absolute Difference in Variance = 7.13mins^2 (improved absolute variance) – 19.6 mins^2(current taxi-out time variance) = -12.47mins^2

6.) Absolute Predictability difference (PRD1) at ECAC level = -12.47 mins^2 (absolute difference in variance) * 50% (departures traffic contribution) * 59.5% (high density airports traffic contribution) = -3.71 mins^2

7.) Relative Predictability difference at ECAC level = -1.22 mins^2 (absolute predictability benefit at ECAC level) / 49.0 mins^2 (B2B variance) * 100 = -7.57%

The following methodology describes how the PRD1metric was obtained for AO-0323 (PWS-D), when compared to a reference scenario of RECAT-EU departure wake separations:

Aggregation

1.) Reduction in taxi-out time variability (PRD1) at ECAC level = 11.1 (RTS5) + 5.3 (RTS6)/2 = 8.2%

Extrapolation of Aggregated results

1.) Current Taxi-Out time Variance = 49.0 min^2 (B2B variance) * 40% (taxi-out contribution to variability) = 19.60 mins^2

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2.) Current Taxi-Out time Standard Deviation = sqrt (19.6 mins^2 (current taxi out time variance)) = 4.43 minutes

3.) Improved Absolute Standard Deviation = 4.43 minutes (current taxi-out time variability) * (100-8.2% reduction in taxi-out variability) = 4.06 minutes

4.) Improved Absolute Variance = 4.06 minutes (current taxi out time variability) ^2 = 16.52 mins^2

5.) Absolute Difference in Variance = 16.52 mins^2 (improved absolute variance) – 19.6 mins^2 (current taxi-out time variance) = -3.08mins^2

6.) Absolute Predictability difference (PRD1) at ECAC level = -3.08mins^2 (absolute difference in variance) * 50% (departures traffic contribution) * 59.5% (high density airports traffic contribution) = -0.92 mins^2

7.) Relative Predictability difference at ECAC level = -0.92 mins^2 (absolute predictability benefit at ECAC level) / 49.0 mins^2 (B2B variance) * 100 = -1.87%

The following methodology describes how the PRD1metric was obtained for AO-0304 (WDS-D):

1.) Current Taxi-Out time Variance = 49.0 min^2 (B2B variance) * 40% (taxi-out contribution to variability) = 19.60 mins^2

2.) Current Taxi-Out time Standard Deviation = sqrt (19.6 mins^2 (current taxi out time variance)) = 4.43 minutes

3.) Improved Absolute Standard Deviation = 4.43 minutes (current taxi-out time variability) * (100-8.1% reduction in taxi-out variability) = 4.07 minutes

4.) Improved Absolute Variance = 4.07 minutes (current taxi out time variability) ^2 = 16.55 mins^2

5.) Absolute Difference in Variance = 16.55 mins^2 (improved absolute variance) – 19.6 mins^2(current taxi-out time variance) = -3.05mins^2

6.) Absolute Predictability difference (PRD1) at ECAC level = -3.05 mins^2 (absolute difference in variance) * 50% (departures traffic contribution) * 59.5% (high density airports traffic contribution) = -0.91 mins^2

7.) Relative Predictability difference at ECAC level = -0.91 mins^2 (absolute predictability benefit at ECAC level) / 49.0 mins^2 (B2B variance) * 100 = -1.85%

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KPIs / PIs	Unit	Calculation	Mandatory	Absolute expected performance benefit in SESAR2020	% expected performance benefit in SESAR2020
PRD1 Variance of Difference in actual & Flight Plan or RBT durations	Minutes²	Variance of Difference in actual & Flight Plan or RBT durations	YES	AO-0329 (OSD) = **1.22mins^2 reduction** in flight duration variability, compared to RECAT-EU TBS without OSD tool support, with a Heathrow traffic mix. AO-0323 (PWS-D): - **3.71mins^2 reduction** in flight duration variability, compared to ICAO without OSD tool support, with a Barcelona traffic mix; - **0.92mins^2 reduction** in flight duration variability, compared to RECAT-EU without OSD tool support, with Heathrow and Barcelona traffic mixes. AO-0304 (WDS-D) in the context of PWS-D (AO-0323) = **0.91 mins^2 reduction** in flight duration variability, compared to RECAT-EU without OSD tool support, with a Heathrow traffic mix.	AO-0329 (OSD) = **2.5% reduction** in flight duration variability, compared to RECAT-EU TBS without OSD tool support, with a Heathrow traffic mix. AO-0323 (PWS-D): - **7.57% reduction** in flight duration variability, compared to ICAO without OSD tool support, with a Barcelona traffic mix; - **1.87% reduction** in flight duration variability, compared to RECAT-EU without OSD tool support, with Heathrow and Barcelona traffic mixes. AO-0304 (WDS-D) in the context of PWS-D (AO-0323) = **1.85% reduction** in flight duration variability, compared to RECAT-EU without OSD tool support, with a Heathrow traffic mix.

Table 16: Predictability benefits for Mandatory KPIs /PIs

Table 17 is showing the impact on flight phases (provided when it is possible).

	Taxi out	TMA departure	En-route	TMA arrival	Taxi in
PRD1 Variance of Difference in actual &	AO-0329 (OSD) = 1.22mins^2 reduction in flight duration variability, compared to RECAT-EU TBS without OSD tool support, with a Heathrow traffic mix.	N/A	N/A	N/A	N/A

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Flight Plan or RBT durations	AO-0323 (PWS-D): - 3.71mins^2 reduction in flight duration variability, compared to ICAO without OSD tool support, with a Barcelona traffic mix; - 1.76 mins^2 reduction in flight duration variability, compared to RECAT-EU without OSD tool support, with a Heathrow traffic mix. AO-0304 (WDS-D) in the context of PWS-D (AO-0323) = 0.91 mins^2 reduction in flight duration variability, compared to RECAT-EU without OSD tool support, with a Heathrow traffic mix.				

Table 17: Predictability benefit per flight phase

4.6.4 Discussion of Assessment Result

The results show an improvement in predictability due to reduce ground delays as a result of improved departure throughput. There is low confidence in the results.

4.6.5 Additional Comments and Notes

No additional comments.

4.7 Human Performance

4.7.1 HP arguments, activities and metrics

PIs	Activities & Metrics	Second level indicators	Covered
HP1 Consistency of human role with respect to human capabilities and limitations	**Partner workshop** **Pre-RTS5 end-user workshop** **RTS5** **Post-RTS5 partner/end-user workshop** **Structured interviews, observations, WL, SA, UA scales, tailored HP scales**	**HP1.1** Clarity and completeness of role and responsibilities of human actors Tower controllers indicated that procedures and practices within their roles are clear to them. Qualitative and quantitative data taken during the listed activities have been processed and results fall within the desired areas. As controller responsibilities for the separation of departing A/C remain the same only with the addition of an automated element, a WL-benefit in a form of a more efficient time-management has been observed. For details, see Part IV of the OSED (HP Assessment Report, the corresponding HP Log, tab *Issue-Objective-Outcome* and *Recommendations Register, Requirements Register* tabs)	Yes
		HP1.2 Adequacy of operating methods (procedures) in supporting human performance The role of a Tower Supervisor, esp. in AO-0304 (WDS-D) hasn't been assessed thoroughly and remains a requirement for the next stages of the project to analyse	**Yes/Open**

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PIs	Activities & Metrics	Second level indicators	Covered
		For details, see Part IV of the OSED (HP Assessment Report, the corresponding HP Log, tab *Issue-Objective-Outcome* and *Recommendations Register, Requirements Register* tabs)	
		HP1.3 Capability of human actors to achieve their tasks in a timely manner, with limited error rate and acceptable workload level Workload data collected during the assessment activities for all OI show acceptable values. HE rates have been reported as slightly higher WRT controller omitting to take SID information into consideration of the separation between departing A/C, where SID separation is not a part of the tool-provided figure. Appropriate mitigations have been produced in a form of Recommendations and Requirements. For details, see Part IV of the OSED (HP Assessment Report, the corresponding HP Log, tab *Issue-Objective-Outcome* and *Recommendations Register, Requirements Register* tabs)	Yes
HP2 Suitability of technical system in supporting the tasks of human actors	**Partner workshop** **Pre-RTS5 end-user workshop** **RTS5** **Post-RTS5 partner/end-user workshop** **Structured interviews, observations, tailored HMI questionnaires**	**HP2.1** Adequacy of allocation of tasks between the human and the machine (i.e. level of automation). With the exception described in HP1.2, the use of the technical equipment has been successfully assessed for its suitability in supporting the tasks of human actors. Feedback on the HMI prototypes has been collected as well as HMI-related mitigations in a form of Recommendations and Requirements to residual HP Hazards have been produced. For details, see Part IV of the OSED (HP Assessment Report, the corresponding HP Log, tab *Issue-Objective-Outcome* and *Recommendations Register, Requirements Register* tabs)	Yes/Open
		HP2.2 Adequacy of technical systems in supporting Human Performance with respect to timeliness of system responses and accuracy of information provided. HP data collected during the Validation exercise, where the technical system was used in a high-fidelity testing environment, provided acceptable feedback wrt the system timely and accurate performance. Further details were explored during workshop activities and mitigations against residual HP risks have been produced. For details, see Part IV of the OSED (HP Assessment Report, the corresponding HP Log, tab *Issue-Objective-Outcome* and *Recommendations Register, Requirements Register* tabs)	
		HP2.3 Adequacy of the human machine interface in supporting the human in carrying out their tasks. HMI-specific questionnaires were used during the RTS5 exercise and satisfactory feedback gained. Residual HP risks have been addressed - for details; see Part IV of the OSED (HP Assessment Report, the corresponding HP Log, tab *Issue-Objective-Outcome* and *Recommendations Register, Requirements Register* tabs).	
	Partner workshop	**HP3.1** Adequacy of team composition in terms of identified roles	Yes

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PIs	Activities & Metrics	Second level indicators	Covered
HP3 Adequacy of team structure and team communication in supporting the human actors	**Pre-RTS5 end-user workshop** **RTS5** **Post-RTS5 partner/end-user workshop** **Structured interviews, observations, WL, SA, Teamwork and Communication questionnaires**	No changes in team composition	
		HP3.2 Adequacy of task allocation among human actors Please HP1.2 of this table refer to	**Yes/Open**
		HP3.3 Adequacy of team communication with regard to information type, technical enablers and impact on situation awareness/workload Impact on communication requiring mitigations hasn't been identified, with the exception of AO-0304 (WDS-D), where further input from airline representatives has been recorded as a Requirement. Qualitative and quantitative data on teamwork and the ability to communicate effectively are acceptable and show no significant difference from the Reference scenario. For details, see Part IV of the OSED (HP Assessment Report, the corresponding HP Log, tab *Issue-Objective-Outcome* and *Recommendations Register, Requirements Register* tabs)	**Yes**
HP4 Feasibility with regard to HP-related transition factors	**Partner workshop** **Pre-RTS5 end-user workshop** **RTS5** **Post-RTS5 partner/end-user workshop** **Structured interviews, observations, UA scale**	**HP4.1** User acceptability of the proposed solution User acceptability data that were collected during the RTS5 exercise show values within the desired range. For details, see Part IV of the OSED (HP Assessment Report, the corresponding HP Log, tab *Issue-Objective-Outcome* and *Recommendations Register, Requirements Register* tabs)	Yes
		HP4.2 Feasibility in relation to changes in competence requirements. No impact has been identified wrt ATC licencing, however training on the use of the tool within the relevant procedures will be required. For details, see Part IV of the OSED (HP Assessment Report, the corresponding HP Log, tab *Issue-Objective-Outcome* and *Recommendations Register, Requirements Register* tabs)	Yes
		HP4.3 Feasibility in relation to changes in staffing levels, shift organization and workforce relocation. No changes identified for AO-0329 (OSD) AO-0323 (PWS-D) AO-0304 (WDS-D)	Yes
		HP4.4 Feasibility in relation to changes in recruitment and selection requirements. No changes identified for AO-0329 (OSD) AO-0323 (PWS-D) AO-0304 (WDS-D)	Yes
		HP4.5	

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PIs	Activities & Metrics	Second level indicators	Covered
		Feasibility in terms of changes in training needs with regard to its contents, duration and modality. The content of training has been analysed and output has been recorded in a form of Recommendations and Requirements. Duration and modality will be defined in the future stages of the project. For details, see Part IV of the OSED (HP Assessment Report, the corresponding HP Log, tab *Issue-Objective-Outcome* and *Recommendations Register, Requirements Register* tabs)	

Table 18: HP arguments, activities and metrics

4.7.2 Extrapolation to ECAC wide

There is no ECAC wide extrapolation required for this KPI.

4.7.3 Open HP issues/ recommendations and requirements

PIs	Number of open issues/ benefits	Number of recommendations	Number of requirements
HP1 Consistency of human role with respect to human capabilities and limitations	**NATS** 77 for AO-0304 (WDS-D) 27 for AO-0329 (OSD) 35 for AO-0323 (PWS-D)	**ECTL+NATS 12**	**ECTL+NATS 126**
HP2 Suitability of technical system in supporting the tasks of human actors	**NATS** 77 for AO-0304 (WDS-D) 27 for AO-0329 (OSD) 35 for AO-0323 (PWS-D)	**ECTL+NATS 36**	**ECTL+NATS 116**
HP3 Adequacy of team structure and team communication in supporting the human actors	**NATS** 77 for AO-0304 (WDS-D) 27 for AO-0329 (OSD) 35 for AO-0323 (PWS-D)	**0**	**ECTL+NATS 1 (Please note, this req overlaps with HP1)**
HP4 Feasibility with regard to HP-related transition factors	**NATS** 77 for AO-0304 (WDS-D) 27 for AO-0329 (OSD) 35 for AO-0323 (PWS-D)	**ECTL+NATS 13**	**ECTL+NATS 33**

Table 19: Open HP issues/ recommendations and requirements

4.7.4 Concept interaction

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4.7.5 Most important HP issues

PIs	Most important issue of the solution	Most important issues due to solution interdependencies
HP1 Consistency of human role with respect to human capabilities and limitations	Clarity and consistency of responsibilities between ATCOs (e.g. APP & TWR), pilots and supervisors, including between mode transition (ECTL+NATS).	
	Change to procedures and tasks as a result of different modes (ECTL).	
	Potential for human error and reduced trust in system as a result of inability/issues carrying out tasks and incorporating information in a time-efficient manner. Also leading to concerns regarding situation awareness and workload (ECTL).	
	Accuracy of the system information, trust in system and reliable transition from automatic to manual modes and vice versa (ECTL). Over-reliance on tool by ATC and omission of other non-wake related spacing (NATS)	
	Workload of the user (ECTL).	
HP2 Suitability of technical system in supporting the tasks of human actors	Information requirements, timeliness of information, alarms and alerts and HMI/workstation usability. Tool integration and compliance with CWP/platform (ECTL).	
	Communication load where tool leads to increase in R/T between pilots and ATCOs (ECTL).	
	Current phraseology between ATCOs and pilots does not support some modes (e.g. WDS) (ECTL).	
	WDS-D requires a small change in x-wind value transmission from ATC to air-crews (NATS)	
	Issues related to job satisfaction as a result of tool deployment (ECTL).	
	Knowledge and skills, competence and training required to utilise tool effectively (ECTL).	
	Potential licensing concerns (ECTL).	
	Training on the use of the tool required, simulation time, while current skills retained	
HP3 Adequacy of team structure and team communication in supporting the human actors	N/A	N/A
HP4 Feasibility with regard to HP-related transition factors	4.1.1-1: Supervisors and Systems Engineers are not accepting of the new responsibilities introduced to their roles to support the D-PWS-A ML model.	N/A
	4.1.2-1: The new responsibilities introduced to support D-PWS-A negatively impact the job satisfaction of Supervisors and Systems Engineers.	N/A
	4.5.1-1: The training curricula does not take into account potential operating methods changes or HMI updates.	N/A
	4.5.1-2: Actors are not properly trained on D-PWS-A operations and are not able to provide separation under normal, abnormal and degraded modes of operations.	N/A

Table 20: Most important HP issues

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4.7.6 Additional Comments and Notes

No additional comments.

4.8 Gap Analysis

KPI	Validation Targets – Network Level (ECAC Wide)	Performance Benefits at Network Level (ECAC Wide or Local depending on the KPI)	Rationale[9]
FEFF1: Fuel Efficiency – Fuel burn per flight	26.7 kg	AO-0329 (OSD) = **1.79 kg,** compared to RECAT-EU TBS without OSD tool support, with a Heathrow traffic mix. AO-0323 (PWS-D): - **10.53kg** compared to RECAT-EU without OSD tool support, with a Barcelona traffic mix; - **2.28kg** compared to RECAT-EU without OSD tool support, with a Heathrow traffic mix. AO-0304 (WDS-D) in the context of PWS-D (AO-0323) = **2.23 kg**, compared to RECAT-EU without OSD tool support, with a Heathrow traffic mix.	The fuel efficiency results show a reduction in taxi-out time in each of the OI steps due to increased departure throughputs and hence reduced delays. There is low confidence in these results.
CAP3: Airport Capacity – Peak Runway Throughput (Mixed mode).	2.6%	OSD (AO-0329) – **1.0% increase**, compared to RECAT-EU TBS without OSD tool support, with a Heathrow traffic mix. PWS-D (AO-0323): - **8.65% increase** compared to ICAO without OSD tools support, with a Barcelona traffic mix; - **2.41% increase**, compared to RECAT-EU without OSD tool	Varying performance between runs for some controllers led to unexpected departure throughput results. It was expected that AO-0329 (OSD) would bring negligible benefit due to keeping the wake separation scheme the same. AO-0304 (WDS-D) was expected to have a benefit in-line with AO-0323 (PWS-D) but it shows a smaller benefit. However, because of low departure throughput in the reference scenario the OSD and PWS-D throughputs are higher. Also, controllers noted during WDS-D runs that they were sequencing departures to try to achieve a reduced WDS-D separation, which may have not been the most optimal

[9] Discuss the outcome if, and only if, the gap indicates a different understanding of the contribution of the Solution (for example, the Solution is enabling other Solutions and therefore is not contributing a direct benefit).

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		- support, with a Heathrow traffic mix. WDS-D (AO-0304) in the context of PWS-D (AO-0323) – **0.1% increase**, compared to RECAT-EU without OSD tool support, with a Heathrow traffic mix.	departure sequence. Hence, the WDS-D benefits showed a lower benefit than PWS-D. Therefore, it is recommended that validation exercises are conducted in the local environment to determine the benefits.
PRD1: Predictability – Variance of Difference in actual & Flight Plan or RBT durations	0.27%[10]	AO-0329 (OSD) = **1.22mins reduction** (2.5%), compared to RECAT-EU TBS without OSD tool support, with a Heathrow traffic mix. AO-0323 (PWS-D): - **3.71mins reduction** (7.57%) compared to ICAO without OSD tool support, with a Barcelona traffic mix; - **0.92 mins reduction** (1.87%), compared to RECAT-EU without OSD tool support, with a Heathrow traffic mix. AO-0304 (WDS-D) in the context of PWS-D (AO-0323) = **0.91 mins reduction** (1.85%), compared to RECAT-EU without OSD tool support, with a Heathrow traffic mix.	The results show an improvement in predictability due to reduce ground delays as a result of improved departure throughput. There is low confidence in the results.
CEF2: ATCO Productivity – Flights per ATCO -Hour on duty	Yes, TWR TMA Controller productivity Medium (Impact level 2) 0.35-0.98%	0.00-0.85% benefit Arrival (50%) flights into very large (30%) and large (8%) airports = 19% of all ECAC flights impacted	N/A

Table 21: Gap analysis Summary

[10] In Validation Targets [18] the unit for PRD1 is % Reduction in variance of block-to-block flight time.

5 References

This PAR complies with the requirements set out in the following documents:

[1] 08.01.03 D47: AIRM v4.1.0

[2] B05 Performance Assessment Methodology for Step 1 PJ19.04.01 Methodology for Performance Assessment Results Consolidation (2020)

[3] SESAR Performance Framework (2019), Edition 01.00.01, Dec 2019

https://stellar.sesarju.eu/?link=true&domainName=saas&redirectUrl=%2Fjsp%2Fproject%2Fproject.jsp%3FobjId%3Dxrn%3Adatabase%3Aondb%2Frecord%2F16414675

[4] Performance Assessment and Gap Analysis Report (2019), Edition 00.01.02, Dec 2019

[5] Methodology for the Performance Planning and Master Plan Maintenance, Edition 0.13, Dec 2017

Content Integration

[6] SESAR ATM Lexicon

Performance Management

[7] PJ19.04 D4.1 Validation Targets - Wave 2 (2020)

Validation

[8] European Operational Concept Validation Methodology (E-OCVM) - 3.0 [February 2010]

Safety

[9] SESAR, Safety Reference Material, Edition 4.0, April 2016

https://stellar.sesarju.eu/jsp/project/qproject.jsp?objId=1795089.13&resetHistory=true&statInfo=Ogp&domainName=saas

[10]SESAR, Guidance to Apply the Safety Reference Material, Edition 3.0, April 2016

https://stellar.sesarju.eu/jsp/project/qproject.jsp?objId=1795102.13&resetHistory=true&statInfo=Ogp&domainName=saas

[11]SESAR, Final Guidance Material to Execute Proof of Concept, Ed00.04.00, August 2015

[12]Accident Incident Models – AIM, release 2017

https://stellar.sesarju.eu/servlet/dl/ShowDocumentContent?doc_id=3658775.13&att=attachment&statEvent=Download

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[13]16.06.05 D 27 HP Reference Material D27

[14]16.04.02 D04 e-HP Repository - Release note

Environment Assessment

[15]SESAR, Environment Assessment Process (2019), PJ19.4.2, Deliverable D4.0.080, Sep 2019.

https://stellar.sesarju.eu/servlet/dl/DownloadServlet?downloadKey=xrn%3Adatabase%3Aondb%2Frecord%2F14665451&resuming=true&zip=true&disposition=attachment&domainName=saas&domainName=saas

[16]ICAO CAEP – "Guidance on Environmental Assessment of Proposed Air Traffic Management Operational Changes" document, Doc 10031.

https://www.icao.int/publications/pages/publication.aspx?docnum=10031

Security

[17]16.06.02 D103 SESAR Security Ref Material Level

[18]16.06.02 D137 Minimum Set of Security Controls (MSSCs).

[19]16.06.02 D131 Security Database Application (CTRL_S)

Other Reference Documents

The following documents were used to provide input / guidance / further information / other:

[20]ED-78A GUIDELINES FOR APPROVAL OF THE PROVISION AND USE OF AIR TRAFFIC SERVICES SUPPORTED BY DATA COMMUNICATIONS.[11]

[21]D4.16.002 – PJ.02-01-06 OSED-SPR-INTEROP (Final) Part I – 00.01.00

[22]D4.16.002 – PJ.02-01-06 OSED-SPR-INTEROP (Final) Part II – 00.03.00

[23]D4.16.002 – PJ.02-01-06 OSED-SPR-INTEROP (Final) Part IV – 00.01.00

[24]D4.16.008 – PJ.02-01-06 TS/IRS (Final) – 00.01.00

[25]D4.16.004 – PJ.02-01-06 VALR (Final) – 00.02.00

[26]CREDOS Final Concept of Operations Description D4-11, Version 1.0, 10/11/2009

[27]PJ.02-01-06 London Heathrow Capacity Benefits Analysis, Version 1.0, November 2019, Huw Murray

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Appendix A Detailed Description and Issues of the OI Steps (PJ.02-01-06)

OI Step ID	Title	Consistency with latest Dataset
AO-0329	Optimised Separation Delivery for Departure	Full (DS20)
AO-0323	Wake Turbulence Separations (for Departures) based on static Aircraft Characteristics	Full (DS20)
AO-0304	Weather-Dependant Reductions of Wake Turbulence Separations for Departures	Full (DS20)

Table 22: OI Steps allocated to the Solution

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