SESAR Solution PJ02-03 SPR/INTEROP-OSED - Part V - Performance Assessment Report (PAR)

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PJ02 EARTH

INCREASED RUNWAY AND AIRPORT THROUGHPUT

This SPR-INTEROP/OSED Part V document is part of a project that has received funding from the SESAR Joint Undertaking under grant agreement No 731781 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 02-03 (Minimum Pair Separations Based on Required Surveillance Performance (RSP)) which consists of the extrapolation to ECAC wide level of the performance assessment results conducted according to V3 level of maturity for the concept scope and process applied to obtain the results.

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1 Executive Summary

This document[1] provides the Performance Assessment Report (PAR) for SESAR 2020 Wave 1 SESAR Solution 02-03 Minimum Pair Separations Based on Required Surveillance Performance (RSP)

The PAR is consolidating Solution performance validation results addressing KPIs/PIs and metrics from the SESAR2020 Performance Framework [3].

Description:

The in-trail MRS constraint on final approach is currently typically 3 NM, or can be 2.5 NM under certain conditions as prescribed by international and / or local regulations. The benefits that can be gained from the wake turbulence separation optimisation concepts for arrivals, including Time Based Separation (TBS), Static Pair Wise Separation (S-PWS) and Time Based Static Pairwise Separation (TB S-PWS), are limited by the in-trail 2.5 NM MRS on final approach. This solution aims to address this issue by facilitating a reduction of the in-trail MRS on final approach to 2 NM.

The Air Traffic Controllers retain responsibility for spacing and delivery on final approach, application of the in-trail 2 NM MRS on final approach will be dependent on the surveillance service being employed and of course satisfying the RSP requirements for 2 NM separation. The spacing required between arrival pairs will also be constrained by other factors such as satisfying the Runway Occupancy Time (ROT) requirements for clearance to land, which is being addressed by the Optimised Runway Delivery (ORD) ATC tool support being developed and validated in SESAR Solution PJ02-01.

The RSP requirements for 2 NM separation on final approach will need to be established in such a way that the requirements can be applied to the changing technological and operational environments of the future. As such, all requirements are to be general performance requirements that are disengaged from a specific technological implementation. The proposed approach to establishing these RSP requirements for 2 NM separation is the expert judgement and modelling extrapolation of the RSP requirements that have been set in Europe for the 5 NM and 3 NM horizontal separations.

Overall cost efficiency will be ensured by considering revision of the MRS on the basis of the performance of currently deployed surveillance technology options for final approach at very large, large and medium airports.

The proposed application of the in-trail 2 NM MRS on final approach is to be demonstrated as safe in design and in application by the controllers responsible for setting up and delivering the arrival aircraft spacing on final approach

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

Assessment Results Summary:

The following tables summarises the assessment outcomes per KPI (Table 1) and mandatory PI (Table 2)

KPI	Validation Targets – Network Level (ECAC Wide)	Performance Benefits Expectations at Network Level (ECAC Wide or Local depending on the KPI)[2]	Confidence in Results[3]
FEFF1: Fuel Efficiency – Fuel burn per flight	*6.07 kg*	*[0, 43.9] reduction kg of fuel per flight*	*Medium*
CAP3.2: Airport Capacity – Peak Runway Throughput (Segregated mode).	*1.299%*	*[0%, 13.7%] increase in movements/hour*	*Medium*
CEF2: ATCO Productivity – Flights per ATCO -Hour on duty	*0.667%*[4]	*[0, 5.7] increase in movements/hour*	*Medium*
SAF1: Safety - Total number of fatal accidents and incidents with ATM Contribution per year	*-0.63%*[5]	*NA*	*NA*

Table 1: KPI Assessment Results Summary

[2] Negative impacts are indicated in red.

[3] High – the results might change by +/-10%
Medium – the results might change by +/-25%
Low – the results might change by +/-50% or greater
N/A – not applicable, i.e., the KPI cannot be influenced by the Solution

[4] In Validation Targets [18] the unit for CEF2 is % increase in ATCO productivity.

[5] In Validation Targets [18] the unit for SAF1 is % reduction in the total number of fatal accidents per year.

Mandatory PI	Performance Benefits Expectations at Network Level (ECAC Wide or Local depending on the KPI)[6]	Confidence in Results[7]
FEFF2: CO2 Emissions.	*[0, 43.2] reduction kg CO2 per flight*	*Medium*
FEFF3: Reduction in average flight duration.	*[0, 0.74] reduction minutes per flight*	*Medium*
CAP4: Un-accommodated traffic reduction	*[0, 2080.5] increase in flights/year*	*Low*
HP1: Consistency of human role with respect to human capabilities and limitations	***HP1.1*** *Clarity and completeness of role and responsibilities of human actors* ***N/A*** ***HP1.2*** *Adequacy of operating methods (procedures) in supporting human performance covered* ***HP1.3*** *Capability of human actors to achieve their tasks in a timely manner, with limited error rate and acceptable workload level* ***covered***	*NA*
HP2: Suitability of technical system in supporting the tasks of human actors	***HP2.1*** *Adequacy of allocation of tasks between the human and the machine (i.e. level of automation).* ***covered*** ***HP2.2*** *Adequacy of technical systems in supporting Human Performance with respect to timeliness of system responses and accuracy of information provided* ***covered*** ***HP2.3***	*NA*

[6] Negative impacts are indicated in red.

[7] High – the results might change by +/-10%
Medium – the results might change by +/-25%
Low – the results might change by +/-50% or greater
N/A – not applicable, i.e., the KPI cannot be influenced by the Solution

	Adequacy of the human machine interface in supporting the human in carrying out their tasks. ***Covered***	
HP3: Adequacy of team structure and team communication in supporting the human actors	***HP3.1*** *Adequacy of team composition in terms of identified roles* ***N/A*** ***HP3.2*** *Adequacy of task allocation among human actors* ***covered*** ***HP3.3*** *Adequacy of team communication with regard to information type, technical enablers and impact on situation awareness/workload* ***covered***	*NA*
HP4: Feasibility with regard to HP-related transition factors	***HP4.1*** *User acceptability of the proposed solution* ***covered*** ***HP4.2*** *Feasibility in relation to changes in competence requirements* ***covered*** ***HP4.3*** *Feasibility in relation to changes in staffing levels, shift organization and workforce relocation.* ***covered*** ***HP4.4*** *Feasibility in relation to changes in recruitment and selection requirements .* ***N/A*** ***HP4.5*** *Feasibility in terms of changes in training needs with regard to its contents, duration and modality.* ***N/A***	*NA*

Table 2 Mandatory PIs Assessment Summary

Additional Comments and Notes:

The detailed explanation of the results is provided in the next paragraphs, in the Validation report and the CBA of the solution.

This solution provides benefits mainly in challenging wind conditions on final approach. For non-challenging low wind conditions on final approach the benefits impact is towards zero.

2 Introduction

2.1 Purpose of the document

The Performance Assessment covers the Key Performance Areas (KPAs) defined in the SESAR2020 Performance Framework [3]. Assessed are at least the Key Performance Indicators (KPIs) and the mandatory Performance Indicators (PIs), but also additional PIs as needed to capture the performance impacts of the Solution. It considers the guidance document on KPIs/PIs [3] for practical considerations, for example on metrics.

The purpose of this document [8]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.

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 PJ19, which will aggregate all the performance assessment results from the SESAR2020 solution projects PJ1-18, and provide the data to PJ20 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.

2.3 Inputs from other projects

The document includes information from the following SESAR 1 projects:

- B.05 D72 [5]: SESAR 1 Final Performance Assessment, where are described the principles used in SESAR1 for producing the performance assessment report.

PJ19 will manage and provide:

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- PJ19.04.01 D4.1 [3]: Performance Framework (2018), guidance on KPIs and Data collection supports.
- PJ19.04.03 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 PJ19 have put in place the Community of Practice (CoP)[9] 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
ANS	Air Navigation Service
ANSP	Air Navigation Service Provider
ATFM	Air Traffic Flow Management
ATM	Air Traffic Management
BAD	Benefits Assessment Date
BAER	Benefit Assessment Equipment Rate
CBA	Cost Benefit Analysis
DOD	Detailed Operational Description
E-ATMS	European Air Traffic Management System
ECAC	European Civil Aviation Conference
DB	Deployment Baseline

9 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

KPA	Key Performance Area
KPI	Key Performance Indicator
N/A	Not Applicable
OI	Operational Improvement
PAR	Performance Assessment Report
PI	Performance Indicator
PRU	Performance Review Unit
QoS	Quality of Service
RBT	Reference Business / Mission Trajectory
SESAR	Single European Sky ATM Research Programme
SJU	SESAR Joint Undertaking (Agency of the European Commission)
SESAR2020 Programme	The programme which defines the Research and Development activities and Projects for the SJU.

Table 3: Acronyms and terminology

3 Solution Scope

3.1 Detailed Description of the Solution

The in-trail MRS constraint on final approach is currently typically 3 NM, or can be 2.5 NM under certain conditions as prescribed by international and / or local regulations. The benefits that can be gained from the wake turbulence separation optimisation concepts for arrivals, including Time Based Separation (TBS), Static Pair Wise Separation (S-PWS) and Time Based Static Pairwise Separation (TB S-PWS), are limited by the in-trail 2.5 NM MRS on final approach. This solution aims to address this issue by facilitating a reduction of the in-trail MRS on final approach to 2 NM.

The Air Traffic Controllers retain responsibility for spacing and delivery on final approach, application of the in-trail 2 NM MRS on final approach will be dependent on the surveillance service being employed and of course satisfying the RSP requirements for 2 NM separation. The spacing required between arrival pairs will also be constrained by other factors such as satisfying the Runway Occupancy Time (ROT) requirements for clearance to land, which is being addressed by the Optimised Runway Delivery (ORD) ATC tool support being developed and validated in SESAR Solution PJ02-01.

The RSP requirements for 2 NM separation on final approach will need to be established in such a way that the requirements can be applied to the changing technological and operational environments of the future. As such, all requirements are to be general performance requirements that are disengaged from a specific technological implementation. The proposed approach to establishing these RSP requirements for 2 NM separation is the expert judgement and modelling extrapolation of the RSP requirements that have been set in Europe for the 5 NM and 3 NM horizontal separations.

Overall cost efficiency will be ensured by considering revision of the MRS on the basis of the performance of currently deployed surveillance technology options for final approach at very large, large and medium airports.

The proposed application of the in-trail 2 NM MRS on final approach is to be demonstrated as safe in design and in application by the controllers responsible for setting up and delivering the arrival aircraft spacing on final approach.

The main development and validation needs include establishing the RSP requirements for 2 NM separation on final approach with particular focus on the safety assurance evidence, the characterisation of the actual performance of currently deployed surveillance technologies employed on final approach at very large, large and medium airports, the validation of the impact of the in-trail 2 NM MRS on the controller delivery of the arrival spacing on final approach with particular focus on the human performance and safety assurance evidence, and the development and validation of the business case with particular focus on the benefits evidence

More information on the solution concept can be found in the Part I of the OSED-SPR/Interop of PJ02-03.

3.2 Detailed Description of relationship with other Solutions

In the case of using ORD Tool, PJ02-03 is using a controller separation tool (ORD) based on the tool developed in PJ02-01, to help controller apply the separations in case of Pair Wise Separation (PWS). To maximise the benefits of the MRS Reduction, the work developed in PJ02-08 can be related to the work in this solution

Solution Number	Solution Title	Relationship	Rational for the relationship
PJ02-01	Wake turbulence separation optimization	PJ02-03 is using a tool from PJ02-01	The ORD tool developed in PJ02-01 is able to manage Pair Wise separation .
PJ02-08 Concept 3	Concept 3	PJ02-03 is using the same tool as PJ02-08	Reducing the MRS can be combined with a separation based on the Runway Occupancy Time and the minimum separation that can be applied is the max between both values.

Table 4: Relationships with other Solutions

4 Solution Performance Assessment

4.1 Assessment Sources and Summary of Validation Exercise Performance Results

Previous Validation Exercises (pre-SESAR2020, etc.) relevant for this assessment are listed below.

Organisation	Document Title	Publishing Date
SJU	OFA 01.03.01 Enhanced Throughput Consolidated Final Step 1 OSED	31.05.16

Table 5: Pre-SESAR2020 Exercises

SESAR Validation Exercises of this Solution (completed ones and planned ones) are listed below.

Exercise ID	Exercise Title	Release	Maturity	Status
FTS01	FTS01	2018	V3	Completed
RTS02	RTS02	2018	V3	Completed
FTS03	FTS03	2018	V3	Completed

Table 6: SESAR2020 Validation Exercises

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

Exercise	OI Step	Exercise scenario & scope	Performance Results	Notes
FTS01	AO-0309	to support the CBA for the reduction of the in-trail radar separation minima to 2.0 NM on the final approach. The FTS covered multiple generic environments with the aim to support the validation of the capacity and flight efficiency benefit for a large range of operational configurations	FEFF1: up to 43.9Kg fuel reduction per flight FEFF2: up to 43.2 reduction kg CO2 per flight CAP: 13.7 increase in movements per hour	FTS01 showed TBS together with a reduced MRS allows significant benefits in terms of reduction of go-arounds. The benefits are larger for traffic mix with higher fraction of medium aircraft types and in stronger headwind

				conditions. Those observations are made for ICAO, RECAT-EU and RECAT-EU-PWS separation schemes
RTS02	AO-0309	A real time simulation conducted by EUROCONTROL to assess the operational feasibility and acceptability of reducing the in-trail Minimum Radar Separation (MRS) from 2.5 NM to 2 NM under applicable separation scheme on the final approach under IMC. Safety and human performance aspects were also assessed to investigate whether the controllers are able to safely apply an in-trail separation minima of 2.0 NM under applicable separation scheme on the final approach to the separation delivery point without any negative impacts on human performance	HP SAFETY	The TB PWS-A 2.0NM MRS concept with the ORD tool was considered to be operationally feasible in Vienna environment with segregated mode runway operations. No increase of go-arounds was observed during the solution runs to compare to the reference runs. The evidence showed that aircraft were successfully delivered in TB PWS-A with 2.0NM MRS separation and the ORD tool. The accuracy of separation delivery was found to improve in the solution runs. Additionally there was no increase in separation non-

				conformances before alignment or on the base leg due to reduction of MRS to 2.0NM MRS. The runway throughput has increased when the TB PWS-A 2.0NM MRS with the ORD tool was applied. Although the runway throughput increased, the controller workload in approach position was found to decrease with TB PWS-A 2.0NM MRS and the ORD tool compared to the reference scenario ICAO DBS 2.5NM and PWS 2.5NM MRS with ORD tool. The level of situation awareness was found to be higher or the same with the solution scenario as in the reference scenario. The controller performance

				was found to increase in solution scenario with TB PWS 2.0NM MRS separation and the ORD tool. No increase of potential human error was observed during the exercises. Both approach and tower controller provided feedback in debriefing sessions, confirming the TB PWS-A 2.0 NM MRS concept is operationally feasible in Vienna environment with segregated mode runway operations. The evidence obtained in the RTS indicates significant gains in runway throughput. The controllers were seen to apply the safe standard practices when applying TB-PWS MRS 2NM

				with ORD tool in the simulation.
FTS03	AO-0309	to define the surveillance performance required to safely support the reduction to the in-trail 2 NM MRS on final approach	SAF	current surveillance modes fulfil the criteria for safe operations under certain conditions and ADS-B under all. Only a few certain pairs of aircraft might need to be limited in separation for weather dependent separations where the wake vortex separation is not taken into consideration.

Table 7: Summary of Validation Results.

4.2 Conditions / Assumptions for Applicability

The following Table 8 summarises the applicable operating environments.

OE	Applicable sub-OE	Special characteristics
Terminal	ALL	TMA
Airports	Very Large and Large	Runway Configuration

Table 8: Applicable Operating Environments.

The table below presents the list of targeted APTs as defined by WP2.2 (PJ20)

ICAO Code	Full Name of Airport	State Name	Airports' Group in 2018 according to SESAR 2020 Airports' Classification Scheme
EDDF	Flughafen Frankfurt/Main	Germany	Very large
EHAM	Amsterdam Airport	Netherlands	Very large
LFPG	Aéroport de Paris-Charles de Gaulle	France	Very large
EGLL	Heathrow Airport	United Kingdom	Very large
LTBA	Atatürk International Airport	Turkey	Very large
EDDM	Munich Airport	Germany	Very large
LEMD	Aeropuerto de Adolfo Suárez Madrid-Barajas	Spain	Very large
LEBL	Aeropuerto de Barcelona-El Prat	Spain	Very large
LIRF	Aeroporto di Roma-Fiumicino	Italy	Very large
EGKK	Gatwick Airport	United Kingdom	Very large
LSZH	Flughafen Zürich	Switzerland	Very large
EKCH	Copenhagen Airport	Denmark	Very large
ENGM	Oslo-Garnemoen Airport	Norway	Very large
LOWW	Vienna International Airport	Austria	Very large
ESSA	Stockholm-Arlanda Airport	Sweden	Large
EIDW	Dublin Airport	Ireland	Large
LFPO	Aéroport de Paris-Orly	France	Large
EBBR	Brussels Airport	Belgium	Large
LTFJ	Sabiha Gökçen International Airport	Turkey	Large
LEPA	Aeropuerto de Palma de Mallorca	Spain	Large
EDDL	Düsseldorf International Airport	Germany	Large
LPPT	Lisbon Airport	Portugal (Madeira and Azores)	Large
LGAV	Athens International Airport	Greece	Large
EGCC	Manchester Airport	United Kingdom	Large
EGSS	Stansted Airport	United Kingdom	Large
LIMC	Milano Malpensa	Italy	Large
EFHK	Helsinki-Vantaa Airport	Finland	Large
EPWA	Warsaw Frederic Chopin Airport	Poland	Large
LTAI	Antalya International Airport	Turkey	Large

The following Table 9 summarises the essential deployment details.

BAD	Specific geographical and/or stakeholder deployment
Start of deployment date: the start of investments for the first deployment location: 2021	EGLL (NATS)
End of deployment date: the end of the investments for the final deployment location: 2035	
Initial Operating Capability (IOC): the time when the first benefits occur following the *minimum deployment* necessary to provide them. Costs continue after this date as further deployment occurs at other locations: 2028	

Final Operating Capability (FOC): Maximum benefits from the *full deployment*[10] of the Solution at applicable locations. Investment costs are considered to end[11] here although any operating cost impacts would continue: 2035	

Table 9: Deployment details.

No Specific Equipage is needed for the implementation of this solution.

[10] Where ***full deployment*** means deploying the Solution in the all the locations where it makes sense to deploy it (i.e. it does not mean it has to be deployed everywhere)

[11] The basic assumption is that infrastructure does not need to be replaced during the CBA period

4.3 Safety

The information reported here refers to the V3 phase outcomes of PJ.02 Solution 03; it has been collected from the Safety Plan [43], Safety Assessment Report[44], and Validation Report[45].

4.3.1 Safety Criteria and Performance Mechanism

Safety Criteria (SAC) define the acceptable level of safety (i.e. accident and incident risk level) to be achieved by the Solution under assessment, considering its impact on the ATM/ANS functional system and its operation.

The SAC setting is driven by the analysis of the impact of the Change on the relevant AIM models and it needs to be consistent with the SESAR safety validation targets defined by PJ 19.04. The following AIM models have been considered to be relevant for this solution:

- Wake Turbulence on Final Approach (WT on FAP)
- Mid-Air Collision on Final Approach (MAC on FAP)
- Runway Collision (RWY Col)

Two sets of safety criteria are formulated:

- A first one aimed at ensuring an appropriate Separation design i.e. definition of separation minima and associated application rules which, if correctly followed in operation, guarantee safe operations on final approach path;
- A second one aimed at ensuring correct Separation delivery i.e. that the defined separation minima and associated application rules are correctly followed for separation delivery by ATC.

Note the SACs derived in the next paragraphs are applicable when the 2NM MRS concept is applied both with and without the Separation Delivery Tool. Details about if the Separation Delivery Tool could/needs to be used to demonstrate a specific SAC are provided in the safety assurance strategy for each SAC.

SEPARATION DESIGN

With regards to the design of the surveillance separation minima below 2.5NM and down to 2NM:

- on risk of infringement of surveillance separation minima on final approach path, with potential for Imminent collision (see in AIM MAC FAP model MF4):

M-SAC#1: The probability per approach of aircraft infringing the surveillance separation minima (with potential for Imminent collision) on final approach path when the ATM/ANS functional system is performing as specified shall be no greater in operations with reduced MRS down to 2NM than with MRS at 2.5NM.

Safety assurance strategy for the design of MRS 2NM separation minima&rules with or without the tool:

- providing evidence that the RSP enables safe employment of the 2NM MRS (potential need for collision risk modelling)
- providing evidence that ATCO can manage the separation on final approach path without infringing the surveillance separation minima more often than with MRS at 2.5NM (based on time estimation of sequences of events, potentially fed by RTS observation of the actual ATCO reaction time); two aspects need to be included:
  - the ATCO performance without triggering the STCA alert;
  - the ATCO reaction in response to an STCA alert (basically similar to the one in Baseline operations, but is it still fast enough in order to prevent an imminent collision i.e. triggering a TCAS RA ?)

With regards to the design of the WT separation minima, i.e. identifying aircraft pairs and wind conditions for which there is no wake constraint above the 2NM minima:

- on risk of WT Encounter on Final Approach related to correct application of the WT scheme under consideration (see in AIM WT on Final Approach model the outcome of precursor WE6S "Imminent wake encounter under fault-free conditions" not mitigated by barrier B2 "Wake encounter avoidance"):

W-SAC#1: For an aircraft type pair on Final Approach path spaced at a value below 2.5NM but above 2NM, and in the applicable wind conditions, the pair-wise wake turbulence encounter severity shall not be higher than the severity of reference aircraft type pair (selected as acceptable baseline with proven extensive operations) at ICAO minima and in reasonable worst-case conditions[12].

Safety assurance strategy for the design of WT separation minima&rules:

- For Static MRS reduction:
  - With or without the tool: make use of the RECAT-EU WT scheme, by retaining only those pairs with minima equal or below 2NM.
  - With tool only: make use of the RECAT-EU-PWS WT scheme (Table 19 in RECAT-EU-PWS Safety Case), by retaining only those pairs with minima equal or below 2NM.
- For wind based conditional MRS reduction (i.e. when applying the 2NM MRS concept with the ICAO WT scheme) with or without the tool: make use of the demonstration based on data mining/analysis allowing to define WT separation minima within PJ02-01 and within SESAR 1 PJ6.8.1. The risk of under-separation induced by the uncertainty in glideslope

[12] Reasonable worst case conditions recognized for WT separation design as detailed at **Error! Reference source not found.** §4.2.1

wind prediction and in the actual final approach speed profile needs to be mitigated by pre-determining the wind-based criterion for the activation of the MRS reduction mode and/or a buffer in the design of the WT separation minima

- Note for wind based conditional MRS reduction with the tool, there is an additional possibility for mitigating the risk of under-separation induced by the uncertainty in glideslope wind prediction and in the actual final approach speed profile by adding a separation buffer in the computation of the separation indicators displayed to the Controllers.

The following safety issue remains still to be addressed:

ISSUE#001: The frequency of wake turbulence encounters at lower severity levels might increase for MRS infringements bigger than 0.5NM due to the reduced separation minima. As the frequency of wake turbulence encounters at each level of severity depends on local traffic mix, local wind conditions and proportion of time of application of the concept, there is a need to find a suitable way for controlling the associated potential for WT-related risk increase.

Proposed strategy:

- Either to perform assessment for several airport samples in order to demonstrate the low effect of MRS reduction on frequency of WT encounter of higher severities.
- Or to derive a safety recommendation for the local implementation of a specific WT separation concept to conduct an analysis which, for the given local traffic mix and wind conditions, estimates the net effect on the frequency of wake turbulence encounters at each level of severity in comparison to an accepted baseline.

With regards to the design of separations accounting for the ROT spacing constraint, i.e. identifying aircraft pairs and/or wind conditions that maintain situations when the ROT spacing is higher than the 2NM minima to an acceptable level:

- on risk of Imminent Inappropriate Landing (see in AIM RWY collision model the precursor RP4C which might be caused by e.g. spacing management by APP ATCO without considering ROT constraint and which outcome is mitigated by B3A: Runway Monitoring involving e.g. a Go Around instructed by TWR ATCO):

R-SAC#1: For an aircraft type pair on Final Approach path spaced at a value below 2.5NM but above 2NM, and in the applicable wind conditions, the probability of Imminent Inappropriate Landing when correctly following the applicable ROT spacing minima shall be no higher than that probability for a reference aircraft type pair (selected as acceptable baseline with proven extensive operations) in reasonable worst-case conditions and with MRS at 2.5NM.

Safety assurance strategy to account for the ROT spacing constraint:

- The data analysis will identify the aircraft pairs and/or the wind conditions, in each Use Case, for which MRS can be reduced while maintaining the probability of separation provision below ROT minima to an acceptable level. This will be performed by comparing the ROT distribution to the time separation distribution corresponding to the reduced

MRS. The ROT distribution is intrinsically aircraft type and airport-dependent (as it depends on the runway exit geometry). Example of application of the developed methodology will be analysed based on data from some exemplary airports. The “acceptable” rate of aircraft pairs delivered below ROT minima will also be defined on a local basis corresponding to the value observed today, and allowing the APP and TWR ATCO to safely deal with them. For airports with high average ROT, the ROT constraint might become a show-stopper for the concept. Therefore, as an intermediate solution, reduced MRS might be allowed only for certain pairs and under certain headwind minima conditions. Note the ROT conditional application is only required if the 2NM MRS concept is applied without a tool. There is no need for ROT conditional application when the 2NM MRS concept is applied with the tool. This is because the separation delivery tool takes into account the ROT constraint.

- In the Real Time Simulation (RTS), the traffic samples with the pre-calculated rate of ROT-constrained aircraft pairs will be presented to ATCOs in order to validate that they can operate safely (based on ATCOs debriefing/subjective feedback and on counting the Go arounds due to ROT, ensuring the acceptable Go around rate is not overpassed).

SEPARATION DELIVERY

MAC accident :

A set of SACs are defined in order to ensure that the reduced MRS down to 2NM is correctly applied for **separation assurance and delivery of the non-wake constrained pairs**, i.e. that the right System in terms of People, Procedures, Equipment (e.g. separation delivery tool) is designed such as to enable safe operation. The correct application of reduced MRS down to 2NM needs to account for the radar separation constraints during interception. For achieving that, the safety risk related to radar under-separation (during interception and Final Approach path) and its precursors needs to be controlled, driven by the AIM MAC Final Approach model.

- on risk of Imminent collision during interception and final approach path (see in AIM MAC FAP model MF4):

M-SAC#F1: The probability per approach of Imminent collision during interception & final approach shall be no greater in operations with reduced MRS down to 2NM than with MRS at 2.5NM.

Safety assurance strategy with or without the tool:

- recording of 2NM radar separation infringements and comparison against the number of 2.5NM radar separation infringements in Baseline (separation minima to be modulated for the interception area) (from RTS, acknowledging the limited statistical relevance in relation to the rare occurrences);
- expert-based analysis of failure causes, risk assessment and mitigation.
- Note: the risk assessment, in terms of harmful effect of the 2NM separation infringement should also account for the WT encounter effect. As explained in the next paragraph (definition SACs for Wake turbulence accident), a large infringement (with more than

0.5NM) of the 2NM separation minima has a higher potential for wake encounter than an equivalent infringement of the 2.5NM separation minima.

The following Safety issue (coupled with a performance issue) has been identified:

ISSUE#002: In current operations, under specific conditions (applicable at most of the Very large, large and medium airports) MRS is reduced to 2.5NM on the Final Approach path (up to a certain distance from the threshold) but 3NM apply on the base leg and upstream. Heathrow represent an exception, as the reduction to 2.5NM is extended to the base leg provided that the second aircraft of any given pair is within 20 NM from the threshold. It is expected that the extension of 2.5NM MRS to the base leg will be beneficial for the gain in RWY throughput (the RTS will assess the expected reduction of the gain in RWY throughput in relation to the need for maintaining 3NM until aircraft is converging for interception and then progressively catching up attempting to reach 2NM MRS later on the final approach path). Furthermore, it is expected that the extension of 2.5NM MRS to the base leg would contribute to the reduction of the separation minima infringement during the transitioning to 2NM MRS on final approach, thanks to the smoothening of this transition (progressive reduction from 3NM to 2.5NM followed by 2.5NM to 2NM). A safety assessment is required for the extension of 2.5NM MRS to the base leg on Very large, large and medium airports other than Heathrow. The related safety case performed by NATS for Heathrow would be a desirable input for addressing within the PJ02-03 the above safety&performance issue.

- on risk of Imminent infringement (radar separation) during interception and final approach path (see in AIM MAC FAP model MF5.1 & MF5.2):

M-SAC#F2: The probability per approach of Imminent infringement during Interception & final approach shall be no greater in operations with reduced MRS down to 2NM than with MRS at 2.5NM

Safety assurance strategy <u>with or without the tool</u>:

- recording the 2NM under-separations (large and small) and comparison against the number of 2.5NM under-separations (from RTS)
- expert-based analysis of failure causes, risk assessment and mitigation (similar to the one performed for PJ02-01).

- on risk of Crew/Aircraft induced spacing conflicts (spacing conflicts induced by Crew/Aircraft and not related to ATC instructions) during interception and final approach (see in AIM MAC FA model MF9 and MF7):

M-SAC#F3: The probability per approach of Crew/Aircraft induced spacing conflicts during interception & final approach shall be no greater in operations with reduced MRS down to 2NM than with MRS at 2.5NM

Safety assurance strategy <u>with or without the tool</u>: The reduction of MRS down to 2NM might increase the occurrence of speed deviations due to Pilots reluctance of getting closer to the leading aircraft. The risk will be considered and a potential mitigation could be a requirement for the new reduced MRS information to be widely disseminated to Pilots.

Wake turbulence accident:

No specific SAC is defined for the issue regarding the large infringement (more than 0.5NM) of the 2NM separation minima which has a higher potential for wake encounter compared to the same infringement of the 2.5NM separation minima. This is because the safety assurance strategy proposed to be applied in relation to the M-SAC#F1 (that has been identified for the MAC accident) is considered sufficient for covering both the risk for imminent collision and the risk for severe wake encounter which are associated to the separation minima infringement.

Regarding the activation/deactivation of the reduced MRS down to 2NM separation mode (for the conditional application of the concept, i.e. when applying 2NM MRS with the ICAO WT scheme):

- on risk of Unmanaged WT under-separation induced by inadequate selection & management of separation mode i.e. selection of and transition between MRS 2NM and MRS 2.5NM under DBS (see WE 7F.2 in AIM WT accident on Final Approach model):

W-SAC#F3: The probability per approach of unmanaged WT under-separation during interception & final approach shall not increase due to inadequate selection of or transition between reduced MRS down to 2NM mode and MRS 2.5NM under DBS mode

Safety assurance strategy with or without the tool: expert-based analysis of failure causes, risk assessment and mitigation.

Regarding the **potential side effect** of the 2NM separation minima (applied to non wake constrained pairs) **on the separation delivery of the wake constrained pairs**, via impact on ATCOs workload or Situation Awareness, the following need to be considered:

- on risk of Unmanaged under-separation (wake) during interception and final approach of the wake constrained aircraft pairs (see in AIM WT model WE 7F.1):

W-SAC#F2: The probability per approach of Unmanaged under separation (wake) of wake constrained pairs during interception & final approach shall be no greater in operations with reduced MRS down to 2NM than with MRS at 2.5NM.

Safety assurance strategy with or without the tool: via RTS -both debriefing with participating ATCOs and comparison of significant wake separation infringements (e.g. more or equal than 0.25NM) between Solution and Baseline, (acknowledging the limited statistical relevance in relation to the rare occurrences).

- on risk of Imminent infringement (wake) during interception and final approach (related to wake constrained aircraft pairs) (see in AIM WT model WE 8):

W-SAC#F4: The probability per approach of Imminent infringement (wake) of wake constrained pairs during Interception & final approach shall be no greater in operations with reduced MRS down to 2NM than with MRS at 2.5NM

Safety assurance strategy with or without the tool: via RTS -both debriefing with participating ATCOs and comparison of minor wake separation infringements (e.g. less than 0.25NM) between Solution and Baseline.

RWY Collision accident:

- on risk of Imminent Inappropriate Landing (see in AIM RWY collision model, the precursor RP2.4 which might be caused by e.g. spacing management by APP ATCO without considering ROT constraint and which outcome is mitigated by B2: ATC Collision Avoidance involving e.g. last moment detection by TWR ATCO with or without Runway Incursion Monitoring and Conflict Alert System RIMCAS):

R-SAC#F1: The probability per approach of Runway Conflict resulting from Conflicting ATC clearances shall be no greater in operations with reduced MRS down to 2NM than with MRS at 2.5NM

- on risk of Runway conflict due to premature landing (see in AIM RWY collision model the precursor RP2.1 which might be caused by e.g. TWR ATCO failure to correctly monitor the RWY and to initiate Go around and which outcome is mitigated by B2: ATC Runway Collision Avoidance involving last moment detection by TWR ATCO with or without RIMCAS):

  Safety assurance strategy (with or without the tool) for R-SAC#1 and R-SAC#2: from RTS debriefing and measurements, considering that:

  - R-SAC#1 is intended for ensuring that the number of occurrences where APP ATCO transfers to TWR ATCO an aircraft without enough ROT spacing (thus involving Go around) will not increase.

It should be noted that no SAC was derived for the risk of Runway conflict due to premature landing (not cleared by ATCO) or unauthorised RWY entry of ac/vehicle as no change is introduced by the 2NM MRS concept compared to today's operations.

4.3.2 Data collection and Assessment

The information reported here has been extracted from sections 3.10 and 4.6 from the Safety Assessement Report [44].

From the Safety Criteria listed in the previous section and by following the SRM process, Safety Objectives (SO) have been developed within the success approach (ensuring that the design enables safe operations in absence of failure within the solution scope) and the failure approach (via identification of operational hazards). Therefore, the Safety Criteria are implicitly achieved by the design through the demonstration that the design meets the aforementioned SOs. The safety demonstration, documented in the SAR is based on a combination of evidences gathered from the validation exercises and evidences produced within the safety assessment based on safety workshops, reviews and interviews with relevant operational and technical experts.

Moreover, safety validation objectives (which were subsequently traced back to the relevant SACs) were derived for each of the validation exercises in PJ02.03. The validation results are summarized in the table below, whilst indicating the level of safety evidence that has been obtained for each of the applicable validation safety objective.

Exercise ID, Name, Objective	Exercise Validation objective	Success criterion	Safety Criteria coverage	Validation results & Level of safety evidence
EXE-PJ02-03 VALP-RTS02: RTS conducted by EUROCONTROL to assess the operational feasibility and acceptability of reducing the in-trail Minimum Radar Separation (MRS) from 2.5 NM to 2 NM under applicable separation scheme on the final approach under IMC. The main focus of this real time simulation was to assess the in-trail 2 NM MRS combined with TB PWS for arrivals and the ORD tool (Use case [MRS-2a] MRS 2NM with ORD Tool) under segregated mode runway operations.	**OBJ-PJ2.03-V3-VALP-SA1** To assess the impact on operational safety of applying an in-trail Minimum Radar Separation of 2NM during interception and final approach compared to applying the 2.5NM Minimum Radar Separation.	**CRT-PJ2.03-V3-VALP-SA3-001** The level of operational safety is maintained and not negatively impacted under the in-trail 2 NM MRS with ORD tool during interception and final approach compared to when applying the in-trail 2.5 NM MRS without indicators, despite the potential increase in controller workload (in relation to the expected throughput increase).	**M-SAC#1** **W-SAC#F2** **W-SAC#F4**	Overall, the controllers were seen to apply the safe standard practices when applying TB-PWS MRS 2NM with ORD tool in the simulation, during nominal operations. Regarding degraded mode of operations, two types of failure were simulated: ORD tool failure, wrong a/c type in the flight plan. During both failure modes, the APP and TWR Controllers successfully employed safe contingency procedures to deal with the non-nominal situations.
		CRT-PJ2.03-V3-VALP-SA3-002 Evidence that using the in-trail 2 NM MRS with ORD tool will decrease the number of separation minima infringements compared to using the in-trail 2.5 NM MRS without indicators (in order to compensate for the potential severity increase of the wake separation infringements and	**M-SAC#F1** **M-SAC#F2**	Given the limited number of runs and the low number of under-separation events, a meaningful statistical analysis could not be done to draw a conclusion for comparison of the number of under-separations between the reference and the solution runs. Also note that although there was one small under-separation in the solution scenario, this does not

		of the radar separation infringements – the latter in relation to the reduction of the time available for ATCO and Pilot reaction time)		allow us to conclude that safety is degraded compared to the reference scenario. As for the separation infringements on base leg, it was concluded that there was no increase in separation non-conformances before alignment or on the base leg due to reduction of MRS to 2.0NM.
		CRT-PJ2.03-V3-VALP-SA3-003 The number of Go around due to inadequate consideration of ROT constraint is not increased (for RWY conflicts)	**R-SAC#F1** **R-SAC#F2**	The number of ROT related Go-arounds was of same order of magnitude in the solution scenario compared to the reference. However, the validity of this conclusion is limited by the low relevance of the statistics involved by the low number of runs.
	RTS02 Prototyping session: 2NM MRS DBS ICAO NO SUPPORTING TOOL		conducted to assess the operational feasibility and acceptability of applying 2.0NM MRS between medium-medium aircraft pairs with DBS ICAO separations and no controller support tool. The results of the prototyping session showed that safety was not negatively impacted in the solution scenario (i.e. 2.0NM MRS applied between M-M ICAO pairs with no tool) compared to the reference scenario:	

			• Under the wind conditions tested, the number of go-arounds was not found to increase in solution scenario (2.0NM MRS applied between ICAO M-M pairs with no tool) compared to the reference scenario (Vienna current operations – i.e. 2.5NM MRS applied for all MRS aircraft); • There was no increase in the number of under spacings observed in the solution scenario exercise runs compared to the reference scenario exercise runs; The reduction of MRS to 2.0 NM for M-M MRS pairs under certain wind conditions did not lead to more separation non-conformances before alignment, as only one case occurred during a reference run.	
EXE-PJ02-03 VALP-FTS03: Conducted by CRIDA to support the Safety Assessment for the in-trail 2 NM arrival separation concept on the final approach. This FTS assessed the safety impact of the in-trail 2 NM arrival separation solution on the final approach with regards to the risk of collision due to a catch up scenario using multiple	**OBJ-PJ02.03-V3-VALP-SA1** To provide evidence that the minimal pair arrival separation reduction to 2 NM on final approach is safe using currently available surveillance means	**CRT-PJ2.03-V3-VALP-SA3-001** At least one of the surveillance means tested shows no collisions for all included aircraft pairs.	**M-SAC#1**	ulfils the criteria for safe operations under certain conditions, whereas ADS-B fulfils the criteria under all conditions. Only a few certain pairs of aircraft might need to be limited in separation for weather dependent separations where the wake vortex separation is not taken into consideration. *For an example of a local surveillance performance assessment case study which contains the Surveillance*

aircraft types as the leader and follower pairs. This FTS focused on Use case [MRS-2b] MRS 2NM without ORD Tool				*Performance Assessment of 2NM Separations at Heathrow Airport.*
EXE-PJ02-03 VALP-FTS01 Conducted by EUROCONTROL to support the CBA for the reduction of the in-trail radar separation minima to 2 NM on the final approach. This RTS covered multiple generic environments and supported the validation of the capacity benefit for a range of operational configurations. This FTS focused on Use case [MRS-2a] MRS 2NM with ORD Tool.	No Safety Validation Objective needed to be set for this FTS			

4.3.3 Extrapolation to ECAC wide

The results obtained from the validation activities are for the moment limited to the specific set of aerodrome environments the concepts have been simulated in. This is in terms of layout and configuration (single runway segregated operations departures) as well as in terms of traffic (as per the traffic in medium and large airports with Medium/High Complexity TMAs).

These results could be extrapolated to similar aerodromes in ECAC, but not enough evidence is available to extrapolate this statement to the rest of aerodromes in other categories. 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

With regard to all the success criteria about the quantification of the under-separations and go-arounds:

- Based on the data collected in the RTS and due to the limited number of scenarios and conditions that can be tested in an RTS, only a limited statistical analysis could be performed for these success criteria, as the data is insufficient to derive a significant statistical conclusion. However, these results do give an indication of trends. Thus, this quantitative data in combination with the qualitative safety data/results obtained from the RTS and other safety related activities (e.g. workshops, HAZIDs) enables us to conclude that safety is not negatively impacted.

With regard to abnormal and degraded mode of operations:

- Even though some degraded mode of operations have been tested in the simulations, this is not true for all the abnormal and degraded modes due to the limitation of the simulation environment. However, anything that has not been tested in simulations was at least brainstormed in workshops with relevant experts.

4.3.5 Additional Comments and Notes

No additional comments.

4.4 Environment / Fuel Efficiency

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

The solution reviews the minimum surveillance separation to be applied between consecutive arrivals. By delivering aircraft at threshold closer there is a reduction of flying time that also impacts fuel and emissions. See the BIM in the OSED for details.

4.4.2 Assessment Data (Exercises and Expectations)

Fuel Efficiency benefits due to the application of operational concepts addressed by PJ02.03 have been identified taking into account:

- average flight duration;
- number of go-around (effect on increased flying time duration);

Fuel efficiency has been assessed in FTS01. See VALR for details about the exercise.

The fuel burn savings for a given scenario is computed based on the comparison of the averaged flying time per flight. Indeed because the aircraft flights are released in all runs at the same positions, the traffic pressure and the applicable separation minima will impact the aircraft trajectories and hence their flying time. Moreover, a go-around also significantly increases the flying time which is taken into account by the model.

The relationship between averaged flying time reduction compared to baseline and fuel burn savings is then established using assumptions found in “Standard Inputs for EUROCONTROL Cost-Benefit Analyses” (EUROCONTROL, January 2018). In particular, the fuel burn rates for arrival management per RECAT category is obtained as an average of the values provided for several aircraft and reported in the table below.

Phase of flight	S5H0	S5H10	S5H20	S5H30	S5H40	S0H20	S10H20
All	41.8	48.3	55.3	62.3	68.9	47.4	63.3
Arrival 50% max loading	36.3	41.8	47.7	53.6	59.1	41.0	54.5
Arrival 65% max loading	38.6	44.9	51.6	58.2	64.5	44.0	59.1

Table 10: Fuel burn rates [kg/min] for the various traffic samples used for sensitivity analysis

The table below summarises the results obtained when comparing the different wake schemes with surveillance minima at 2.0 NM vs the same wake scheme at 2.5 NM. A negative value indicates a saving in fuel emissions.

Wind		low wind		strong headwind		strong crosswind	
Separation scheme and mode	MRS	min	max	min	max	min	max
ICAO TBS	2	0.0%	0.0%	-0.6%	-3.0%	-	-
RECAT-EU	2	0.0%	0.0%	-0.5%	-4.2%	-	-
RECAT-EU-PW TBS	2	-0.9%	-1.9%	-1.8%	-4.1%	-	-

ICAO TB-WDS	2	-	-	-	-	0.0%	-1.9%
RECAT-EU TB-WDS	2	-	-	-	-	0.0%	-1.7%
RECAT-EU-PW TB-WDS	2	-	-	-	-	-1.1%	-1.9%

Table 11: Summary of the fuel burn savings if operating the test scheme versus the MRS=2.5NM baseline case at maximum test case traffic pressure for the various separation schemes and modes and in various wind conditions

4.4.3 Extrapolation to ECAC wide

The following PJ19 common assumptions have been used:

- High density airports traffic contribution to total airport traffic = 59.5%
- Arrivals traffic contribution to total traffic = 50%
- Average ECAC flight time = 90 minutes
- CO_2/Fuel ratio = 3.15
- With the traffic mixes described above the obtained fuel burn rates for all phases of flight are detailed in Table 10:
  - Fuel burn rate 50% loading = [36.3, 59,1] kg/min
  - Fuel burn rate 65% loading = [38.6, 64,5] kg/min

Due to the different combinations of wind and wake scheme only the lowest and highest benefits are reported below to consider a range for the extrapolation. As reported in the results the lowest benefit is equal to 0%. For the fuel burn rate the 50% loading values are used.

FEFF3

1. Flight time reduction per arrival = [2.5] min. This is the highest benefit obtained assessing different traffic samples and different parameters, from FTS01 results.

2. Flight time reduction (FEFF3) at ECAC level = 50% (arrivals traffic contribution) * 59.5% (high density airports traffic contribution) * 2.5 minutes (flight-time reduction per arrival) = 0.74 minutes per flight

3. Relative flight time reduction at ECAC level = 0.74 minutes (flight time reduction at ECAC level) / 90 minutes (average ECAC flight time) * 100 = 0.82%

FEFF1

Fuel burn rate 50% loading = [36.3, 59,1] kg/min

1. Fuel consumption reduction per arrival #1 = 2.5 (flight time reduction per arrival) * 36.3 (fuel burn rate for arrival) = 90.7 kg/flight

2. Relative fuel consumption reduction = 90.7 kg/flight (fuel consumption reduction on arrival #1) / 3321 kg (Average fuel burn per flight) * 100 = 2.73%

3. Fuel consumption reduction (FEFF1) at ECAC level = 50% (arrivals traffic contribution) * 59.5% (high density airports traffic contribution) * 2.73% (relative fuel consumption reduction) = 0.8% = 26.5 kg/flight

4. Fuel consumption reduction per arrival #2 = 2.5 (flight time reduction per arrival) * 59.1 (fuel burn rate for arrival #2)= 147.75 kg/flight
5. Relative fuel consumption reduction #2 = 147.75 kg/flight (fuel consumption reduction on arrival #2) / 5407 kg (Average fuel burn per flight #2) * 100= 2.73%
6. Fuel consumption reduction (FEFF1) at ECAC level #2 = 50% (arrivals traffic contribution) * 59.5% (high density airports traffic contribution) * 2.73% (relative fuel consumption reduction #1) = 0.8% = 43.9 kg/flight

FEFF2

1. CO2 emission reduction per arrival = 90.7 (Fuel consumption reduction on arrival #1) * 3.15 (CO2/Fuel Ratio) = 285.7 kg CO2 per flight
2. Relative CO2 emission reduction on arrival = 285.7 (CO2 emission reduction #1) / 3321 (Average Fuel burn per flight) / 3.15 (CO2/Fuel ratio) * 100 = 2.7%
3. Relative CO2 emission reduction on arrival (FEFF2) at ECAC level = 50% (arrivals traffic contribution) * 59.5% (high density airports traffic contribution)* x 2.7% (Relative CO2 emission reduction on arrival) = 0.8% = 26.5 kg CO2/flight
4. CO2 emission reduction on arrival #2 = 147.75 (Fuel consumption reduction on arrival #2) * 3.15 (CO2/Fuel Ratio) = 465.4 kg CO2 per flight
5. Relative CO2 emission reduction on arrival #2 = 465.4 (CO2 emission reduction #2) / 5407 (Average Fuel burn per flight #1) / 3.15 (CO2/Fuel ratio) * 100= 2.7%

6. Relative CO2 emission reduction on arrival #2 (FEFF2) at ECAC level = 50% (arrivals traffic contribution) * 59.5% (high density airports traffic contribution)* x 2.7% (Relative CO2 emission reduction on arrival #1) = 0.8% = 43.2 kg CO2/flight

KPIs / PIs	Unit	Calculation	Mandatory	Benefit in SESAR1 (if applicable)	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	*NA*	*AO-0309 -Minimum Pair Separations Based on Required Surveillance Performance (RSP) = [0, 43.9]* reduction kg of fuel per flight	*AO-0309 -Minimum Pair Separations Based on Required Surveillance Performance (RSP) = [0%, 0.8%]* reduction kg of fuel per flight
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	*NA*	*AO-0309 -Minimum Pair Separations Based on Required Surveillance Performance (RSP) = [0, 43.2]* reduction kg CO_2 per flight	*AO-0309 -Minimum Pair Separations Based on Required Surveillance Performance (RSP) = [0%, 0.8%]* reduction kg CO_2 per flight
FEFF3 Reduction in average flight duration	Minutes per flight	Average actual flight duration measured in the Reference Scenario – Average flight duration measured in	YES	*NA*	*AO-0309 -Minimum Pair Separations Based on Required Surveillance Performance (RSP) = [0, 0.74]* reduction minutes per flight	*AO-0309 -Minimum Pair Separations Based on Required Surveillance Performance (RSP) = [0%, 0.82%]* reduction minutes per flight

KPIs / PIs	Unit	Calculation	Mandatory	Benefit in SESAR1 (if applicable)	Absolute expected performance benefit in SESAR2020	% expected performance benefit in SESAR2020
		the Solution Scenario				

Table 12 is showing the impact on flight phases (provided when it is possible).

	Taxi out	TMA departure	En-route	TMA arrival	Taxi in
FEFF1 Actual Average fuel burn per flight	NA	NA	NA	[0, 43.9] reduction kg of fuel per flight	NA
FEFF2 Actual Average CO_2 Emission per flight	NA	NA	NA	[0, 43.2] reduction kg CO2 per flight	NA
FEFF3 Reduction in average flight duration	NA	NA	NA	[0, 0.74] reduction minutes per flight	NA

Table 12: Fuel burn reduction per flight phase.

4.4.4 Discussion of Assessment Result

These results can meet and exceed the performance targets defined from PJ19 that were reduction of 6.07 kg of fuel per flight. The only exceptions are when AO-0309 is used in low wind conditions with ICAO and RECAT-EU Wake schemes.

The confidence estimate in the results is moderate, they are based on generic characteristics that that are common in other European airports. The benefits identified are an estimation applicable to very large, very large, large and medium airports that are capacity constrained during traffic peaks because of the wake turbulence constraints, surveillance minima and the separation delivery on approach. For each local airports the exact benefits are depending on several factors including specific traffic mix, length of traffic peak, wind conditions, glide parameters, runway occupancy time, glide length, runway layout, airport infrastructure, etc.

The benefits are mainly in challenging wind conditions on final approach. For non-challenging low wind conditions on final approach the benefits impact is towards zero.

4.4.5 Additional Comments and Notes

No further comments.

4.5 Environment / Noise and Local Air Quality

NA

4.6 Airspace Capacity (Throughput / Airspace Volume & Time)

NA

4.7 Airport Capacity (Runway Throughput Flights/Hour)

4.7.1 Performance Mechanism

The solution reviews the minimum surveillance separation to be applied between consecutive arrivals. By delivering aircraft at threshold closer there is a reduction of flying time that also affects runway throughput. See the BIM in the OSED for details.

4.7.2 Assessment Data (Exercises and Expectations)

The results are extracted from the FTS01 exercise, FTS02 focus was on defining the surveillance performance required to safely support the reduction to the in-trail 2 NM MRS on final approach.

Being PJ02.03 a solution focused only on Arrivals OIs only CAP3.2 KPI is reported below.

CAP3.2:
in low wind conditions, MRS reduction to 2NM has only an impact if Tb PWS (AO-306) is applied with benefits of up to 14 % in terms of arrival runway throughput capacity.

In strong headwind (i.e.15 kts), the MRS reduction to 2NM positively impacts the throughput values for all TBS separation schemes assessed i.e. ICAO, RECAT-EU and PWS.

In strong crosswind conditions (13knots pure crosswind), MRS reduction impacts the throughput values for the WDS (AO-0310) separation schemes whereas this was not found to be the case in moderate crosswind (8 kts pure crosswind) values for which its influence is neutral for ICAO and RECAT-EU TB-WDS schemes.

Wind		low wind		strong headwind		strong crosswind	
Separation scheme and mode	MRS	min	max	min	max	min	max
ICAO DBS	2.5	35.48	43.82	31.03	40.6	34.95	43.06
ICAO TBS	2.5	35.32	43.08	33.39	41.12	-	-
	2	35.32	43.08	34.85	43.01	-	-
RECAT-EU	2.5	38.43	44.05	36.51	41.96	-	-
	2	38.43	44.05	38.11	44.02	-	-
PW TBS	2.5	39.33	44.1	37.65	42.01	-	-
	2	40.6	47.31	40.75	47.75	-	-
ICAO TB-WDS	2.5	-	-	-	-	35.95	43.28
	2	-	-	-	-	35.95	45
RECAT-EU TB-WDS	2.5	-	-	-	-	38.47	43.62
	2	-	-	-	-	38.47	45.41
PW TB-WDS	2.5	-	-	-	-	39.45	43.65
	2	-	-	-	-	40.86	46.47

Table 13 Summary of the maximum throughput for the various separation schemes and modes and in various wind conditions and with MRS set at 2.5 or 2.0 NM.

CAP4:
Assuming that the constrained airport has a single traffic peak of 1 hour during the day, the results of CAP3.2 are multiplied per the number of days in a year, to obtain a lower bound estimation of the benefit.

AO-0309 = [0, 2080.5] increase in flights/year

KPIs / PIs	**Unit**	**Calculation**	**Mandatory**	**Benefit in SESAR1 (if applicable)**	**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	*NA*	*NA*	*NA*
CAP3.1 Peak Departure throughput per hour (Segregated mode)	% 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 measured against the maximum observed throughput during peak demand hours in the segregated-mode RWY operations airports group.	YES	*NA*	*NA*	*NA*
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	YES	*NA*	*AO-0309 -Minimum Pair Separations Based on Required Surveillance Performance (RSP) = [0, 5.7]* increase in movements/hour	*AO-0309 -Minimum Pair Separations Based on Required Surveillance Performance (RSP) = [0%, 13.7%]* increase in movements/hour

KPIs / PIs	Unit	Calculation	Mandatory	Benefit in SESAR1 (if applicable)	Absolute expected performance benefit in SESAR2020	% expected performance benefit in SESAR2020
		during peak demand hours in the segregated-mode RWY operations airports group.				
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.	*NA*	*AO-0309 -Minimum Pair Separations Based on Required Surveillance Performance (RSP) = [0, 2080.5]* increase in flights/year	*AO-0309 -Minimum Pair Separations Based on Required Surveillance Performance (RSP) = [0%, 13.7%]* increase in flights/year

4.7.3 Extrapolation to ECAC wide

There is no ECAC wide extrapolation required for this KPI.

4.7.4 Discussion of Assessment Result

As explained in the section above, the benefits of the AO-0309 depends on the wake scheme used and the wind conditions.

These results meet and exceed the performance targets defined from PJ.19 that was a 1.299% increase in capacity, the only exceptions are when AO-0309 is used in low wind conditions with ICAO and RECAT-EU Wake schemes.

The confidence estimate in the results is moderate, they are based on generic characteristics that that are common in other European airports. The benefits identified are an estimation applicable to very large, very large, large and medium airports that are capacity constrained during traffic peaks because of the wake turbulence constraints and the separation delivery on approach.

For each local airports the exact benefits are depending on several factors including specific traffic mix, length of traffic peak, wind conditions, runway occupancy time, glide length, type of approach, runway layout, airport infrastructure, etc..; these factors were taken in account in the FTS as fixed parameters (e.g. ROT) or dynamic parameters modified in each run (e.g. the traffic mix, wind conditions, …) to provide as many different cases as possible.

The benefits are mainly in challenging wind conditions on final approach. For non-challenging low wind conditions on final approach the benefits impact is towards zero.

4.7.5 Additional Comments and Notes

RTS02 also showed an increase in runway throughput capacity when there was a reduction from 2.5NM to 2NM MRS for in-trail aircraft on the final approach with TB PWS. With the ''classical" runway throughput metric for arrivals (definition of throughput consisting in counting the number of landed aircraft per unit time or equivalently dividing the number of landed aircraft reduced by 1 by the total simulation time (time of last landing – time of first landing first landing throughput metric (including go-arounds)) showed a gain of 2 ac/h for ATCO1 and 3 ac/h for ATCO2 in the heavy traffic and challenging wind conditions tested. When pairs for which either the leader or the follower performed a go-around or pairs where there was a gap insertion excluded from the runway throughput analysis the gains in runway throughput between TB PWS 2NM MRS & ORD compared to TB 2.5NM MRS & ORD were increased to 5 a/c per hour and 6 a/c per hour per ATCo respectively.

The benefits are mainly in challenging wind conditions on final approach. For non-challenging low wind conditions on final approach the benefits impact is towards zero.

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

NA

4.9 Predictability (Flight Duration Variability, against RBT)

NA

4.10 Punctuality (% Departures < +/- 3 mins vs. schedule due to ATM causes)

NA

4.11 Civil-Military Cooperation and Coordination (Distance and Fuel)

NA

4.12 Flexibility

NA

4.13 Cost Efficiency

4.13.1 Performance Mechanism

The solution reviews the minimum surveillance separation to be applied between consecutive arrivals. By delivering aircraft at threshold closer there is a reduction of flying time that also affects runway throughput and the number of flights handled by ATCOs. See the BIM in the OSED for details.

4.13.2 Assessment Data (Exercises and Expectations)

As per Capacity KPI above.

in low wind conditions, MRS reduction to 2NM has only an impact if Tb PWS (AO-306) is applied with benefits of up to 14 % in terms of arrival runway throughput capacity.

In strong headwind (i.e.15 kts), the MRS reduction to 2NM positively impacts the throughput values for all TBS separation schemes assessed i.e. ICAO, RECAT-EU and PWS.

In strong crosswind conditions (13knots pure crosswind), MRS reduction impacts the throughput values for the WDS (AO-0310) separation schemes whereas this was not found to be the case in moderate crosswind (8 kts pure crosswind) values for which its influence is neutral for ICAO and RECAT-EU TB-WDS schemes.

Wind		low wind		strong headwind		strong crosswind	
Separation scheme and mode	MRS	min	max	min	max	min	max
ICAO DBS	2.5	35.48	43.82	31.03	40.6	34.95	43.06
ICAO TBS	2.5	35.32	43.08	33.39	41.12	-	-
	2	35.32	43.08	34.85	43.01	-	-
RECAT-EU	2.5	38.43	44.05	36.51	41.96	-	-
	2	38.43	44.05	38.11	44.02	-	-
PW TBS	2.5	39.33	44.1	37.65	42.01	-	-
	2	40.6	47.31	40.75	47.75	-	-
ICAO TB-WDS	2.5	-	-	-	-	35.95	43.28
	2	-	-	-	-	35.95	45
RECAT-EU TB-WDS	2.5	-	-	-	-	38.47	43.62
	2	-	-	-	-	38.47	45.41
PW TB-WDS	2.5	-	-	-	-	39.45	43.65
	2	-	-	-	-	40.86	46.47

Table 14 Summary of the maximum throughput for the various separation schemes and modes and in various wind conditions and with MRS set at 2.5 or 2.0 NM.

4.13.3Extrapolation to ECAC wide

CEF2 is defined as ''# of flights handled by the Atco in 1 hour''. For a Tower and Final Approach controller, this metric is equivalent to the runway throughput observed in 1h hour, so equivalent to the CAP3.2 target. As extrapolation to ECAC wide is not requested for CAP3.2 KPI, the same is applied to the CEF2. The ECAC wide effect will be taken in account by the CBA.

KPIs / PIs	Unit	Calculation	Mandatory	Benefit in SESAR1 (if applicable)	Absolute expected performance benefit in SESAR2020	% expected performance benefit in SESAR2020
CEF2[13] Flights per ATCO-Hour on duty	Nb	Count of Flights handled divided by the number of ATCO-Hours applied by ATCOs on duty.	YES	*No*	*AO-0309* - Minimum Pair Separations Based on Required Surveillance Performance (RSP) = [0, 5.7] increase in movement/hour	*AO-0309 - Minimum Pair Separations Based on Required Surveillance Performance (RSP) = [0%, 13.7%]*

[13] The benefits are determined by converting workload reduction to a productivity improvement, and then scale it to peak traffic in the applicable sub-OE category. It has to be peak traffic because there must be demand for the additional capacity (note that in this case the assumption is that the additional capacity is used for additional traffic).

4.13.4 Discussion of Assessment Result

On top of the increased productivity for ATCOs, the results from RTS1 show that workload was acceptable and not negatively impacted when the concept was applied, see VALR for details.

4.13.5 Additional Comments and Notes

No further comments.

4.14 Airspace User Cost Efficiency

NA

4.15 Security

NA

4.16Human Performance

4.16.1HP arguments, activities and metrics

The HP Assessment performed for PJ02.03 ensured that relevant HP aspects have been identified and considered for the operational and technical development of the Minimum Pair Separations Based on Required Surveillance Performance concept, based on the HP Assessment Process methodology. This would support the reduction of the in-trail Minimum radar Separation from 2.5 NM to 2 NM on final approach in order to provide a direct positive impact on runway throughput. The conclusions of the HP Assessment work can be found in Part IV of the OSED- the HP Assessment Report where the requirements and recommendations identified for V3 have been formulated.

Considering the evidence gathered during the HP validation activities, with the respect to HP maturity criteria it can be concluded that the 2NM MRS on the final approach (AO-0309) with time based pairwise wake turbulence separations based on static aircraft characteristics for arriving aircraft (static Pair Wise Separations - PWS-A -AO-0310) with ORD (AO-0328) has completed a V3 level of maturity. The concept of 2.0NM MRS instead of 2.5NM MRS with ICAO DBS separations and no tool under nominal conditions in a single approach environment, has reached a V3 level of maturity. As a result, the status of the issues and benefits is closed.

PIs	Activities & Metrics	Second level indicators	Covered
HP1 Consistency of human role with respect to human capabilities and limitations	Stakeholder Workshop RTS	**HP1.1** Clarity and completeness of role and responsibilities of human actors	N/A
		HP1.2 Adequacy of operating methods (procedures) in supporting human performance	covered
		HP1.3 Capability of human actors to achieve their tasks in a timely manner, with limited error rate and acceptable workload level	covered
HP2 Suitability of technical system in supporting the tasks of human actors	Stakeholder Workshop RTS	**HP2.1** Adequacy of allocation of tasks between the human and the machine (i.e. level of automation).	covered
		HP2.2 Adequacy of technical systems in supporting Human Performance with respect to timeliness of system responses and accuracy of information provided	covered
		HP2.3 Adequacy of the human machine interface in supporting the human in carrying out their tasks.	Covered
HP3		**HP3.1** Adequacy of team composition in terms of identified roles	N/A
		HP3.2 Adequacy of task allocation among human actors	covered

PIs	Activities & Metrics	Second level indicators	Covered
Adequacy of team structure and team communication in supporting the human actors	Stakeholder Workshop RTS	**HP3.3** Adequacy of team communication with regard to information type, technical enablers and impact on situation awareness/workload	covered
HP4 Feasibility with regard to HP-related transition factors	Stakeholder Workshop RTS	**HP4.1** User acceptability of the proposed solution	covered
		HP4.2 Feasibility in relation to changes in competence requirements	covered
		HP4.3 Feasibility in relation to changes in staffing levels, shift organization and workforce relocation.	covered
		HP4.4 Feasibility in relation to changes in recruitment and selection requirements .	N/A
		HP4.5 Feasibility in terms of changes in training needs with regard to its contents, duration and modality.	N/A

4.16.2Extrapolation to ECAC wide

No ECAC wide extrapolation is required for this KPI.

4.16.3Open HP issues/ recommendations and requirements

A total number of 87 issues have been identified for PJ02.03. All issues have been closed.

PIs	Number of open issues/ benefits	Nr. of recommendations	Number of requirements
HP1 Consistency of human role with respect to human capabilities and limitations	**0 open issues**	**5 recommendations**	**6 requirements**
HP2 Suitability of technical system in supporting the tasks of human actors	**0 open issues**	**1 recommendations**	**2 requirements**
HP3 Adequacy of team structure and team communication in supporting the human actors	**0 open issue**	**N/A**	**N/A**
HP4 Feasibility with regard to HP-related transition factors	**0 open issues**	**N/A**	**2 requirements**

4.16.4Concept interaction

The following list of projects have been identified to interact with PJ02-03.

- SESAR Project PJ02 Increased Runway and Airport Throughput project members
- SESAR Project PJ01 Enhanced Arrivals and Departures project members
- SESAR Project PJ04 Total Airport Management project members
- SESAR Project PJ09 Advanced Demand & Capacity Balancing project members

However, the most prominent interaction has been identified from an HP perspective with PJ02-01. Therefore all requirements and recommendations applicable to a conditional application of reduced separations and the use of the ORD tool that have been formulated in PJ02-01 shall apply for PJ02-03 due to the conditional application of 2.0NM MRS.

Additionally, if the concept is implemented with the use of the ORD tool – which is recommended- all PJ02-01 ORD tool related requirements and recommendations shall apply as well.

4.16.5 Most important HP issues

Given the fact that through the stakeholder workshops and real time simulations all issues have been addressed and closed, the table below is not seen as applicable for the PJ02-03 concept. However, the formulated requirements indicate remaining issues to be addressed in local implementation.

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	N/A	N/A
	N/A	N/A
	N/A	N/A
HP2 Suitability of technical system in supporting the tasks of human actors	N/A	N/A
	N/A	N/A
	N/A	N/A
HP3 Adequacy of team structure and team communication in supporting the human actors	N/A	N/A
	N/A	N/A
	N/A	N/A
HP4 Feasibility with regard to HP-related transition factors	N/A	N/A
	N/A	N/A
	N/A	N/A
	N/A	N/A
	N/A	N/A

4.16.6Additional Comments and Notes

No further comments.

4.17 Gap Analysis

The objective of the gap analysis is a comparison between the validation targets and the performance assessment. Resume in next table the comparison done in sections 4.3.4, 4.4.4 and 4.13.4.

KPI	Validation Targets – Network Level (ECAC Wide)	Performance Benefits Expectations at Network Level (ECAC Wide or Local depending on the KPI)[14]	Rationale[15]
FEFF1: Fuel Efficiency – Fuel burn per flight	*6.07 kg*	*[0, 43.9] reduction kg of fuel per flight*	*Benefits depending on wake scheme used, wind conditions and traffic mix during peak.*
CAP3.2: Airport Capacity – Peak Runway Throughput (Segregated mode).	*1.299%*	*[0%, 13.7%] increase in movements/hour*	*Benefits depending on wake scheme used, wind conditions and traffic mix during peak.*
CEF2: ATCO Productivity – Flights per ATCO -Hour on duty	*0.667%*[16]	*[0, 5.7] increase in movements/hour equivalent to 13.7% increase*	*Benefits depending on wake scheme used, wind conditions and traffic mix during peak.*
SAF1: Safety - Total number of fatal accidents and incidents with ATM Contribution per year	*X%*[17]	*X No.* *And in addition the % reduction in the total number of fatal accidents per year to compare it with the Validation Targets*	

Table 15: Gap analysis Summary

[14] Negative impacts are indicated in red.

[15] 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).

[16] In Validation Targets [18] the unit for CEF2 is % increase in ATCO productivity.

[17] In Validation Targets [18] the unit for SAF1 is % reduction in the total number of fatal accidents per year.

It is to be noted that the benefits are mainly in challenging wind conditions on final approach. For non-challenging low wind conditions on final approach the benefits impact is towards zero.

As explained in the VALR and the sections above, in low wind conditions, MRS reduction has a positive impact only if RECAT-EU-PWS is applied. In strong headwind, MRS reduction impacts positively all KPIs for all separation schemes.

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

[3] PJ19.04 D4.4 Performance Framework (2018), Edition 01.00.00, August 2018

[4] B.05 Guidance for Performance Assessment Cycle 2013

[5] B.05 D72, Updated Performance Assessment in 2016

https://stellar.sesarju.eu/servlet/dl/ShowDocumentContent?doc_id=1669873.13&att=attachment&statEvent=Download

[6] B05 Data Collection and Repository Cycle 2015

[7] Methodology for the Performance Planning and Master Plan Maintenance (edition 0.13)

https://stellar.sesarju.eu/servlet/dl/ShowDocumentContent?doc_id=4731333.13&att=attachment&statEvent=Download

Content Integration

[8] B.04.01 D138 EATMA Guidance Material

[9] EATMA Community pages

[10]SESAR ATM Lexicon

Content Development

[11]PJ19.02.02 D2.1 SESAR 2020 Concept of Operations Edition 2017, Edition 01.00.00, November 2017

System and Service Development

[12]08.01.01 D52: SWIM Foundation v2

[13]08.01.01 D49: SWIM Compliance Criteria

[14]08.03.10 D45: ISRM Foundation v00.08.00

[15]B.04.03 D102 SESAR Working Method on Services

[16]B.04.03 D128 ADD SESAR1

[17]B.04.05 Common Service Foundation Method

Performance Management

[18]PJ19.04.01 D4.5 Validation Targets (2018), Edition 01.00.00, April 2018

https://stellar.sesarju.eu/servlet/dl/ShowDocumentContent?doc_id=6784461.13&att=attachment&statEvent=Download

[19]16.06.06-D68 Part 1 –SESAR Cost Benefit Analysis – Integrated Model

[20]16.06.06-D51-SESAR_1 Business Case Consolidated_Deliverable-00.01.00 and CBA

[21]Method to assess cost of European ATM improvements and technologies, EUROCONTROL (2014)

[22]ATM Cost Breakdown Structure_ed02_2014

[23]Standard Inputs for EUROCONTROL Cost Benefit Analyses

[24]16.06.06_D26-08 ATM CBA Quality Checklist

[25]16.06.06_D26_04_Guidelines_for_Producing_Benefit_and_Impact_Mechanisms

Validation

[26]03.00 D16 WP3 Engineering methodology

[27]Transition VALS SESAR 2020 - Consolidated deliverable with contribution from Operational Federating Projects

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

System Engineering

[29]SESAR Requirements and V&V guidelines

Safety

[30]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

[31]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

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

[33]Accident Incident Models – AIM, release 2017

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

Human Performance

[34]16.06.05 D 27 HP Reference Material D27

[35]16.04.02 D04 e-HP Repository - Release note

Environment Assessment

[36]SESAR, Environment Reference Material, alias, "Environmental impact assessment as part of the global SESAR validation", Project 16.06.03, Deliverable D26, 2014.

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

Security

[38]16.06.02 D103 SESAR Security Ref Material Level

[39]16.06.02 D137 Minimum Set of Security Controls (MSSCs).

[40]16.06.02 D131 Security Database Application (CTRL_S)

5.1 Reference Documents

[41]ED-78A GUIDELINES FOR APPROVAL OF THE PROVISION AND USE OF AIR TRAFFIC SERVICES SUPPORTED BY DATA COMMUNICATIONS.[18]

[42]SESAR Solution PJ02-03 SPR/INTEROP-OSED for V3 Part I , Edition 00.01.02, 21/11/2019

[43]SESAR Solution PJ02-03 Validation Plan part II Safety Plan, Edition 00.01.00, 11 March 2019

[44] SESAR Solution PJ02-03 SPR/INTEROP-OSED - Part IV - Safety Assessment Report (SAR) Ed. 00.00.04. 28th November 2019.

[45] SESAR Solution PJ02-03 Validation Report, Ed. 00.00.04. 28th June 2019.

[46] SESAR Solution PJ02-03 SPR/INTEROP-OSED - Part IV – Human Performance Assessment Report (HPAR) Part IV for V3: Human Performance Assessment Report. Ed. 00.01.00. 28th November 2019.

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