

PJ.02-W2-14.2 SPR- INTEROP/OSED V3 Part V - Final

Deliverable ID:	D4.2.002
Dissemination Level:	PU
Project Acronym:	AART
Grant:	874477
Call:	H2020-SESAR-2019-1
Topic:	SESAR-IR-VLD-WAVE2-03-2019 PJ.02 W2 Airport airside and runway throughput
Consortium Coordinator:	EUROCONTROL
Edition Date:	5 August 2022
Edition:	00.01.00
Template Edition:	00.00.09

Authoring & Approval

Authors of the document

Beneficiary	Date
EUROCONTROL	February 2021 to August 2022

Reviewers internal to the project

Beneficiary	Date
EUROCONTROL	August 2022

Reviewers external to the project

Beneficiary	Date
None	

Approved for submission to the S3JU By - Representatives of all beneficiaries involved in the project

Beneficiary	Date
EUROCONTROL	5 August 2022

Rejected By - Representatives of beneficiaries involved in the project

Beneficiary	Date
None	

Document History

Edition	Date	Status	Beneficiary	Justification
00.00.01	16/02/2021	Draft	EUROCONTROL	First draft from PJ02-02 W1 document
00.01.00	5/08/2022	Final	EUROCONTROL	Final version for Data Pack

Copyright Statement

© – 2022 – EUROCONTROL. All rights reserved. Licensed to SESAR3 Joint Undertaking under conditions.

AART

AIRPORT AIRSIDE AND RUNWAY THROUGHPUT

This Performance Assessment Report is part of a project that has received funding from the SESAR 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 2 Solution PJ.02-W2-14.2, SRAP Second Runway Aiming Point (Enhanced Arrival Procedures) which consists of the extrapolation to ECAC wide level of the performance assessment results obtained through validation activities conducted for the concepts in PJ02-02 scope.

Table of Contents

Abstract	3
1 Executive Summary	8
2 Introduction	12
2.1 Purpose of the document.....	12
2.2 Intended readership	12
2.3 Inputs from other projects	12
2.4 Glossary of terms.....	13
2.5 Acronyms and Terminology	13
3 Solution Scope	16
3.1 Detailed Description of the Solution.....	16
3.2 Detailed Description of relationship with other Solutions	16
4 Solution Performance Assessment	17
4.1 Assessment Sources and Summary of Validation Exercise Performance Results.....	17
4.2 Conditions / Assumptions for Applicability	18
4.3 Safety.....	20
4.3.1 Safety Criteria	20
4.3.2 Data collection and Assessment.....	25
4.3.3 Extrapolation to ECAC wide.....	31
4.3.4 Discussion of Assessment Result.....	31
4.3.5 Additional Comments and Notes	31
4.4 Environment / Fuel Efficiency.....	32
4.4.1 Performance Mechanism	32
4.4.2 Assessment Data (Exercises and Expectations).....	32
4.4.3 Extrapolation to ECAC wide.....	35
4.4.4 Discussion of Assessment Result.....	38
4.4.5 Additional Comments and Notes	38
4.5 Environment / Noise and Local Air Quality	39
4.5.1 Performance Mechanism	39
4.5.2 Assessment Data (Exercises and Expectations).....	40
4.5.3 Extrapolation to ECAC wide.....	62
4.5.4 Discussion of Assessment Result.....	62
4.5.5 Additional Comments and Notes	62
4.6 Airspace Capacity (Throughput / Airspace Volume & Time).....	63
4.7 Airport Capacity (Runway Throughput Flights/Hour)	64
4.7.1 Performance Mechanism	64
4.7.2 Assessment Data (Exercises and Expectations).....	64
4.7.3 Extrapolation to ECAC wide.....	66
4.7.4 Discussion of Assessment Results	66
4.7.5 Additional Comments and Notes	67
4.8 Resilience (% Loss of Airport & Airspace Capacity Avoided).....	67

69	4.9	Flight times	67
70	4.10	Predictability (Flight Duration Variability, against RBT)	67
71	4.11	Punctuality (% Departures < +/- 3 mins vs. schedule due to ATM causes)	67
72	4.12	Civil-Military Cooperation and Coordination (Distance and Fuel)	67
73	4.13	Flexibility	68
74	4.14	Cost Efficiency	68
75	4.14.1	Performance Mechanism.....	68
76	4.14.2	Assessment Data (Exercises and Expectations)	68
77	4.14.3	Extrapolation to ECAC wide	68
78	4.14.4	Discussion of Assessment Result	69
79	4.14.5	Additional Comments and Notes.....	69
80	4.15	Airspace User Cost Efficiency	70
81	4.16	Security	70
82	4.17	Human Performance	70
83	4.17.1	HP arguments, activities and metrics	70
84	4.17.2	Extrapolation to ECAC wide	71
85	4.17.3	Open HP issues/ recommendations and requirements.....	71
86	4.17.4	Concept interaction	71
87	4.17.5	Most important HP issues.....	71
88	4.17.6	Additional Comments and Notes.....	72
89	4.18	Other Pls	73
90	4.19	Gap Analysis	73
91	5	References	74
92	5.1	Reference Documents	76
93			
94		List of Tables	
95		Table 1: KPI Assessment Results Summary	9
96		Table 2: Mandatory Pls Assessment Summary	11
97		Table 3: Acronyms and terminology	15
98		Table 4: Relationships with other Solutions.....	16
99		Table 5: SESAR2020 W1 PJ02-02 Validation Exercises	17
100		Table 6: Summary of Validation Results.....	18
101		Table 7: Summary of the maximum throughput gain/loss compared to ICAO DBS with tool for the ICAO	
102		SRAP runs	19
103		Table 8: Summary of the maximum throughput gain/loss compared to ICAO DBS without tool for the	
104		ICAO SRAP runs	19
105		Table 9: Wake separation minima modification for operation of SRAP in combination with conventional	
106		(LOWER) procedure	26

107	Table 10: mean fuel burn for arrival per RECAT-EU category. (*) Values for Cat-A and Cat-C are obtained	
108	from Cat-B values weighted by the difference in averaged MLW of the category.....	33
109	Table 11: Fuel burn rates [kg/min] for the various traffic samples used for sensitivity analysis.....	34
110	Table 12: traffic mix based on RECAT-EU categories using the percentage of aircraft types reported in	
111	(Eurocontrol, January 2018)	34
112	Table 13: Summary of the fuel burn savings if operating the test schemes versus ICAO DBS at maximum	
113	test case traffic pressure for the different traffic mix.....	35
114	Table 14: Fuel burn reduction per flight phase.....	38
115	Table 15: Whole contour surfaces for airports with the largest fraction of MEDIUM aircraft, different	
116	dB levels.....	42
117	Table 16: Contour surfaces for $x \geq 0$ NM from runway threshold for airports with a large fraction of	
118	MEDIUM aircraft, different dB levels	43
119	Table 17: Contour surfaces for $x \geq 1$ NM from runway threshold for airports with a large fraction of	
120	MEDIUM aircraft, different dB levels	44
121	Table 18: Whole contour surfaces for airports with a large fraction of HEAVY aircraft, different dB levels	
122		47
123	Table 19: Contour surfaces for $x \geq 0$ NM from runway threshold for airports with a large fraction of	
124	HEAVY aircraft, different dB level	48
125	Table 20: Contour surfaces for $x \geq 1$ NM from runway threshold for airports with a large fraction of	
126	HEAVY aircraft, different dB levels.....	49
127	Table 21: Population associated to whole contours for airports with a large fraction of MEDIUM aircraft	
128		52
129	Table 22: Population associated to contours with $x \geq 0$ NM for airports with a large fraction of MEDIUM	
130	aircraft	53
131	Table 23: Population associated to contours with $x \geq 1$ NM for airports with a large fraction of MEDIUM	
132	aircraft	54
133	Table 24: Population associated to whole contours for airports with a large fraction of HEAVY aircraft	
134		56
135	Table 25: Population associated to contours with $x \geq 0$ NM for airports with a large fraction of HEAVY	
136	aircraft	57
137	Table 26: Population associated to contours with $x \geq 1$ NM for airports with a large fraction of HEAVY	
138	aircraft	58
139	Table 27: Relative scale of benefits associated to different solutions.....	59
140	Table 28: Gap analysis Summary.....	73
141		

List of Figures

Figure 1: Fuel burn rates for various aircraft types in flight phases (Source: (Eurocontrol, January 2018))	33
Figure 2: Averaged fuel burn rate in flight (Source: (Eurocontrol, January 2018))	34
Figure 3: Averaged flying time for IFR flights (Source: (Eurocontrol, January 2018))	35
Figure 4: Baseline for noise assessment	39
Figure 5: SRAP test case for noise assessment	39
Figure 6: Contour definitions	41
Figure 7: Baseline, SRAP contours (DEN) for EDDF and LFPO for the 60dB level	41
Figure 8: Comparison of contour surfaces for EDDF	45
Figure 9: Comparison of contour surfaces for EGLL	46
Figure 10: Comparison of contour surfaces for EHAM	46
Figure 11: Closest large residential area to runway 07L at EDDF	51
Figure 12: Closest large residential area to runway 09L at LFPG	51

1 Executive Summary

This document provides the Performance Assessment Report (PAR) for SESAR 2020 Wave 2 PJ.02-W2-14.2, Second Runway Aiming Point.

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

Description

PJ.02-W2-14.2 solution develops the Enhanced Arrival Operations using Second Runway Aiming Point (SRAP) with the objective of reducing environmental impact, mainly noise, and when possible, improving capacity.

This procedure can be guided by GBAS, RNP.

Assessment Results Summary:

The following tables summarises the assessment outcomes per KPI (Table 1) and mandatory PI (Table 2) puts them side-by side against Validation Targets in case of KPI from PJ19 [18]. The impact of a Solution on the performances are described in Benefit Impact Mechanism. All the KPI and mandatory PI from the Benefit Mechanism the Solution potentially affects, have to be assessed via validation results, expert judgment etc.

There are three cases:

1. An assessment result of 0 with confidence level other 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 have an impact on 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 have an impact at all on the KPI or mandatory PI consistently with the Benefit Mechanism.

KPI	Validation Network Wide)	Targets – Level (ECAC	Performance Benefits Expectations at Network Level (ECAC Wide or Local depending on the KPI) ¹	Confidence in Results ²
FEFF1: Fuel Efficiency – Fuel burn per flight	6.07 Kg		AO-0319 SRAP = [2.65, 55.1] reduction kg of fuel per flight	Medium
CAP3.2: Airport Capacity – Peak Runway Throughput (Segregated mode).	1.372%		AO-0319 SRAP = [-1.8%, 7.7%] increase in movements/hour	Medium
CEF2: ATCO Productivity – Flights per ATCO -Hour on duty	0.267%		AO-0319 SRAP = [-1.8%, 7.7%] increase in movements/hour	Medium
SAF1: Safety - Total number of fatal accidents and incidents with ATM Contribution per year	-0.12% MAC-TMA -0.22% RWY-CoI -1.05% CFIT -0.24% WAKE FAP		NA	Low

Table 1: KPI Assessment Results Summary

184

¹ Negative impacts are indicated in red.

² 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

Mandatory PI	Performance Benefits Expectations at Network Level (ECAC Wide or Local depending on the KPI) ³	Confidence in Results ⁴
SAF2.X: Mid-air collision – TMA	NA	NA
SAF3.X: RWY-collision accident	NA	NA
SAF6.X: CFIT accident	NA	NA
SAF7.X: Wake related accident	NA	NA
FEFF2: CO2 Emissions.	AO-0319 SRAP = [2.65, 55.1] reduction kg CO ₂ per flight	Medium
FEFF3: Reduction in average flight duration.	AO-0319 SRAP = [0.07, 0.94] reduction minutes per flight	Medium
NOI1: Relative noise scale	AO-0319 SRAP = [1] For Airport with large fraction of MEDIUM aircraft AO-0319 SRAP = [0-1] For Airport with large fraction of HEAVY aircraft	Medium
NOI2: Size and location of noise contours	AO-0319 SRAP 55db = [-0.75, 0.63] contour size evolution km2 AO-0319 SRAP 65db = [-0.33, -0.14] contour size evolution km2 AO-0319 SRAP 75db = [-0.13, -0.06] contour size evolution km2	Medium
NOI4: Number of people exposed to noise levels exceeding a given threshold	AO-0319 SRAP 55db = [-1920, 3780] residents AO-0319 SRAP 65db = [-1800, -840] residents AO-0319 SRAP 75db = [-480, -360] residents	Medium
LAQ1: Geographic distribution of pollutant concentrations	X (local)	X

³ Negative impacts are indicated in red.

⁴ 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

Mandatory PI	Performance Benefits Expectations at Network Level (ECAC Wide or Local depending on the KPI) ³	Confidence in Results ⁴
CAP4: Un-accommodated traffic reduction	AO-0319 SRAP = [-281, 1116] increase in flights/year	Medium
HP1: Consistency of human role with respect to human capabilities and limitations	HP1.1 Clarity and completeness of role and responsibilities of human actors Not covered 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 Adequacy of the human machine interface in supporting the human in carrying out their tasks. Covered	NA
HP3: Adequacy of team structure and team communication in supporting the human actors	HP3.1 Adequacy of team composition in terms of identified roles Not covered HP3.2 Adequacy of task allocation among human actors Not 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 Not covered HP4.3 Feasibility in relation to changes in staffing levels, shift organization and workforce relocation. Not covered HP4.4 Feasibility in relation to changes in recruitment and selection requirements. Not covered HP4.5 Feasibility in terms of changes in training needs with regard to its contents, duration and modality. Covered	NA

Table 2: Mandatory PIs Assessment Summary

2 Introduction

2.1 Purpose of the document

The Performance Assessment covers the Key Performance Areas (KPA) 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 SRAP Solution. It considers the guidance document on KPIs/PIs [3] for practical considerations, for example on metrics.

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.

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:

- 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.

- 221 - For guidance and support PJ19 have put in place the Community of Practice (CoP) within
222 STELLAR, gathering experts and providing best practices.

223 2.4 Glossary of terms

224 N/A

225 2.5 Acronyms and Terminology

Term	Definition
A/C	Aircraft
A-IGS	Adaptive Increased Glide Slope
AIM	Accident Incident Models
ANS	Air Navigation Service
ANSP	Air Navigation Service Provider
ATC	Air traffic Control
ATCO	Air traffic Controller
ATFM	Air Traffic Flow Management
ATM	Air Traffic Management
BAD	Benefits Assessment Date
BIM	
CBA	Cost Benefit Analysis
CCDF	Complementary Cumulative Density Function
CFIT	Control Flight Into Terrain
CSPR-ST	Closely Spaced Parallel Runways using Staggered Thresholds
DB	Deployment Baseline
DBS	Data Base System
EAP	Enhanced Arrival Procedures
E-ATMS	European Air Traffic Management System
EDDF	Frankfurt Airport
ECAC	European Civil Aviation Conference

EGCC	Manchester Airport
EGLL	Heathrow Airport
EHAM	Amsterdam Airport Schiphol
EIDW	Dublin Airport
FMS	Flight Management System
FTS	Fast Time Simulation
GBAS	Ground Based Augmentation System
HAZID	
HP	Human Performance
ICAO	International Civil Aviation Organization
IGE	In Ground Effect
IGS	Increased Glide Slope
IGS-to-SRAP	Increased Glide Slope to a Second Runway Aiming Point
ILS	Instrument Landing System
KPA	Key Performance Area
KPI	Key Performance Indicator
LDEN	
LHR	Heathrow Airport
MAC on FAP	Mid-Air Collision on Final Approach
MLW	Maximum Landing weight
N/A	Not Applicable
OGE	Out-of-Ground Effect
OI	Operational Improvement
ORD	
OSED	Operational Service and Environment Definition
PAR	Performance Assessment Report
PI	Performance Indicator
PWS	Pair Wise Separation(s)

QoS	Quality of Service
RECAT	Re-categorisation of Wake Turbulence Separation Minima
RIMCAS	Runway Incursion Monitoring and Conflict Alert System
RMC	Rolling Moment Coefficient
RNAV	Radio Navigation
RNP	Required Navigation Performance
ROT	Runway Occupancy Time
RTS	Real Time Simulation
RWY EXC	Runway Excursion
RWY Col	Runway Collision
SAC	Safety Criteria
SESAR	Single European Sky ATM Research Programme
SJU	SESAR Joint Undertaking (Agency of the European Commission)
SO	Safety Objective
SRAP	Second Runway Aiming Point
SRM	
TDZ	Touchdown Zone
TMA	Terminal Manoeuvring Area
VALP	Validation planning??
VALR	Validation Report
WT on FAP	Wake Turbulence on Final Approach
WVE	Wake Vortex Encounter

Table 3: Acronyms and terminology

3 Solution Scope

3.1 Detailed Description of the Solution

PJ.02-W2-14.2 solution develops the Enhanced Arrival procedures using Second Runway Aiming Point (SRAP) with the objectives of reducing environmental impact, mainly noise, and when possible, improving capacity.

This procedure can be guided by GBAS, RNP.

PJ.02-W2-14.2 will be active, in addition to the standard approach procedure.

3.2 Detailed Description of relationship with other Solutions

PJ.02-W2-14.2 is using a controller separation assistance tool based on the tool developed in SESAR W 2020 W1 PJ02-01, to help controllers apply the complex separations between aircraft flying or not an enhanced procedure.

Solution Number	Solution Title	Relationship	Rational for the relationship
PJ02-01	Wake turbulence separation optimization	PJ.02-W2-14.2 is using a tool from PJ02-01	The tool developed in PJ02-01 is able to manage complex separation tables linked to wake vortex categories. Similarly, the separation tables that have to be used in PJ02-02 to ensure correct wake separation between aircraft flying on different glides towards the same runway, are complex and linked to the same wake vortex categories. Therefore, the tool from PJ02-01 is a basis of what is needed in PJ02-02 where more tables have to be applied according to which aircraft is on which glide slope.

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.) are relevant for this assessment. No performance assessment will be performed in SESAR 2020 W2 for solution PJ.02-W2-14.2.

The document is developed on activities performed in SESAR 2020 W1, solution PJ02-02.

SESAR 2020 W1 PJ02-02 performed height validation activities, four fast time simulations and four real time simulations. They are listed in the table below.

Exercise ID	Exercise Title	Release	Maturity	Status
F06	Assessment of capacity and environmental impact of SRAP concept	R9	V3	Report was not available when PAR was written
F08	Assessment of the capacity and environmental impact of Enhanced Arrival procedures using Secondary Runway Aiming Points (SRAP) at Spanish airport	R9	V3	Finished
F12	FTS on SRAP	R9	V3	Finished
F13	Evaluation of benefits/drawbacks of SRAP.	R9	V3	Finished
R02	Second Runway Aiming Point (SRAP)	R9	V3	Finished
R03	Second Runway Aiming Point (SRAP)	R9	V3	Finished
R05	Runway Marking and Lighting for SRAP	R9	V3	Finished
R07	Assessment of HP and safety impact of SRAP concept	R9	V3	Report available mid-November 2019

Table 5: SESAR2020 W1 PJ02-02 Validation Exercises

Among these validation activities, only fast-time simulations have been considered relevant when developing the Performance Assessment report. Real-time simulations were excluded because too little runs took place to provide results statistically meaningful.

Among the four fast-time simulations, FTS8 and FTS9 were as well not considered for the following reasons:

- F08 considered the particular case of a second threshold distant of less than 1000m from the existing one. That case is not developed by PJ02-02.
- F09 reported that a second threshold distance of 1000m is not a realistic option for the considered airport's current layout. This circumstance led to the development of solution scenarios from whom it was not possible to obtain results suitable for contributing to the performance assessment.

So main data used to develop the Performance Assessment Report come from one fast-time exercises, F13, as F06 report was not available when the PAR W1 was developed.

The following table provides a summary of information collected from available performance outcomes. Refer to [41] for detailed results.

Exercise	OI Step	Exercise scenario & scope	Performance Results
F13	AO-0319	Fast Time simulation to evaluate benefits/drawbacks in terms of Throughput, number of go-arounds, separation delivery accuracy and fuel burn SRAP.	Most of the runs show an increase in throughput. In a few examples, the throughput is decreased by 5-10% but if taken overall, it is either maintained or increased.

Table 6: Summary of Validation Results.

4.2 Conditions / Assumptions for Applicability

SRAP leads to a capacity increase (in most cases) combined with noise reduction in the airport surroundings.

Nevertheless, the runway needs to be long enough to accommodate the implementation of the second threshold, and local studies need to be performed to evaluate the impact of the use of the second threshold on runway occupancy time, according to the position of the exits usable by aircraft landing on the second threshold.

Capacity benefits depend on the percentage of Medium aircraft able to fly SRAP and on the distance between the two thresholds. In addition, benefits are as well influenced by the number of glide interception altitudes implemented.

The two tables below show the capacity loss or gain with (Table 7) and without (Table 8) a controller separation assistance tool, for different SRAP configurations (the distance corresponds to the vertical distance between the two glides at one wingspan from the first threshold), for ICAO separations.

%age Medium on SRAP	10%	25%	50%		75%	100%	
Separation scheme			min	max		min	max
ICAO SRAP 45 m 1 inter alt	-3.9%	-7.0%	-19.6%	-5.1%	-3.5%	-1.3%	-0.8%
ICAO SRAP 45 m 2 inter alt	-3.7%	-6.7%	-19.6%	-4.8%	-3.2%	-1.3%	-0.4%

ICAO SRAP 60 m 1 inter alt	-3.5%	-6.7%	-19.6%	-4.9%	-3.2%	-0.9%	-0.4%
ICAO SRAP 60 m 2 inter alt	-2.8%	-5.0%	-19.5%	-2.8%	-1.0%	-0.6%	2.2%
ICAO SRAP 65 m 1 inter alt	-3.5%	-6.7%	-19.6%	-4.9%	-3.2%	-0.9%	-0.4%
ICAO SRAP 65 m 2 inter alt	-1.6%	-2.5%	-17.9%	0.5%	1.7%	0.7%	5.3%

Table 7: Summary of the maximum throughput gain/loss compared to ICAO DBS with tool for the ICAO SRAP runs

%age Medium on SRAP	10%	25%	50%		75%	100%	
Separation scheme			min	max		min	max
ICAO DBS w/ tool	-0.6%	-0.6%	-1.7%	-0.2%	-0.6%	-1.7%	-0.2%
ICAO SRAP 45 m 1 inter alt	-4.5%	-7.6%	-21.0%	-5.5%	-4.2%	-2.9%	-1.3%
ICAO SRAP 45 m 2 inter alt	-4.3%	-7.3%	-21.0%	-5.2%	-3.8%	-2.9%	-0.7%
ICAO SRAP 60 m 1 inter alt	-4.1%	-7.3%	-20.9%	-5.3%	-3.8%	-2.6%	-0.9%
ICAO SRAP 60 m 2 inter alt	-3.5%	-5.7%	-20.8%	-3.2%	-1.6%	-2.2%	1.9%
ICAO SRAP 65 m 1 inter alt	-4.1%	-7.3%	-20.9%	-5.3%	-3.8%	-2.6%	-0.9%
ICAO SRAP 65 m 2 inter alt	-2.3%	-3.1%	-19.3%	0.1%	1.0%	-1.0%	4.8%

Table 8: Summary of the maximum throughput gain/loss compared to ICAO DBS without tool for the ICAO SRAP runs

4.3 Safety

The information reported here refers to the V3 phase outcomes of PJ.02 Solution 02; it has been collected from the Safety Plan [42], Safety Assessment Report [43] and Validation Report [41].

4.3.1 Safety Criteria

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 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 performance targets defined by PJ 19.04. The following AIM models have been considered 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)
- Control Flight Into Terrain (CFIT)
- Runway Excursion (RWY EXC)

The Safety Assessment addresses all the PJ02.02 OI steps, namely:

- AO – 0319 - Enhanced Arrival procedures using Second Runway Aiming Points (SRAP)

Two sets of safety criteria are formulated:

- A first one aimed at ensuring an appropriate Separation design i.e. definition of WT separation minima which, if correctly applied in operations, guarantee safe operations on final approach segment and respectively on initial common approach path;
- A second one aimed at ensuring the Final Approach path is correctly intercepted and flown, the Separation is delivered correctly (i.e. that the defined WT separation minima or the minimum surveillance separation are correctly applied for separation delivery by ATC) and the RWY separation is not infringed.

SEPARATION DESIGN

The following definition will be employed to designate a **pair of aircraft**:

Two consecutive arrivals at same runway, OR two consecutive arrivals at Dependant or Closely Spaced Parallel Runways OR an arrival following a departure in Mixed mode on same runway or on Dependent or CSPRs.

A SAC dedicated to each enhanced arrival concept (involving adaptations of the WT scheme in order to account for the displaced glide path in terms of slope and/or aiming point) is defined such as to encompass all types of operations/RWY configuration in which a pair of aircraft can be found, driven by the WT accident on Final Approach AIM model.

- on risk of WT Encounter⁵ on Final Approach (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”):

SRAP-SAC#WT-1: The probability per approach of wake turbulence encounter of a given severity for a given traffic pair for any type of operations/RWY configuration in which that pair of aircraft can be found spaced on Final Approach segment at the WT minima adapted in order to account for the applied SRAP concept shall not increase compared to the same traffic pair spaced at reference distance WTC-based minima conducted on a nominal (3°) and continuous final approach path angle, with a non-displaced threshold, in reasonable worst case conditions*.

** Reasonable worst-case conditions recognized for WT separation design

Once the Design has met the SAC above, the following safety issue still remains to be addressed:

Safety issue: The frequency of wake turbulence encounters at lower severity levels might increase due to the reduced wake turbulence separation minima. As the frequency of wake turbulence encounters at each level of severity depends on local traffic mix, local wind conditions and intensity of application of the concept (e.g. proportion of time, proportion of aircraft), there is a need to find a suitable way for controlling the associated potential for WT-related risk increase.

An additional SAC is defined in order to cap the safety risk from the case where the correctly defined WT separation minima are not correctly applied, with potential for severe wake encounter higher than if those minima were correctly applied.

- on risk of Imminent wake encounter under unmanaged under-separation (see WE 6F in AIM WTA Final Approach model):

SRAP-SAC#WT-F1: The probability per approach of imminent wake encounter under unmanaged under-separation on Final Approach for any type of operations/RWY configuration in which a pair of aircraft can be found shall be no greater in operations with applicable WT minima adapted in order to account for the applied SRAP concept than in current operations applying reference distance WTC-based minima on a nominal (3°) and continuous final approach path angle, with a non-displaced threshold.

The strategy intended for meeting the SRAP-SAC#WT-F1 relies upon qualitatively showing that the use of the separation supporting tool will involve a significant reduction of the frequency of unmanaged

⁵ In case of aircraft inability to recover from a severe wake encounter a wake accident will occur (encompassing loss of control or uncontrolled flight into terrain; that is not related to the Controlled Flight into Terrain accident and associated AIM model)

under-separations which will compensate for the risk increase brought in by the higher probability of imminent wake encounter associated to those unmanaged under-separations.

FINAL APPROACH PATH INTERCEPTED&FLOWN, SEPARATION DELIVERY and RWY SEPARATION

A set of SACs, dedicated to SRAP enhanced arrival procedure/concept, are defined in order to ensure that the Final Approach path is correctly intercepted and flown (encompassing safe landing and RWY vacation), that the adapted WT separation minima or the Minimum Radar Separation (MRS) are correctly applied for separation delivery and that the runway separation is ensured, i.e. that the right Functional System in terms of People, Procedures, Equipment (e.g. new airborne functionalities, ATC separation delivery tool) is designed such as to enable safe operations in the concept.

FINAL APPROACH PATH INTERCEPTED&FLOWN (encompassing safe landing & RWY vacation)

- on risk of Controlled Flight Towards Terrain (see CF4 following failure of B4: Flight Crew Monitoring in AIM CFIT model):

SRAP-SAC#CFIT-1: The likelihood of “Controlled Flight Towards Terrain” on final approach segment during SRAP operations shall not increase compared to current operations conducted with a nominal (3°) and continuous final approach path angle, with a non-displaced threshold.

- on risk of Flight towards terrain commanded by Pilot (see CF5 following failure of B5: Pilot trajectory management barrier in AIM CFIT model):

SRAP-SAC#CFIT-2: The likelihood of Flight towards terrain commanded by Pilot on final approach segment during SRAP operations shall not increase compared to current operations conducted with a nominal (3°) and continuous final approach path angle, with a non-displaced threshold.

- on risk of Flight towards terrain commanded by Airborne Systems (see CF6 following failure of B6: FMS/RNAV/Flight control management barrier in AIM CFIT model):

SRAP-SAC#CFIT-3: The likelihood of Flight towards terrain commanded by Airborne Systems on final approach segment during SRAP operations shall not increase compared to current operations conducted with a nominal (3°) and continuous final approach path angle, with a non-displaced threshold.

- on risk of Flight towards terrain commanded by ATC (see CF7 following failure of B7: ATC Flight trajectory management barrier in AIM CFIT model):

SRAP-SAC#CFIT-4: The likelihood of Flight towards terrain commanded by ATC on final approach segment during SRAP operations shall not increase compared to current operations conducted with a nominal (3°) and continuous final approach path angle, with a non-displaced threshold.

- on risk of Flight towards terrain commanded by ANS (see CF8 following failure of B8: Route/Procedure design and publication barrier in AIM CFIT model):

SRAP-SAC#CFIT-5: The likelihood of Flight towards terrain commanded by ANS on final approach segment during SRAP operations shall not increase compared to current operations

conducted with a nominal (3°) and continuous final approach path angle, with a non-displaced threshold.

- On risk of Runway excursion following stabilised touchdown in Touch Down Zone (TDZ) (see Failure of Crew/AC for RWY deceleration/stopping action barrier following stabilised touchdown in TDZ in AIM RWY Excursion model):

SRAP-SAC#RWE-1: The likelihood of Runway excursion following stabilised touchdown in TDZ during SRAP operations shall not increase compared to current operations conducted with a nominal (3°) and continuous final approach path angle, with a non-displaced threshold.

- On risk of Runway excursion following touchdown outside TDZ (see Failure of Crew/AC for RWY deceleration/stopping action barrier following touchdown outside TDZ in AIM RWY Excursion model):

SRAP-SAC#RWE-2: The likelihood of Runway excursion following touchdown outside TDZ during SRAP operations shall not increase compared to current operations conducted with a nominal (3°) and continuous final approach path angle, with a non-displaced threshold.

- On risk of Runway excursion following unstable touchdown (e.g. hard landing) (see Failure of Crew/AC for RWY deceleration/stopping action barrier following unstable touchdown in AIM RWY Excursion model):

SRAP-SAC#RWE-3: The likelihood of Runway accident following unstable touchdown (e.g. hard landing) during SRAP operations shall not increase compared to current operations conducted with a nominal (3°) and continuous final approach path angle, with a non-displaced threshold.

- On risk of Touchdown outside TDZ (see Failure to manage short Final & Flare barrier following Stable or Unstable approach in AIM RWY Excursion model):

SRAP-SAC#RWE-4: The likelihood of Touchdown outside TDZ during SRAP operations shall not increase compared to ILS CAT I operations conducted with a nominal (3°) and continuous final approach path angle, with a non-displaced threshold.

- On risk of Unstable touchdown e.g. Hard landing (see Failure to manage short Final & Flare barrier following Stable or Unstable approach in AIM RWY Excursion model):

SRAP-SAC#RWE-5: The likelihood of Unstable touchdown (e.g. Hard landing) during SRAP operations shall not increase compared to current operations conducted with a nominal (3°) and continuous final approach path angle, with a non-displaced threshold.

- on risk of Unstable approach (following Failure to manage stabilization on Final Approach barrier in AIM RWY Excursion model):

SRAP-SAC#RWE-6: The likelihood of Unstable approach during SRAP operations shall not increase compared to current operations conducted with a nominal (3°) and continuous final approach path angle, with a non-displaced threshold.

WAKE SEPARATION DESIGN

The correct application of WT separation minima need to account for the additional separation constraints imposed by the Surveillance separation (during interception and along the final approach path).

- on risk of Unmanaged under-separation (WT or radar) during interception and final approach when WT separation minima adapted to the enhanced arrival procedure are applicable (see WE 7F.1 in AIM WT on Final Approach model and account for MRS minima):

SRAP-SAC#WT-F2: The probability per approach of Unmanaged under-separation (WT or radar) during interception & final approach when WT separation minima adapted to the SRAP procedure are applicable shall be no greater than in current operations applying reference distance WTC-based minima on a nominal (3°) and continuous glide path angle, with a non-displaced threshold.

- on risk of Imminent infringement (WT or radar) during interception and final approach (see WE 8 in AIM WT accident on Final Approach model and account for MRS minima):

SRAP-SAC#WT-F4: The probability per approach of Imminent infringement (WT or radar) during Interception & final approach shall be no greater when WT separation minima adapted to the SRAP procedure are applicable than in current operations applying reference distance WTC-based minima on a nominal (3°) and continuous glide path angle, with a non-displaced threshold.

- on risk of Crew/Aircraft induced spacing conflicts (spacing conflicts induced by Crew/Aircraft and not related to ATC instructions for speed adjustment) during interception and final approach (see WE 10/11 in AIM WT accident on Final Approach model):

SRAP-SAC#WT-F5: The probability per approach of Crew/Aircraft induced spacing conflicts during interception & final approach shall be no greater when WT separation minima adapted to the SRAP procedure are applicable than in current operations applying reference distance WTC-based minima on a nominal (3°) and continuous glide path angle, with a non-displaced threshold.

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

SRAP-SAC#F1: The probability per approach of Imminent collision during interception and final approach shall be no greater in operations when SRAP procedure are applicable than in current operations applying reference distance minima on nominal (3°) and continuous glide path angle, with a non-displaced threshold.

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

SRAP-SAC#F2: The probability per approach of Imminent infringement (radar separation) during interception and final approach shall be no greater in operations when SRAP procedures are applicable than in current operations applying reference distance minima on nominal (3°) and continuous glide path angle, with a non-displaced threshold.

RUNWAY SEPARATION

- on risk of Imminent Inappropriate Landing in the context of a possible decreased situation awareness & overload of the ATCO in relation to RWY increased throughput enabled by the concepts (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; outcome 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):

SRAP-SAC#R-1: The probability per approach of Runway Conflict during SRAP operations resulting from Conflicting ATC Clearances shall not increase compared to current operations conducted with a nominal (3°) and continuous glide path angle, with a non-displaced threshold.

- on risk of Runway conflict due to premature landing or unauthorised RWY entry of A/C or vehicle in the context of a possible decreased situation awareness & overload of the ATCO in relation to RWY increased throughput enabled by the concepts (see AIM RWY collision model 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):

A-SAC#R-2: The probability per approach of Runway Conflict not prevented by ATC (due to decreased situation awareness & overload in relation to RWY increased throughput enabled by the Concept) involving unauthorised runway entry of A/ C or vehicle shall not increase during SRAP operations compared to current operations conducted with a nominal (3°) and continuous glide path angle, with a non-displaced threshold.

4.3.2 Data collection and Assessment

4.3.2.1 Wake Separation Design

The wake separation minima for SRAP operations in combination with a conventional (Lower) glide are determined based on the following principle:

- For a pair for which both aircraft follow the same glide (either conventional or SRAP), the wake separation minima are not modified compared to the currently applied separation scheme.
- For a pair for which the leader aircraft follows an upper SRAP glide and the follower follows a lower glide, the wake separation minima are increased (Detailed results are provided in OSD Annex)
- For a pair for which the leader aircraft follows a conventional glide and the follower follows an upper glide, the wake separation minima are reduced depending on the glide altitude difference at one wingspan altitude of the conventional glide (Detailed results are provided in OSD Annex)

Those three rules are applied to the SRAP concept in the following subsections.

A separation computation tool is provided in OSD Part I Appendix D.

For SRAP operations, see Table 9, the separation minima can be reduced for leader on conventional glide and follower on second aiming point depending on the glide altitude difference. For leader on

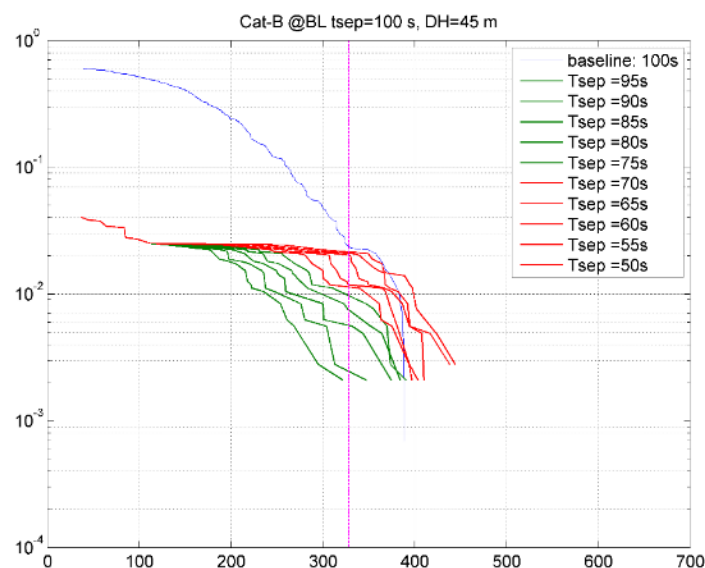
SRAP followed by follower on conventional glide, the separation minima are increased due to the altitude difference in OGE region.

Follower on CONVENTIONAL			Follower on SRAP
Leader on CONVENTIONAL	Baseline	Separation reduction	
Leader on SRAP	Separation increase	Same as baseline	

Table 9: Wake separation minima modification for operation of SRAP in combination with conventional (LOWER) procedure

For In-Ground Effect (IGE) region, the allowed time separation reduction when operating SRAP behind ILS approach, depending on the glide altitude difference is assessed by comparing for each pair type the distribution of RMC compared to that of the baseline (i.e. two consecutive ILS approaches). The allowed separation reduction is that providing an RMC distribution below the baseline one at least for RMC values below the RMC threshold value (with a tolerance of one data point).

The following figure provides an illustration of a CCDF(RMC) comparison results for CAT-B-CAT-D with leader on ILS @ one wind span altitude and follower following a SRAP DH=45 m above the ILS with various separation reductions compared to the baseline time separation (100 s)



On the contrary, for Out-of-Ground Effect (OGE) situation, when an aircraft on a lower glide follows an aircraft flying on an upper SRAP glide, the risk of wake encounter significantly. Indeed, due to the slow decay of wake vortices evolving OGE and the increased exposure frequency due to the follower being always below the leader all along the glide with wake tending to sink.

For that reason, and whatever the altitude difference between the two glides, the separation minima are increased in order to reduce the severity of those potential encounters. The maximum median severity accepted for wake separation minima is here set to RMC=0.04, which represent the absolute maximum acceptable RMC value OGE based on Flight simulator campaign (WISA). The maximum

vortex strength guaranteeing $RMC \leq 0.04$ for any leader and follower at final approach speed is then computed per RECAT-EU category based on RECAT-EU-PWS 96 more frequent aircraft types.

Detailed results on wake separation design are provided in the OSED Part I Section 8 and Appendix A.

For SRAP separation design listed above, the safety criteria for wake separation design are satisfied. Regarding the safety issue expressed about the possible increase of low severity encounters, the results from the wake turbulence safety analysis on the SRAP separation design indicated that such issue is not expected with SRAP as designed. Based on the comparison of risk curves (CCDFs) of allowed time reduction to the reference for all range of wake circulation/strength (characterising the WVE severity), including lower to higher levels, it is shown that the risk of encounter of low severity occurrences is not increased.

4.3.2.2 Final approach and runway separation

The information reported here has been extracted from sections 3.10 and 4.6 from the SAR [43]

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 SRAP 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 [43] 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 PJ02.02. 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.

It should be noted that only the safety relevant validation exercises were included in the next table. All the exercises where it was not deemed necessary to derive safety validation objectives were not stated (e.g. FTS06).

551

Exercise ID, Name, Objective	Exercise Validation objective	Success criterion	Safety Criteria coverage	Validation results & Level of safety evidence
RTS02: RTS conducted by EUROCONTROL in the CDG airport environment to assess the application of the Second Runway Aiming Point (SRAP), in comparison to the conventional approach procedure (ILS featuring a 3° glideslope).	OBJ-02.02-V3-VALP-SRAP.0103 / OBJ-02.02-V3-VALP-ITSR.0103 To confirm that Secondary Runway Aiming Point (SRAP) approach procedure do not negatively affect safety from ATC perspective	CRT-02.02-V3-VALP-SRAP.0103-001 / CRT-02.02-V3-VALP-ITSR.0103-001 There is evidence that the level of operational safety is maintained and not negatively impacted under SRAP procedure compared to the reference scenario from ATC perspective	SRAP-SAC#WT-F2, SRAP-SAC#WT-F4, SRAP-SAC#R-1	No safety related concerns were found in relation to the use of the ORD tool and the SRAP procedure. Safe standard controller practices are used when performing SRAP with ORD tool. Controller feedback and observations indicated that there is no increase in potential human errors with safety implications due to the introduction of SRAP with ORD tool (e.g. either in terms of the severity of current potential human errors or introduction of new potential causes for human errors).
		CRT-02.02-V3-VALP-SRAP.0103-002 / CRT-02.02-V3-VALP-ITSR.0103-002 The probability of aircraft being under-separated and therefore experiencing a wake encounter is not increased under SRAP procedure compared to the reference scenario	SRAP-SAC#WT-F2, SRAP-SAC#WT-F4	The results show that the use of SRAP arrival procedure with ORD tool decreases the percentage of under-spaced aircraft, as compared to the baseline scenario. The probability of go-arounds induced by under-spacing was also less than the reference scenario.

		CRT-02.02-V3-VALP-SRAP.0103-003 / CRT-02.02-V3-VALP-ITSR.0103-003 The probability of a go-around due to inadequate consideration of ROT constraint is not increased under SRAP procedure compared to the reference scenario	SRAP-SAC#R-1	
RTS03: RTS conducted by EUROCONTROL in the CDG airport environment to assess the application of the Second Runway Aiming Point (SRAP) concept in comparison to the conventional approach procedure (typically a 3° glide slope with an ILS procedure).	OBJ-02.02-V3-VALP-SRAP.0103 / OBJ-02.02-V3-VALP-ITSR.0103 To confirm that Secondary Runway Aiming Point (SRAP) approach procedure does not negatively affect safety from ATC perspective	CRT-02.02-V3-VALP-SRAP.0103-001 / CRT-02.02-V3-VALP-ITSR.0103-001 There is evidence that the level of operational safety is maintained and not negatively impacted under SRAP procedure compared to the reference scenario from ATC perspective	SRAP-SAC#WT-F2, SRAP-SAC#WT-F4, SRAP-SAC#R-1	Based on observations and data from the simulation, it has been concluded that the operational safety was not affected when applying SRAP. The controllers did not experience safety issues during the simulations.
		CRT-02.02-V3-VALP-SRAP.0103-002 / CRT-02.02-V3-VALP-ITSR.0103-002 The probability of aircraft being under-separated and therefore experiencing a wake encounter is not increased under SRAP procedure	SRAP-SAC#WT-F2, SRAP-SAC#WT-F4	The results showed that the use of the SRAP arrival procedures with the ORD tool decreased the percentage of under-spaced aircraft conditions compared to the baseline scenario.

		compared to the reference scenario		
		CRT-02.02-V3-VALP-SRAP.0103-003 / CRT-02.02-V3-VALP-ITSR.0103-003 The probability of a go-around due to inadequate consideration of ROT constraint is not increased under SRAP procedure compared to the reference scenario	SRAP-SAC#R-1	An increase in the number of go-arounds was observed in the reference scenario compared to the solution scenario. It can be concluded therefore that the probability of a go-around is not increased in the solution scenario compared to the reference scenario.

552

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 (CDG airport - either single runway segregated arrivals operations or closely spaced parallel runways in mix mode) 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 an additional input for the business case.

4.4.1 Performance Mechanism

The Second Runway Aiming Point (SRAP) depending on the way it is operated, impacts the wake separation between aircraft, by delivering aircraft at threshold closer there is a reduction of flying time that also impacts fuel and emissions. See the BIM in the OSD Part I for more details.

From a wake point of view, the wake separations for the SRAP concept are only defined by the guaranteed altitude difference between the conventional glide and the SRAP glide at one generator wing span altitude. Three altitude differences are here investigated: 45 m, 60 m and 65 m leading to increasing separation reductions. The way this difference is operationally set-up depends on the chosen glide parameters (glide slope or aiming point displacement) and on the vertical navigation system uncertainty when operating on the SRAP glide.

For instance, an altitude difference of 45 m can be obtained with

- SRAP with 1110 m aiming point displacement when navigating with GBAS (or ILS) on SRAP glide ($TSE_{vert}=13$ m)

4.4.2 Assessment Data (Exercises and Expectations)

Fuel Efficiency benefits due to the application of operational concepts addressed by PJ02.02 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 FTS12 and FTS13. See VALR for details about the exercise.

FTS12 looked at (LHR) and one traffic sample (based on 2018 traffic), representing a typical daily traffic at London Heathrow. The Fast Time simulation exercise has been conducted with two different allocations of equipped aircraft within the simulated day (medium BAW aircraft and all medium aircraft). However, some of the constraints applicable to LHR may not be faced at other airports, which could lead to different results at other airports).

In FTS13, different traffic samples have been assessed for the different solution scenarios (5 OIs) and compared to the reference scenario (ICAO DBS). The results are not in contradiction with the FTS12 and are used for the KPI analysis. For details on the FTS results see the VALR.

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 affect the aircraft trajectories and hence their flying time. Moreover, a go-around also significantly increases the flying time that is taken into account by the model.

The relationship between the averaged flying time reduction compared to the reference and fuel burn savings is then established using assumptions found in [36]. In particular, the fuel burn rates for arrival management per RECAT category is obtained as an average of the value provided for several aircraft (see Figure 1). The value for Cat-A and Cat-C aircraft types are obtained from Cat-B value weighted by the differences in averaged MLW per category, see Table 10. Two scenarios are considered: aircraft

weight at 50 % of mx useful load and aircraft weight at 65% of max useful load. Table 10 also provided the mean fuel burn rate for each traffic sample obtained as the average weighted by the traffic mix of each traffic sample. As expected, traffic samples with a higher fraction of heavy aircraft types show larger fuel burn rates.

Value	Fuel burn rates (kg/minutes) in flight phases where delay can occur for most flying and representative A/C types.					
	Flight phase:	Taxi	En route		Arrival management	
	Weight: (% of max useful load)	N/A	65	80	50	65
	Scheduled AC Type					
	B738	12.0	37.7	40.7	36.0	38.3
	A320	11.5	38.5	41.7	35.6	37.4
	A319	10.0	34.8	37.4	35.6	37.0
	A321	13.5	41.7	45.1	40.9	43.1
	E190	9.0	28.8	31.2	27.7	28.9
	DH8D	-	17.1	17.7	14.5	15.0
	B737	12.0	33.3	35.9	32.7	34.6
	CRJ9	-	25.2	27.2	17.0	18.1
	A332	25.0	94.4	102.5	80.4	85.7
	B77W	32.7	144.4	159.4	110.9	125.8
	Business AC Type					
	C56X	-	7.7	8.2	7.7	7.9
	BE20	-	3.9	4.2	4.3	4.4
	PC12	-	2.4	2.6	3.7	3.8
	C510	-	4.7	4.9	4.8	5.0
	F2TH	-	11.5	12.6	9.3	9.7
	Rotorcraft AC Type					
	S92	N/A	8.8	9.5	6.9	7.3
	A139	N/A	5.8	6.1	4.8	5.0
	EC25	N/A	9.0	9.6	6.9	7.3
	EC55	N/A	4.7	4.9	3.7	3.9
Source	EUROCONTROL BADA (Base of Aircraft Data) http://www.eurocontrol.int/services/bada					

Figure 1: Fuel burn rates for various aircraft types in flight phases (Source: (Eurocontrol, January 2018))

	fuel burn rate arrival [kg/min] 50 % max useful load	fuel burn rate arrival [kg/min] 65 % max useful load
Cat-A	162.6*	179.8*
Cat-B	95.7	105.8
Cat-C	61.1*	67.5*
Cat-D	36.2	38.1
Cat-E	19.7	20.7
Cat-F	6.0	6.2

Table 10: mean fuel burn for arrival per RECAT-EU category. (*) Values for Cat-A and Cat-C are obtained from Cat-B values weighted by the difference in averaged MLW of the category

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

(Eurocontrol, January 2018) also reports an average fuel burn per minute of flight of 49 kg when considering all phases of flight and all aircraft types, see Figure 2.

Value 1	1) Average fuel burn per minute of flight = 49 kg 2) Average fuel burn per nautical mile (NM) of flight = 11 kg
Source 1	ICAO (2007) - "Global Aviation Plan", ICAO, Doc 9750 AN/963, 3rd Ed. 2007 (Attachment 1, App-H08) http://www.icao.int/publications/Documents/9750_3ed_en.pdf
Description 1	1) This number is derived by dividing the total JET A1 consumption (55 billion US gal) by the total of minutes flown (3.4 billion) by all airlines (scheduled and non-scheduled) as per IATA statistics for 2005. 2) This number is derived by dividing the total JET A1 consumption (55 billion US gal) by the total of kilometres flown (27.9 billion) by all airlines (scheduled and non-scheduled) as per IATA statistics for 2005.

Figure 2: Averaged fuel burn rate in flight (Source: (Eurocontrol, January 2018))

Note that this average depends on the aircraft traffic mix. (Eurocontrol, January 2018) It provides the percentage of most frequent aircraft in Europe. Using that list the traffic mix per RECAT category is obtained. It is provided in Table 12.

% in traffic mix	
Cat-A	1%
Cat-B	17%
Cat-C	5%
Cat-D	40%
Cat-E	27%
Cat-F	10%

Table 12: traffic mix based on RECAT-EU categories using the percentage of aircraft types reported in (Eurocontrol, January 2018)

For this traffic mix, the arrival fuel burn rate is 42.3 kg/min (at 50% max useful load) and 45.6 kg/min (at 65% max useful load). A corrected average fuel burn rate is then obtained by weighting the average fuel burn per flight by the ratio of fuel burn rate for arrival. It reads:

$$\text{Fuel burn rate} = 49 \frac{\text{kg}}{\text{min}} \frac{1}{2} \left(\frac{\text{fuel burn rate arrival 50\%}}{42.3 \text{ kg/min}} + \frac{\text{fuel burn rate arrival 65\%}}{45.6 \text{ kg/min}} \right).$$

With the traffic mixes described, the obtained fuel burn rates for all phases of flight are detailed in Table 11.

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

Fuel burn rate 65% loading = [38.6, 64,5] kg/min

The average fuel burn per flight in Europe is then computed based on the mean flight duration, as reported in Figure 3, multiplied by the average fuel burn rate. It reads:

649

$$\text{Fuel burn per flight} = \text{Fuel burn rate} \times 91.5 \text{ min}$$

Value 1	Average time from Take-off to Landing	
	Year	Minutes
	2016	91.5
	2015	91.3
(Values based on flights in the ESRA08 ²² area)		
Source 1	EUROCONTROL - Performance Review Report (PRR 2016), July 2017 http://www.eurocontrol.int/publications/performance-review-report-prr-2016	
	EUROCONTROL - Performance Review Report (PRR 2015), June 2016 http://www.eurocontrol.int/publications/performance-review-report-prr-2015	

650

651

Figure 3: Averaged flying time for IFR flights (Source: (Eurocontrol, January 2018))

652

Depending on percentage loading:

653

Average Fuel burn per flight 50% loading = [3321, 5407] kg

654

Average Fuel burn per flight 65% loading = [3532, 5902] kg

655

The mean percentage of fuel burn saving per flight is then estimated as the mean difference of flying time per flight compared to the baseline multiplied by the mean fuel burn rate of the traffic sample divided by the mean fuel burn per flight. It reads:

656

657

658

$$\text{fuel burn saving [\%]} = \frac{\Delta \text{Flying time [min]} \times \text{fuel burn rate [kg/min]}}{\text{Fuel burn per flight [kg]}}$$

659

The results of the assessments are reported in the table below. A negative value indicates a saving in fuel emissions.

660

Wake Scheme – OI – SRAP parameter	Traffic mix				
	S5H0	S5H10	S5H20	S5H30	S5H40
ICAO SRAP 45 1 alt	-0,24%	-0,5%	-1,1%	-1,3%	-1,3%
ICAO SRAP 45 2 alt	-0,2%	-0,7%	-1,2%	-1,7%	-1,6%
ICAO SRAP 60 1 alt	-0,3%	-0,6%	-1,1%	-1,3%	-1,3%
ICAO SRAP 60 2 alt	-0,5%	-1,1%	-1,9%	-2,3%	-2,1%
ICAO SRAP 65 1 alt	-0,3%	-0,6%	-1,1%	-1,3%	-1,3%
ICAO SRAP 65 2 alt	-0,7%	-1,6%	-2,5%	-3,1%	-3,0%

661

Table 13: Summary of the fuel burn savings if operating the test schemes versus ICAO DBS at maximum test case traffic pressure for the different traffic mix.

662

663

4.4.3 Extrapolation to ECAC wide

664

The following PJ19 common assumptions have been used:

665

- High density airports traffic contribution to total airport traffic = 59.5%

666

- Arrivals traffic contribution to total traffic = 50%

667

- Average ECAC flight time = 90 minutes

668

- CO₂/Fuel ratio = 3.15

669

670

Due to the different combinations for each OI, only the lowest and highest benefits are reported below to consider a range for the extrapolation.

671

672

673 **FEFF3, FEFF2 and FEFF1 for AO-0319 (SRAP)**674 **FEFF3**

675 1. Flight time reduction per arrival #1 = [0.25] min. This is the lowest benefit obtained assessing
 676 different traffic samples and different SRAP parameters, from FTS13 results.

677 2. Flight time reduction (FEFF3) at ECAC level #1 = 50% (arrivals traffic contribution) * 59.5%
 678 (high density airports traffic contribution) * 0.25 minutes (flight-time reduction per arrival #1)
 679 = 0.07 minutes per flight

680 3. Relative flight time reduction at ECAC level #1= 0.25 minutes (flight time reduction at ECAC
 681 level #1) / 90 minutes (average ECAC flight time) * 100 = 0.27%

682 4. Flight time reduction per arrival #2 = [3.16] min. This is the highest benefit obtained assessing
 683 different traffic samples and different SRAP parameters, from FTS13 results.

684 5. Flight time reduction (FEFF3) at ECAC level #2 = 50% (arrivals traffic contribution) * 59.5%
 685 (high density airports traffic contribution) * 3.16 minutes (flight-time reduction per arrival #2)
 686 = 0.94 minutes per flight

687 6. Relative flight time reduction at ECAC level #2= 0.94 minutes (flight time reduction at ECAC
 688 level) / 90 minutes (average ECAC flight time) * 100 = 1.04%

689 **FEFF1**

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

691 Fuel burn rate 65% loading = [38.6, 64,5] kg/min

692 For the computations below the respective fuel burn rate for the minimum and maximum flight time
 693 reductions from the FTS13 results for 50% loading are used.

694 1. Fuel consumption reduction per arrival #1 = 0.25 (flight time reduction per arrival) #1 * 36.3
 695 (fuel burn rate for arrival #1) = 9.07 kg/flight

696 2. Relative fuel consumption reduction #1 = 9.07 kg/flight (fuel consumption reduction on arrival
 697 #1) / 3321 kg (Average fuel burn per flight #1) * 100 = 0.27%

698 3. Fuel consumption reduction (FEFF1) at ECAC level #1 = 50% (arrivals traffic contribution) *
 699 59.5% (high density airports traffic contribution) * 0.27% (relative fuel consumption reduction
 700 #1) = 0.08% = 2.65 kg/flight

701 4. Fuel consumption reduction per arrival #2 = 3.16 (flight time reduction per arrival #2) * 59.1
 702 (fuel burn rate for arrival #2)= 186.75 kg/flight

703 5. Relative fuel consumption reduction #2 = 186.75 kg/flight (fuel consumption reduction on
 704 arrival #2) / 5407 kg (Average fuel burn per flight #2) * 100= 3.45%

705 6. Fuel consumption reduction (FEFF1) at ECAC level #2 = 50% (arrivals traffic contribution) *
 706 59.5% (high density airports traffic contribution) * 3.45% (relative fuel consumption reduction
 707 #1) = 1.02% = 55.1 kg/flight

708 **FEFF2**

709 1. CO₂ emission reduction per arrival #1 = 9.07 (Fuel consumption reduction on arrival #1) * 3.15
 710 (CO₂/Fuel Ratio) = 28.57 kg CO₂ per flight

- 711 2. Relative CO₂ emission reduction on arrival #1 = 28.57 (CO₂ emission reduction #1) / 3321
 712 (Average Fuel burn per flight #1) / 3.15 (CO₂/Fuel ratio) * 100 = 0.27%
- 713 3. Relative CO₂ emission reduction on arrival #1 (FEFF2) at ECAC level = 50% (arrivals traffic
 714 contribution) * 59.5% (high density airports traffic contribution)* x 0.27% (Relative CO₂
 715 emission reduction on arrival #1) = 0.08% = 2.65 kg CO₂/flight
- 716 4. CO₂ emission reduction on arrival #2 = 186.75 (Fuel consumption reduction on arrival #2) *
 717 3.15 (CO₂/Fuel Ratio) = 588.2 kg CO₂ per flight
- 718 5. Relative CO₂ emission reduction on arrival #2 = 588.2 (CO₂ emission reduction #2) / 5407
 719 (Average Fuel burn per flight #1) / 3.15 (CO₂/Fuel ratio) * 100 = 3.45%
- 720 6. Relative CO₂ emission reduction on arrival #2 (FEFF2) at ECAC level = 50% (arrivals traffic
 721 contribution) * 59.5% (high density airports traffic contribution)* x 3.45% (Relative CO₂
 722 emission reduction on arrival #1) = 1.02% = 55.15 kg CO₂/flight

KPIs / Pls	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-0319 SRAP = [2.65, 55.1] reduction kg of fuel per flight	AO-0319 SRAP = [0.08, 1.02] 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-0319 SRAP = [2.65, 55.1] reduction kg CO ₂ per flight	AO-0319 SRAP = [0.08%, 1.02%] 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 the Solution Scenario	YES	NA	AO-0319 SRAP = [0.07, 0.94] reduction minutes per flight	AO-0319 SRAP = [0.27%, 1.04%] reduction minutes per flight

723

724 Table 14 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	AO-0319 SRAP = [2.65, 55.1] reduction kg of fuel per flight	NA
FEFF2 Actual Average CO ₂ Emission per flight	NA	NA	NA	AO-0319 SRAP = [2.65, 55.1] reduction kg CO ₂ per flight	NA

FEFF3		NA	NA	NA	AO-0319 SRAP = [0.07, 0.94] reduction minutes per flight	NA
Reduction average duration	in flight					

Table 14: Fuel burn reduction per flight phase.

4.4.4 Discussion of Assessment Result

These results can meet and sometimes exceed the performance targets defined from PJ19 that were reduction of 6.07 kg of fuel per flight depending on the OI.

The confidence estimate in the results is moderate; they are based on generic characteristics that are common in other European airports. The benefits identified are an estimation applicable to 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 airport, the exact benefits are depending on several factors including specific traffic mix, length of traffic peak, wind conditions, applicable surveillance minima, glide parameters, fraction of aircraft type operating on the SRAP glide, runway occupancy time, glide length, runway layout, airport infrastructure, etc.

Results for airports not traffic-constrained that could benefit from noise-related concepts are not available, and could potentially be very different from those presented for traffic-constrained airports.

4.4.5 Additional Comments and Notes

There is no additional comments or notes.

4.5 Environment / Noise and Local Air Quality

4.5.1 Performance Mechanism

The Second Runway Aiming Point (SRAP) concept:

The impact depends on the concept and on the traffic mix. For Noise benefits, one baseline and one test case, illustrated in Figure 4 to Figure 5 are considered:

- The baseline corresponds to a classical ILS approach on a 3 deg descent slope with an interception at 4000 ft
- Test case #1 corresponds to a scenario where all Medium and Light aircraft types follow a glide with a Second Runway Aiming Point (SRAP) displaced by 1200 m whereas the Heavies and Super Heavies are still following the baseline ILS glide both with an interception at 4000 ft.

Baseline: ILS 3 deg

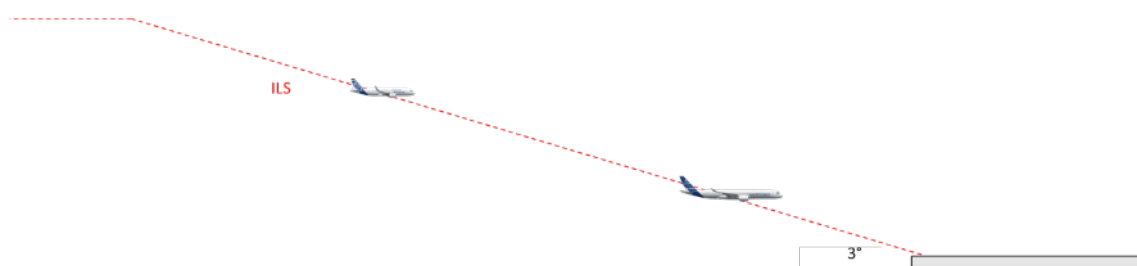


Figure 4: Baseline for noise assessment

Test #1: Second Runway Aiming Point (SRAP)

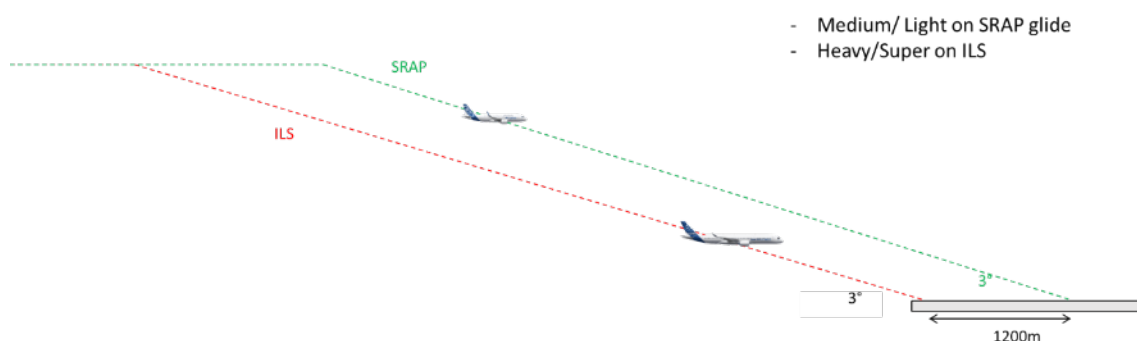


Figure 5: SRAP test case for noise assessment

Those scenarios are tested and compared using the IMPACT tool of EUROCONTROL. The inputs and outputs of this analysis are here presented. For the inputs, two main data were required: the traffic

mix observed at each airport (providing the amount of flights operating on each glide for each scenario) and the approach speed profile followed by each aircraft type (directly affecting its noise footprint and used by the IMPACT tool).

4.5.2 Assessment Data (Exercises and Expectations)

Traffic data processing

In order to generate input traffic data for the IMPACT tool, the arrival CFMU data for the Top 30 ECAC airports in August 2018 are analysed.

For each airport, the average number of each aircraft type is counted considering three time periods:

- Day time: from 7am to 7pm
- Evening time: from 7 pm to 11 pm
- Night time: from 11 pm to 6am

This distinction is performed as the noise abatement rules vary depending on the period of the day.

Speed and trajectory profile modelling

For the noise impact analysis, a trajectory and speed profile for each aircraft type and each procedure has to be defined. The proposed model is based on a combination of experimental measurement and expert judgment in collaboration with EUROCONTROL and Airbus.

Results

Noise contours were computed with the IMPACT tool.

The SRAP contours were compared to those obtained with the standard ILS flown in the Day-Eve-Night period (DEN).

Those contours were then processed and analysed. Results of those analyses are described in the next sections.

NOI2

Airports with a large fraction of MEDIUM aircraft

For airports with a traffic mix presenting a large fraction of MEDIUM aircraft, when comparing the size and location of the whole noise contours not accounting for its location with respect to the runway, surface analysis (see Figure 6 and Table 15) shows that:

- The SRAP solution contours (LDEN) are seen to be larger than the baseline ones (for all dB levels). However, they are seen to be extended on the runway as expected when using a displaced threshold (see Figure 7).

When accounting for contours beginning at the runway threshold (with $x \geq 0\text{NM}$ or $x \geq 1\text{NM}$, see Figure 6), results (see Table 16 and Table 17) show that contour surfaces related to the solution (SRAP) are smaller than the reference ones. The noise contours in the area away from the runway are thus smaller.

Figure 6 and Figure 7 respectively show the evolution of different contour surfaces for the airports EGCC, EIDW and LFPO.

- Runway
- Whole contour
- Contour with $x \geq 0$ NM
- Contour with $x \geq 1$ NM

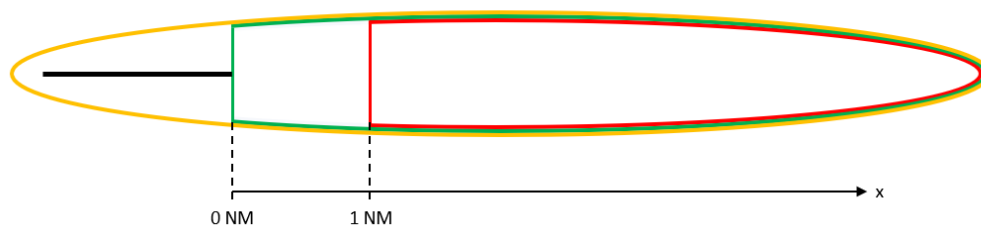


Figure 6: Contour definitions

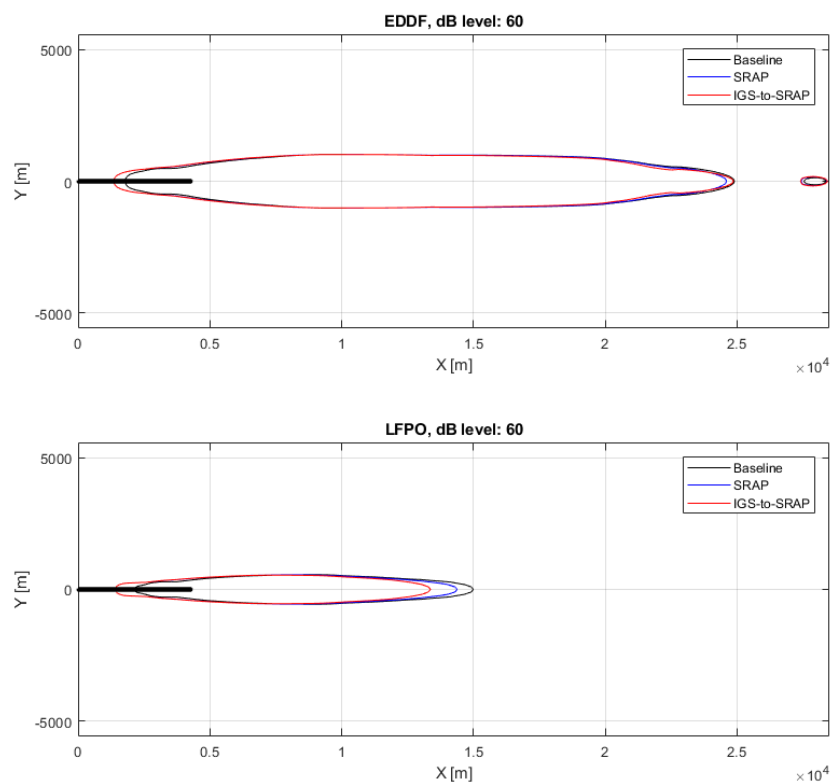


Figure 7: Baseline, SRAP contours (DEN) for EDDF and LFPO for the 60dB level

dB level	Airport	Baseline DEN Surface [km2]	SRAP Surface [km2]	SRAP gains [km2]	SRAP gains [%]
55	EGCC	32.49	32.75	+0.26	+0.8%
	EIDW	33.15	33.52	+0.37	+1.1%
	LFPO	28.55	29.16	+0.61	+2.1%
60	EGCC	12.62	12.77	+0.15	+1.2%
	EIDW	12.65	12.89	+0.24	+1.9%
	LFPO	10.71	10.83	+0.12	+1.1%
65	EGCC	4.68	4.8	+0.12	+2.6%
	EIDW	4.62	4.83	+0.21	+4.5%
	LFPO	3.84	3.95	+0.11	+2.9%
70	EGCC	1.61	1.65	+0.04	+2.5%
	EIDW	1.57	1.65	+0.08	+5.1%
	LFPO	1.24	1.28	+0.04	+3.2%
75	EGCC	0.48	0.52	+0.04	+8.3%
	EIDW	0.45	0.52	+0.07	+15.6%
	LFPO	0.36	0.41	+0.05	+13.9%
80	EGCC	0.13	0.14	+0.01	+7.7%
	EIDW	0.14	0.14	0	
	LFPO	0.1	0.09	-0.01	-10

Table 15: Whole contour surfaces for airports with the largest fraction of MEDIUM aircraft, different dB levels

804

dB level	Airport	Baseline DEN Surface [km2]	SRAP Surface [km2]	SRAP gains [km2]	SRAP gains [%]
55	EGCC	30.46	29.95	-0.51	-1.7%
	EIDW	31.34	30.59	-0.75	-2.4%
	LFPO	26.78	26.46	-0.32	-1.2%
60	EGCC	11.29	10.9	-0.39	-3.5%
	EIDW	11.48	10.96	-0.52	-4.5%
	LFPO	9.55	9.05	-0.5	-5.2%
65	EGCC	3.81	3.59	-0.22	-5.8%
	EIDW	3.86	3.58	-0.28	-7.3%
	LFPO	3.11	2.81	-0.3	-9.6%
70	EGCC	1.07	0.91	-0.16	-15%
	EIDW	1.09	0.88	-0.21	-19.3%
	LFPO	0.78	0.6	-0.18	-23.1%
75	EGCC	0.19	0.12	-0.07	-36.8%
	EIDW	0.19	0.11	-0.08	-42.1%
	LFPO	0.12	0.06	-0.06	-50%
80	EGCC	0.01	0	-0.01	-100%
	EIDW	0.01	0	-0.01	-100%
	LFPO	0.01	0	-0.01	-100%

Table 16: Contour surfaces for $x \geq 0$ NM from runway threshold for airports with a large fraction of MEDIUM aircraft, different dB levels

805

dB level	Airport	Baseline DEN Surface [km2]	SRAP Surface [km2]	SRAP gains [km2]	SRAP gains [%]
55	EGCC	27.87	27.15	-0.72	-2.6%
	EIDW	28.72	27.73	-0.99	-3.4%
	LFPO	24.35	23.81	-0.54	-2.2%
60	EGCC	9.52	9.02	-0.5	-5.3%
	EIDW	9.69	9.02	-0.67	-6.9%
	LFPO	7.91	7.29	-0.62	-7.8%
65	EGCC	2.67	2.4	-0.27	-10.1%
	EIDW	2.7	2.37	-0.33	-12.2%
	LFPO	2.07	1.74	-0.33	-15.9%
70	EGCC	0.41	0.27	-0.14	-34.1%
	EIDW	0.42	0.24	-0.18	-42.9%
	LFPO	0.21	0.08	-0.13	-61.9%
75	EGCC	0	0	0	
	EIDW	0	0	0	
	LFPO	0	0	0	
80	EGCC	0	0	0	
	EIDW	0	0	0	
	LFPO	0	0	0	

Table 17: Contour surfaces for $x \geq 1\text{NM}$ from runway threshold for airports with a large fraction of MEDIUM aircraft, different dB levels

806

Airports with a large fraction of HEAVY aircraft

For airports with a traffic mix presenting a large fraction of HEAVY aircraft, when comparing the size and location of the whole noise contours not accounting for its location with respect to the runway, surface analysis (see Table 18) shows that:

- The SRAP solution contours (LDEN) are seen to be larger than the baseline ones (for all dB levels). However, they are seen to be extended on the runway as expected when using a displaced threshold.

When accounting for contours beginning at the runway threshold (or further upstream, see Table 19 and Table 20), contour surfaces related to the solution (SRAP) are seen to be smaller than the reference ones expected for the SRAP solution for the 55dB level for which an increase of contour surfaces is observed for all airports. This increase is related to the fact that the noise impact on the glide is governed by Heavy traffic on the ILS.

Figure 8, Figure 9 and Figure 10 respectively show the evolution of different contour surfaces for the EDDF, EGLL and EHAM airports.

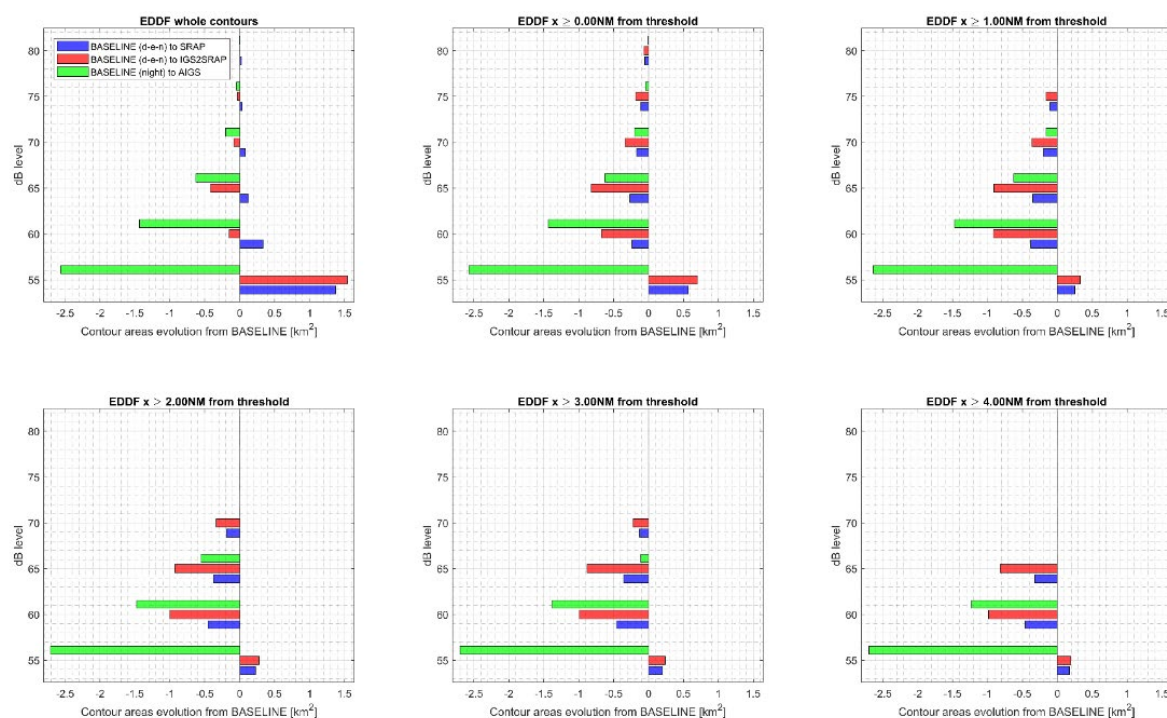


Figure 8: Comparison of contour surfaces for EDDF

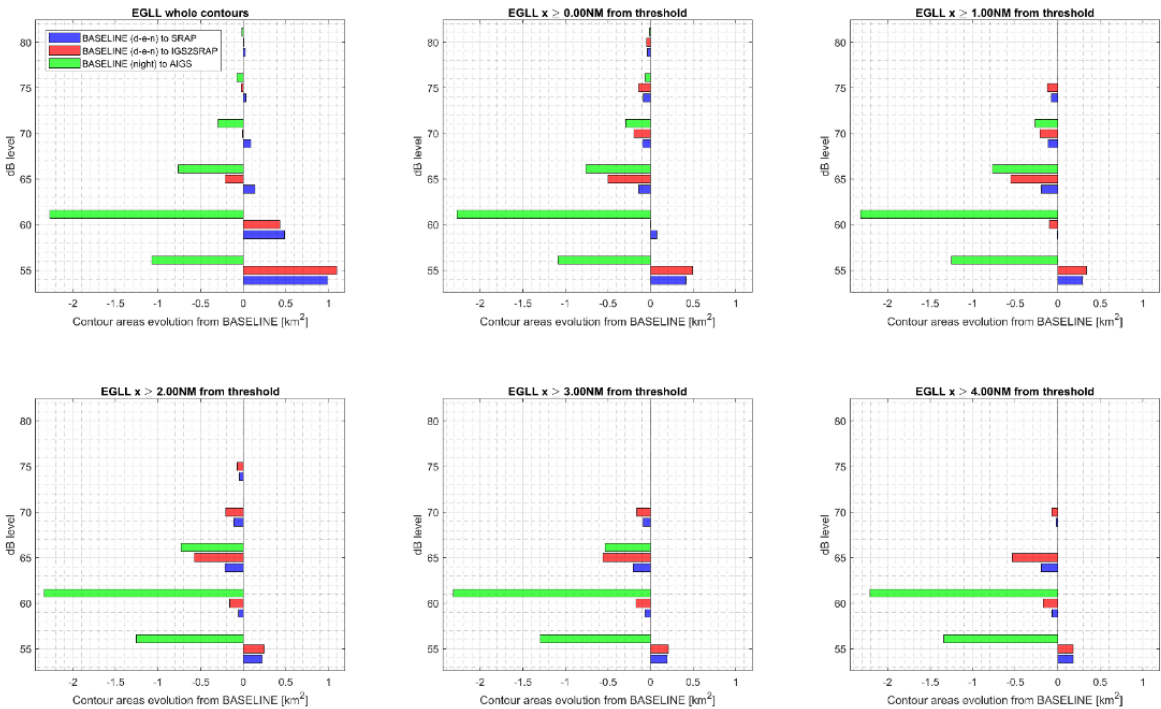


Figure 9: Comparison of contour surfaces for EGLL

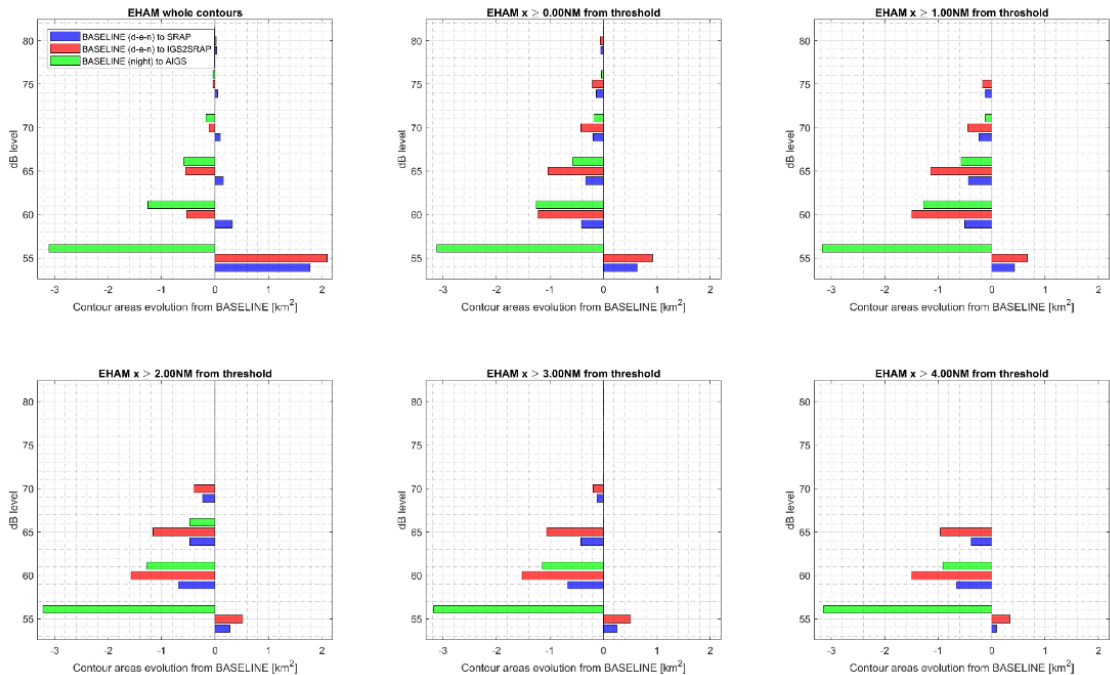


Figure 10: Comparison of contour surfaces for EHAM

dB level	Airport	Baseline DEN Surface [km2]	SRAP Surface [km2]	SRAP gains [km2]	SRAP gains [%]
55	EDDF	113.88	115.26	+1.38	+1.2%
	EHAM	101.48	103.26	+1.78	+1.8%
	EGLL	146.38	147.37	+0.99	+0.7%
60	EDDF	37.37	37.71	+0.34	+0.9%
	EHAM	33.8	34.13	+0.33	+1%
	EGLL	55.65	56.14	+0.49	+0.9%
65	EDDF	14.47	14.59	+0.12	+0.8%
	EHAM	12.93	13.08	+0.15	+1.2%
	EGLL	18.76	18.9	+0.14	+0.7%
70	EDDF	5.23	5.31	+0.08	+1.5%
	EHAM	4.62	4.72	+0.1	+2.2%
	EGLL	6.57	6.66	+0.09	+1.4%
75	EDDF	1.79	1.83	+0.04	+2.2%
	EHAM	1.55	1.59	+0.04	+2.6%
	EGLL	2.31	2.35	+0.04	+1.7%
80	EDDF	0.54	0.57	+0.03	+5.6%
	EHAM	0.44	0.48	+0.04	+9.1%
	EGLL	0.71	0.73	+0.02	+2.8%

Table 18: Whole contour surfaces for airports with a large fraction of HEAVY aircraft, different dB levels

829

dB level	Airport	Baseline DEN Surface [km2]	SRAP Surface [km2]	SRAP gains [km2]	SRAP gains [%]
55	EDDF	110.4	110.97	+0.57	+0.5%
	EHAM	98.42	99.05	+0.63	+0.6%
	EGLL	142.59	143	+0.41	+0.3%
60	EDDF	35.12	34.89	-0.23	-0.7%
	EHAM	31.77	31.36	-0.41	-1.3%
	EGLL	53.22	53.3	+0.08	+0.2%
65	EDDF	13	12.73	-0.27	-2.1%
	EHAM	11.6	11.27	-0.33	-2.8%
	EGLL	17.18	17.04	-0.14	-0.8%
70	EDDF	4.28	4.11	-0.17	-4%
	EHAM	3.77	3.58	-0.19	-5%
	EGLL	5.54	5.45	-0.09	-1.6%
75	EDDF	1.2	1.09	-0.11	-9.2%
	EHAM	1.02	0.89	-0.13	-12.7%
	EGLL	1.67	1.59	-0.08	-4.8%
80	EDDF	0.21	0.16	-0.05	-23.8%
	EHAM	0.16	0.12	-0.04	-25%
	EGLL	0.34	0.3	-0.04	-11.8%

Table 19: Contour surfaces for x≥0NM from runway threshold for airports with a large fraction of HEAVY aircraft, different dB level

830

dB level	Airport	Baseline DEN Surface [km2]	SRAP Surface [km2]	SRAP gains [km2]	SRAP gains [%]
55	EDDF	106.61	106.86	+0.25	+0.2%
	EHAM	94.54	94.97	+0.43	+0.5%
	EGLL	138.31	138.6	+0.29	+0.2%
60	EDDF	32.46	32.08	-0.38	-1.2%
	EHAM	29.17	28.66	-0.51	-1.7%
	EGLL	50.33	50.32	-0.01	0%
65	EDDF	11.17	10.82	-0.35	-3.1%
	EHAM	9.83	9.4	-0.43	-4.4%
	EGLL	15.18	14.99	-0.19	-1.3%
70	EDDF	3.09	2.89	-0.2	-6.5%
	EHAM	2.63	2.39	-0.24	-9.1%
	EGLL	4.23	4.11	-0.12	-2.8%
75	EDDF	0.52	0.41	-0.11	-21.2%
	EHAM	0.38	0.27	-0.11	-28.9%
	EGLL	0.87	0.8	-0.07	-8%
80	EDDF	0	0	0	
	EHAM	0	0	0	
	EGLL	0	0	0	

Table 20: Contour surfaces for $x \geq 1$ NM from runway threshold for airports with a large fraction of HEAVY aircraft, different dB levels

831

Conclusions for NOI2

As the SRAP solution consists in a displacement of the runway threshold for the MEDIUM aircraft only, contours associated to those MEDIUM aircraft are also expected to be displaced, as opposite to those related to the HEAVY aircraft, which are not affected by this solution. Therefore, whole contours related to low dB levels are expected to expand compared to the baseline ones. This expectation is observed in the results shown in Table 15 and Table 18, while being emphasised for airports with large fractions of MEDIUM aircraft.

However, when accounting for contours beginning at the runway thresholds (with $x \geq 0\text{NM}$ or $x \geq 1\text{NM}$, see Figure 6), one observes a decrease in contour surfaces, for all dB levels (see Table 16, Table 17, Table 19 and Table 20). Those gains are again more emphasised for airports presenting a large fraction of MEDIUM aircraft. Only a small increase in contour surfaces is observed for the 55dB level for airports with large fractions of HEAVY aircraft.

The whole contours expansion observed for the SRAP solution for the low dB levels is therefore expected to be mitigated for all airports (either with large fractions of MEDIUM or HEAVY aircraft). This expectation is again observed in the results shown in Table 15 and Table 18, with contour surfaces reduced for almost all noise levels compared to the baseline ones.

Those surface reductions are even more highlighted when looking at contours beginning at runway threshold, with a reduction observed for all dB levels (see Table 16, Table 17, Table 19 and Table 20).

NOI4 Number of people exposed to noise levels

For this section, a constant population density of 6000 residents per km^2 (typical value around large city airports) will be assumed for all airports. Note that the exact value of people density does not affect the conclusions of this analysis since we here use a relative assessment comparing different operations in a same airport environment.

Results shown in Table 21 to Table 26 reflect observations made above for NOI2, as those numbers are direct conversions of surface into numbers of residents.

However, when looking at most airport geographic situations, the analysis of contours beginning at the runway threshold appears to be more relevant in terms of affected population than analysing whole contours, as most large residential areas are located at a certain distance from airports and not in direct proximity of active runways (see Figure 11 and Figure 12). Therefore, results of Table 22, Table 23, Table 25 and Table 26 are those of interest in this section.



Figure 11: Closest large residential area to runway 07L at EDDF

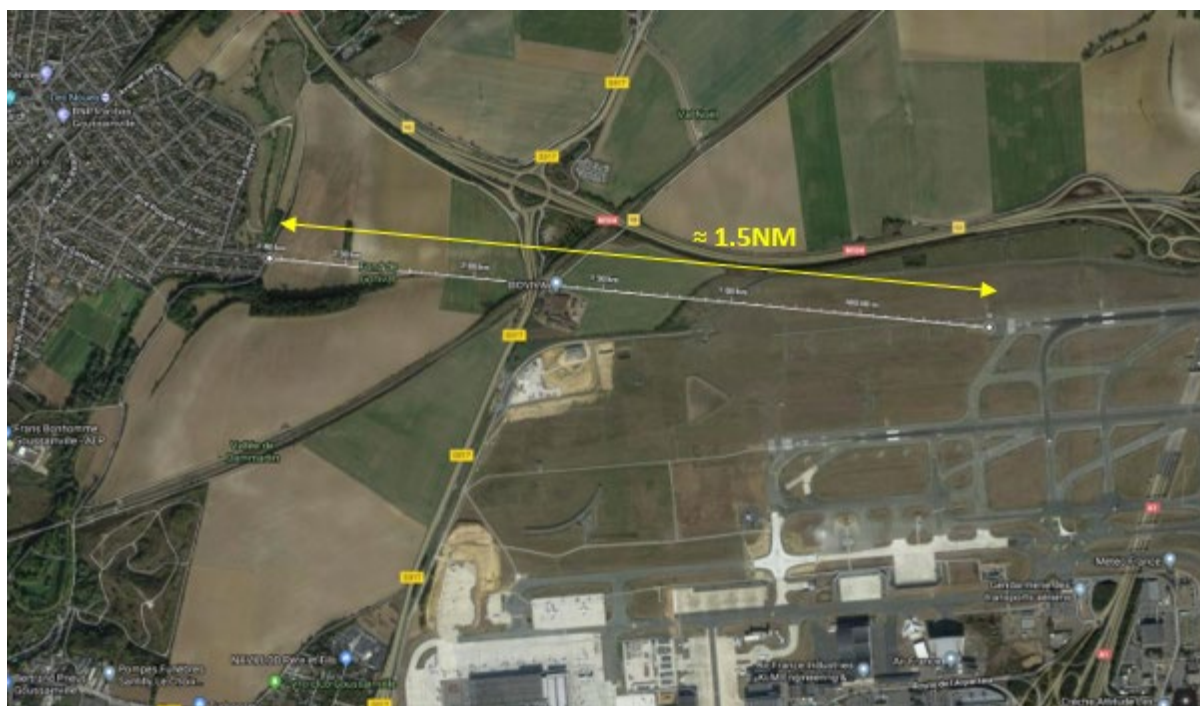


Figure 12: Closest large residential area to runway 09L at LFPG

Airports with a large fraction of MEDIUM aircraft

One observes in Table 22 (contours accounted from the runway threshold) that for the lowest analysed noise level (55dB), reductions of affected residents from -1900 to -4500 people are observed for the SRAP solution.

When looking at contours beginning at 1NM from the runway threshold (see Table 23), reductions of up to -5940 and -18060 residents are observed for the SRAP solution, still for the 55dB level.

dB level	Airport	Population inside Baseline DEN Surface [residents]	Population inside SRAP Surface [residents]	Change in population from baseline to SRAP [residents]
55	EGCC	194940	196500	+1560
	EIDW	198900	201120	+2220
	LFPO	171300	174960	+3660
60	EGCC	75720	76620	+900
	EIDW	75900	77340	+1440
	LFPO	64260	64980	+720
65	EGCC	28080	28800	+720
	EIDW	27720	28980	+1260
	LFPO	23040	23700	+660
70	EGCC	9660	9900	+240
	EIDW	9420	9900	+480
	LFPO	7440	7680	+240
75	EGCC	2880	3120	+240
	EIDW	2700	3120	+420
	LFPO	2160	2460	+300
80	EGCC	780	840	+60
	EIDW	840	840	0
	LFPO	600	540	-60

Table 21: Population associated to whole contours for airports with a large fraction of MEDIUM aircraft

873

dB level	Airport	Population inside Baseline DEN Surface [residents]	Population inside SRAP Surface [residents]	Change in population from baseline to SRAP [residents]
55	EGCC	182760	179700	-3060
	EIDW	188040	183540	-4500
	LFPO	160680	158760	-1920
60	EGCC	67740	65400	-2340
	EIDW	68880	65760	-3120
	LFPO	57300	54300	-3000
65	EGCC	22860	21540	-1320
	EIDW	23160	21480	-1680
	LFPO	18660	16860	-1800
70	EGCC	6420	5460	-960
	EIDW	6540	5280	-1260
	LFPO	4680	3600	-1080
75	EGCC	1140	720	-420
	EIDW	1140	660	-480
	LFPO	720	360	-360
80	EGCC	60	0	-60
	EIDW	60	0	-60
	LFPO	60	0	-60

Table 22: Population associated to contours with $x \geq 0$ NM for airports with a large fraction of MEDIUM aircraft

874

dB level	Airport	Population inside Baseline DEN Surface [residents]	Population inside SRAP Surface [residents]	Change in population from baseline to SRAP [residents]
55	EGCC	167220	162900	-4320
	EIDW	172320	166380	-5940
	LFPO	146100	142860	-3240
60	EGCC	57120	54120	-3000
	EIDW	58140	54120	-4020
	LFPO	47460	43740	-3720
65	EGCC	16020	14400	-1620
	EIDW	16200	14220	-1980
	LFPO	12420	10440	-1980
70	EGCC	2460	1620	-840
	EIDW	2520	1440	-1080
	LFPO	1260	480	-780
75	EGCC	0	0	0
	EIDW	0	0	0
	LFPO	0	0	0
80	EGCC	0	0	0
	EIDW	0	0	0
	LFPO	0	0	0

Table 23: Population associated to contours with $x \geq 1\text{NM}$ for airports with a large fraction of MEDIUM aircraft

875

Airports with a large fraction of HEAVY aircraft

Conversely to airports with a large fraction of MEDIUM aircraft, results related to airports with a large fraction of HEAVY aircraft do not show any clear reduction of the number of affected residents for the 55dB level contours, even for contours accounted from the runway threshold (see Table 25 and Table 26), with an increase of +2460 up to +3780 residents for the SRAP solution (for contours beginning at the runway threshold).

However, those increases of affected population are only observed at the 55dB level, as reductions are observed for higher noise levels. In fact, reductions in exposed population are observed at the 60dB level, with +480 to -2460 residents for the SRAP solution (with contours starting at the runway threshold). When looking at contours beginning at 1NM from the runway threshold, those reductions increase from -60 to -3060 residents for the SRAP solution.

dB level	Airport	Population inside Baseline DEN Surface [residents]	Population inside SRAP Surface [residents]	Change in population from baseline to SRAP [residents]
55	EDDF	683280	691560	+8280
	EHAM	608880	619560	+10680
	EGLL	878280	884220	+5940
60	EDDF	224220	226260	+2040
	EHAM	202800	204780	+1980
	EGLL	333900	336840	+2940
65	EDDF	86820	87540	+720
	EHAM	77580	78480	+900
	EGLL	112560	113400	+840
70	EDDF	31380	31860	+480
	EHAM	27720	28320	+600
	EGLL	39420	39960	+540
75	EDDF	10740	10980	+240
	EHAM	9300	9540	+240
	EGLL	13860	14100	+240
80	EDDF	3240	3420	+180
	EHAM	2640	2880	+240
	EGLL	4260	4380	+120

Table 24: Population associated to whole contours for airports with a large fraction of HEAVY aircraft

887

dB level	Airport	Population inside Baseline DEN Surface [residents]	Population inside SRAP Surface [residents]	Change in population from baseline to SRAP [residents]
55	EDDF	662400	665820	+3420
	EHAM	590520	594300	+3780
	EGLL	855540	858000	+2460
60	EDDF	210720	209340	-1380
	EHAM	190620	188160	-2460
	EGLL	319320	319800	+480
65	EDDF	78000	76380	-1620
	EHAM	69600	67620	-1980
	EGLL	103080	102240	-840
70	EDDF	25680	24660	-1020
	EHAM	22620	21480	-1140
	EGLL	33240	32700	-540
75	EDDF	7200	6540	-660
	EHAM	6120	5340	-780
	EGLL	10020	9540	-480
80	EDDF	1260	960	-300
	EHAM	960	720	-240
	EGLL	2040	1800	-240

Table 25: Population associated to contours with $x \geq 0$ NM for airports with a large fraction of HEAVY aircraft

888

dB level	Airport	Population inside Baseline DEN Surface [residents]	Population inside SRAP Surface [residents]	Change in population from baseline to SRAP [residents]
55	EDDF	639660	641160	+1500
	EHAM	567240	569820	+2580
	EGLL	829860	831600	+1740
60	EDDF	194760	192480	-2280
	EHAM	175020	171960	-3060
	EGLL	301980	301920	-60
65	EDDF	67020	64920	-2100
	EHAM	58980	56400	-2580
	EGLL	91080	89940	-1140
70	EDDF	18540	17340	-1200
	EHAM	15780	14340	-1440
	EGLL	25380	24660	-720
75	EDDF	3120	2460	-660
	EHAM	2280	1620	-660
	EGLL	5220	4800	-420
80	EDDF	0	0	0
	EHAM	0	0	0
	EGLL	0	0	0

Table 26: Population associated to contours with $x \geq 1\text{NM}$ for airports with a large fraction of HEAVY aircraft

889

Conclusion for NOI4

Contours accounting from the runway threshold ($x \geq 0\text{NM}$) or from a certain distance from it ($x \geq 1\text{NM}$), rather than whole contours, have been considered for the analysis of the number of people exposed to different noise levels, as most large residential areas are not located in the direct proximity of airport active runways (see Figure 11 and Figure 12).

Considering this, for airports with a large fraction of MEDIUM aircraft, results provided in Table 22 and Table 23 (respectively for contours with $x \geq 0\text{NM}$ and $x \geq 1\text{NM}$) show reductions in the number of affected residents, going up to over 5900 people and up over to 18000 residents, for the SRAP solution (for the 55dB level).

For airports with a large fraction of HEAVY aircraft, results (see Table 25 and Table 26) show a small increase in the number of exposed residents for the 55dB level, but large reductions for the levels above or equal to 60dB. Those reductions drive up to over 3000 and to over 8900 residents for the SRAP solution for the 60dB level, for contours beginning at 1NM from the runway threshold.

NOI1

Based on results of Performance Indicators **NOI2** and **NOI4**, a qualitative assessment of the analysed solution has been made for two different types of airports (those with a large fraction of MEDIUM aircraft in their traffic mix and those with a large fraction of HEAVY aircraft). Table 27 summarizes the benefits related to the analysed solution on a relative scale going from -2 (very negative benefits) to 2 (very positive benefits).

Solution	Airport with a large fraction of MEDIUM aircraft	Airport with a large fraction of HEAVY aircraft
SRAP (compared to LDEN baseline)	1	0-1

Table 27: Relative scale of benefits associated to different solutions

Conclusion for NOI1

For airports with a large fraction of MEDIUM aircraft, when looking at whole contours, the SRAP solution presents small increases in contour surfaces for all noise levels (compared to baseline), but presents significant reductions when analysing contours accounted from the runway threshold (and hence accounting for exposed population) (see Table 16). For those reasons, the SRAP solution, for airports with a large fraction of MEDIUM aircraft, has been given classification **1** in Table 27.

For airports with a large fraction of HEAVY aircraft, small increases of contour surfaces are observed for the SRAP solution (for whole contours, see Table 18). When looking at contours beginning at the runway threshold, contour expansions are still noticeable for the 55dB level. However, surface reductions are observed for higher noise levels, although smaller than those observed for airports with a large fraction of MEDIUM aircraft. For those reasons, the SRAP solution, for airports with a large fraction of HEAVY aircraft, has been given classification **0 to 1** in Table 27.

For NOI2 and NOI4, as the results depend on the airports, db and contour location, in the summary only the results for contour taking in account the runway location ($x > 0\text{NM}$) are considered, with a range of minimum and maximum from the different airports and for 55-65-75 db are extracted.

PIs	Unit	Calculation	Mandatory	Benefit in SESAR1 (if applicable)	Absolute expected performance benefit in SESAR2020	% expected performance benefit in SESAR2020
NOI1 Relative noise scale	-2 to +2	It is a qualitative scale based on expert judgment. -2 very negative effect or benefit, 0 neutral and +2 very positive effects or benefit. The objective of this metric is to provide a global assessment of the noise impact. This metric is built upon the other quantitative noise PIs (NOI2, NOI3, NOI4, NOI5)	YES for Airport OE Solutions	NA	<i>AO-0319 SRAP = [1]</i> For Airport with a large fraction of MEDIUM aircraft <i>AO-0319 SRAP = [0-1]</i> For Airport with a large fraction of HEAVY aircraft	NA
NOI2 Size and location of noise contours	Contours of noise level thresholds (e.g. LDEN 55 see ERM document for the list of recommended PIs). Surface of these contours (Km2)	Noise contours to be calculated according to the ECAC Doc.29 methodology. Surface of the noise contours calculated using a GIS tool or modules. Suggest the use of IMPACT tool.	YES for Airport OE Solutions	NA	<i>AO-0319 SRAP 55db = [-0.75, 0.63]</i> <i>AO-0319 SRAP 65db = [-0.33, -0.14]</i> <i>AO-0319 SRAP 75db = [-0.13, -0.06]</i> reduction km2	<i>AO-0319 SRAP 55db = [-2.4%, 0.6%]</i> <i>AO-0319 SRAP 65db = [-9%, -2.9%]</i> <i>AO-0319 SRAP 75db = [-50%, -12.7%]</i> reduction km2[%]
(NOI4) Number of people exposed to noise levels exceeding a given threshold	Number of people inside noise contours.	Population count inside the contours calculated above. Need the availability of population census data. Calculated using a GIS tool or modules. IMPACT tool includes this functionality, using the EEA population database.	YES for Airport OE Solutions	NA	<i>AO-0319 SRAP 55db = [-1920, 3780]</i> <i>AO-0319 SRAP 65db = [-1800, -840]</i> <i>AO-0319 SRAP 75db = [-480, -360]</i> residents	<i>AO-0319 SRAP 55db = [-1.19%, 0.64%]</i> <i>AO-0319 SRAP 65db = [-9.65%, -0.81%]</i> <i>AO-0319 SRAP 75db = [-50%, -4.79%]</i> residents[%]

Pls	Unit	Calculation	Mandatory	Benefit in SESAR1 (if applicable)	Absolute expected performance benefit in SESAR2020	% expected performance benefit in SESAR2020
LAQ1 Geographic distribution of pollutant concentrations	Airport Local Air Quality Studies (ALAQs) inventory method generally uses mg/m ³ for each pollutant	Measurement to be performed within LTO cycle. NOx: Nitrogen oxides, including nitrogen dioxide (NO ₂) and nitrogen oxide (NO); VOC: Volatile organic compounds (including non-methane hydrocarbons (NMHC)); CO: Carbon monoxide; PM: Particulate matter (fraction size PM _{2.5} and PM ₁₀); SOx: Sulphur oxides. Recommended tools: Open-ALAQs	YES for Airport OE Solutions relative to LTO (=>below 3000ft)	NA		

926

927 **4.5.3 Extrapolation to ECAC wide**

928 There is no ECAC wide extrapolation required for this KPI.**Discussion of Assessment Result**

929 Please see the section conclusions above for each of KPI. The confidence in the results is moderate.

930 **4.5.5 Additional Comments and Notes**

931 No further comments.

932 **4.6 Airspace Capacity (Throughput / Airspace Volume & Time)**

933 NA

4.7 Airport Capacity (Runway Throughput Flights/Hour)

4.7.1 Performance Mechanism

The Second Runway Aiming Point (SRAP) concept depending on the way it is operated, impacts the wake separation between aircraft, see the BIM in the OSED Part I [44] for more details.

From a wake point of view, the wake separations for the SRAP concept are only defined by the guaranteed altitude difference between the conventional glide and the SRAP glide at one generator wing span altitude. Three altitude differences are here investigated: 45 m, 60 m and 65 m leading to increasing separation reductions. The way this difference is operationally set-up depends on the chosen glide parameters (glide slope or aiming point displacement) and on the vertical navigation system uncertainty when operating on the SRAP glide.

An altitude difference of 45 m can, for instance, be obtained with

- SRAP with 1110 m aiming point displacement when navigating with GBAS (or ILS) on SRAP glide ($TSE_{vert}=13$ m)

4.7.2 Assessment Data (Exercises and Expectations)

The results are extracted from the FTS12 and FTS13 exercises. In particular FTS12 looked at the SRAP OIs. The FTS13 looked at all the 5 OIs.

Being PJ02.02 a solution focused only on Arrivals OIs only CAP3.2 KPI is reported below.

CAP3.2:

Several RTS and FTS have been performed during the solution lifecycle. RTS are not the most appropriate method to measure capacity benefits, therefore the CAP3.2 results (segregated mode) are based on the more comprehensive set of results obtained by the FTS12 exercise and FTS13 exercise. Due to limitations FTS8 and FTS9 results are not used, see rationale in VALR for details.

FTS12 looked at (LHR) and one traffic sample (based on 2018 traffic), representing a typical daily traffic at London Heathrow. The Fast Time simulation exercise has been conducted with two different allocations of equipped aircraft within the simulated day (medium BAW aircraft and all medium aircraft). However, some of the constraints applicable to LHR may not be faced at other airports, which could lead to different results at other airports.

The FTS12 results look at:

SRAP = Runway capacity is increased (+2.5 to 4.5 mvts per hour)

In FTS13 different traffic samples have been assessed for the different solution scenarios (5 OIs) and compared to the reference scenario (ICAO DBS).

The tables below summarize throughput % change obtained where the negative value represents a decrease in throughput compared to the baseline. Those throughput values are depending on the traffic sample as a higher percentage of Heavy aircraft increases the possibility to reduce wake separations and on glide parameters (altitude difference, number of interception points) as explained above. The results are not in contradiction with the FTS12 and are used for the KPI analysis. For details on the FTS results see the VALR.

Wake Scheme – OI – SRAP parameter	Traffic mix				
	S5H0	S5H10	S5H20	S5H30	S5H40
ICAO SRAP 45 1 alt	-1,8%	-0,2%	1,2%	1,8%	1,9%
ICAO SRAP 45 2 alt	-1,8%	0,0%	1,8%	2,8%	2,7%
ICAO SRAP 60 1 alt	-1,7%	-0,1%	1,3%	1,8%	2,0%
ICAO SRAP 60 2 alt	-1,4%	1,4%	3,8%	4,8%	5,0%
ICAO SRAP 65 1 alt	-1,7%	-0,1%	1,3%	1,8%	2,0%
ICAO SRAP 65 2 alt	-0,6%	3,2%	6,6%	7,7%	8,0%

974

975

CAP4:

976

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.

977

978

979

980

AO-0319 SRAP = [-281, 1116] increase in flights/year.

981

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)	% Flight hour and per	% 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 (Segregate d mode)	% Flight hour and per	% 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

KPIs / PIs	Unit	Calculation	Mandatory	Benefit in SESAR1 (if applicable)	Absolute expected performance benefit in SESAR2020	% expected performance benefit in SESAR2020
CAP3.2 Peak Arrival throughput per hour (Segregated mode)	% Flight hour and 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	NA	<i>AO-0319 SRAP = [-0.77, 3.06] increase in movements/hour</i>	<i>AO-0319 SRAP = [-1.8%, 7.7%] increase in movements/hour</i>
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.	<i>To be completed if there were any benefits obtained in SESAR1 for this Solution? (YES/NO and value of the benefit) If yes, does the SESAR2020 Solution's performance comes in addition to SESAR1 or replace it?</i>	<i>AO-0319 SRAP = [-281, 1116] increase in flights/year</i>	<i>AO-0319 SRAP = [-1.8%, 7.7%] increase in flights/year</i>

982

983 **4.7.3 Extrapolation to ECAC wide**

984 There is no ECAC wide extrapolation required for this KPI.

985 **4.7.4 Discussion of Assessment Results**

986 These results meet and exceed the performance targets defined from PJ19 that were 1.372% increase
 987 in capacity when 3 of the OIs of the solution are applied. Some results of the combined PJ02.02 and
 988 PJ02.01 benefits are presented in the next paragraph.

989 The confidence estimate in the results is moderate, they are based on generic characteristics that are
 990 common in other European airports. The benefits identified are an estimation applicable to very large,
 991 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 airport the exact benefits are depending on several factors including specific traffic mix, length of traffic peak, wind conditions, applicable surveillance minima, glide parameters, fraction of aircraft type operating on the SRAP glide, runway occupancy time, glide length, runway layout, airport infrastructure, etc.

Results for airports not traffic-constrained that could benefit from noise-related concepts are not available, and could potentially be very different from those presented for traffic-constrained airports.

4.7.5 Additional Comments and Notes

FTS13 provided also results when combining PJ02.02 to PJ02.01 OIs like PWS-A AO-306, they are reported below. More positive benefits are found for all OIs in different combination.

Wake Scheme – OI – SRAP parameter	Traffic mix				
	S5H0	S5H10	S5H20	S5H30	S5H40
RECATPWS SRAP 45 1 alt	0,8%	5,7%	9,3%	12,2%	14,7%
RECATPWS SRAP 45 2 alt	0,8%	5,7%	9,5%	12,4%	14,9%
RECATPWS SRAP 60 1 alt	0,8%	5,8%	9,4%	12,3%	14,8%
RECATPWS SRAP 60 2 alt	1,2%	6,0%	10,3%	13,3%	15,6%
RECATPWS SRAP 65 1 alt	0,8%	5,8%	9,4%	12,3%	14,8%
RECATPWS SRAP 65 2 alt	1,1%	6,1%	11,0%	14,0%	17,0%

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

NA

4.9 Flight times

NA

4.10 Predictability (Flight Duration Variability, against RBT)

NA

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

NA

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

NA

1014 4.13 Flexibility

1015 NA

1016 4.14 Cost Efficiency

1017 4.14.1 Performance Mechanism

1018 The Second Runway Aiming Point (SRAP) concept depending on the way it is operated, impacts the
 1019 wake separation between aircraft, if aircraft are closer on final, more aircraft can land in 1 hour
 1020 time. See the BIM in the OSED Part I and section above for Capacity KPI for more details.

1021 4.14.2 Assessment Data (Exercises and Expectations)

1022 As per Capacity KPI above.

1023 In FTS13 different traffic samples have been assessed for the different solution scenarios (5 OIs) and
 1024 compared to the reference scenario (ICAO DBS).

1025 The tables below summarize throughput % change obtained where the negative value represents a
 1026 decrease in throughput compared to the baseline. Those throughput values are depending on the
 1027 traffic sample as a higher percentage of Heavy aircraft increases the possibility to reduce wake
 1028 separations and on glide parameters (altitude difference, number of interception points) as explained
 1029 above. For details on the FTS results see the VALR [41].

1030

Wake Scheme – OI – SRAP parameter	Traffic mix				
	S5H0	S5H10	S5H20	S5H30	S5H40
ICAO SRAP 45 1 alt	-1,8%	-0,2%	1,2%	1,8%	1,9%
ICAO SRAP 45 2 alt	-1,8%	0,0%	1,8%	2,8%	2,7%
ICAO SRAP 60 1 alt	-1,7%	-0,1%	1,3%	1,8%	2,0%
ICAO SRAP 60 2 alt	-1,4%	1,4%	3,8%	4,8%	5,0%
ICAO SRAP 65 1 alt	-1,7%	-0,1%	1,3%	1,8%	2,0%
ICAO SRAP 65 2 alt	-0,6%	3,2%	6,6%	7,7%	8,0%

1031

1032 4.14.3 Extrapolation to ECAC wide

1033 CEF2 is defined as “# of flights handled by the ATCO in 1 hour”. For Tower and Final Approach
 1034 controllers, this metric is equivalent to the runway throughput observed in 1h hour, so equivalent to
 1035 the CAP3.2 target. As extrapolation to ECAC wide is not requested for CAP3.2 KPI, the same is applied
 1036 to the CEF2. The ECAC wide effect will be taken in account by the CBA.

1037

KPIs / Pls	Unit	Calculation	Mandatory	Benefit in SESAR1 (if applicable)	Absolute expected performance benefit in SESAR2020	% expected performance benefit in SESAR2020
CEF2⁶ Flights per ATCO-Hour on duty	Nb	Count of Flights handled divided by the number of ATCO-Hours applied by ATCOs on duty.	YES	NA	AO-0319 SRAP = [-0.77, 3.06] increase in movements/hour	AO-0319 SRAP = [-1.8%, 7.7%] increase in movements/hour

1038 4.14.4 Discussion of Assessment Result

1039 On top of the increased productivity for ATCOs, being able to manage more aircraft in 1h, there are
 1040 evidences that workload is reduced when concepts are applied, see VALR for details.

1041 4.14.5 Additional Comments and Notes

1042 No further comments.

⁶ 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 additional capacity (note that in this case the assumption is that additional capacity is used for additional traffic).

1043 **4.15 Airspace User Cost Efficiency**

1044 NA

1045 **4.16 Security**

1046 NA

1047 **4.17 Human Performance**

1048 **4.17.1 HP arguments, activities and metrics**

PIs	Activities & Metrics	Second level indicators	Covered
HP1 Consistency of human role with respect to human capabilities and limitations		HP1.1 Clarity and completeness of role and responsibilities of human actors	Not covered
		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		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 Adequacy of team structure and team communication in supporting the human actors		HP3.1 Adequacy of team composition in terms of identified roles	Not covered
		HP3.2 Adequacy of task allocation among human actors	Not covered
		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		HP4.1 User acceptability of the proposed solution	Covered
		HP4.2 Feasibility in relation to changes in competence requirements	Not covered
		HP4.3	Not covered

PIs	Activities & Metrics	Second level indicators	Covered
		Feasibility in relation to changes in staffing levels, shift organization and workforce relocation.	
		HP4.4 Feasibility in relation to changes in recruitment and selection requirements.	Not covered
		HP4.5 Feasibility in terms of changes in training needs with regard to its contents, duration and modality.	Covered

1049 4.17.2 Extrapolation to ECAC wide

1050 There is no ECAC wide extrapolation required for this KPI.

1051 4.17.3 Open HP issues/ recommendations and requirements

PIs	Number of open issues/ benefits	Nr. of recommendations	Number of requirements
HP1 Consistency of human role with respect to human capabilities and limitations	6	15	20
HP2 Suitability of technical system in supporting the tasks of human actors	1	19	34
HP3 Adequacy of team structure and team communication in supporting the human actors	1	2	7
HP4 Feasibility with regard to HP-related transition factors	0	2	5

1052 4.17.4 Concept interaction

1053 The project is linked to PJ02-01 where the ORD tool is developed, all requirements and
1054 recommendations applying in PJ02-01 for the tool are also applicable for PJ02-02.

1055 4.17.5 Most important HP issues

1056

PIs	Most important issue of the solution	Most important issues due to solution interdependencies
HP1 Consistency of human role with respect to	FC is disoriented by (virtual or physical?) the several available runway markers and lighting indicators and lands on a RAP different from the one cleared for.	

PIs	Most important issue of the solution	Most important issues due to solution interdependencies
human capabilities and limitations	APP PC does not realize that provided weather information (important for the conduct of a certain approach type important) in the ATIS is erroneous (SV input). As a consequence the ATCO clears for a procedure that is not feasible	
	The use of the SRAP functions could be done whereas other cockpit functions are used in the same time. For example, it could concern functions used in the approach phase or approach preparation phase such as CDA, I4D and ASAS functions. The use of SRAP could impact the use of these other cockpit functions if they are not well interfaced from an operational and HMI point of view.	
	Increasing the slope may challenge pilots' habits regarding approach procedure: new perception of the runway, new tasks to accomplish, etc. which may be more mentally demanding than for conventional approaches leading therefore to potential additional workload	
HP2 Suitability of technical system in supporting the tasks of human actors	Aircraft performance and the system ability to fly SRAP has an impact on the actual performance	
HP3 Adequacy of team structure and team communication in supporting the human actors		
HP4 Feasibility with regard to HP-related transition factors		

1057

1058 **4.17.6 Additional Comments and Notes**

1059 The open issues relate to the airside as the project is not finalised yet and the results of the mitigation
 1060 assessment to the issues are not known yet.

4.18 Other Pls

NA

4.19 Gap Analysis

KPI	Validation Targets – Network Level (ECAC Wide)	Performance Expectations at Network Level (ECAC Wide or Local depending on the KPI) ⁷	Benefits at Network Level depending on the KPI	Rationale ⁸
FEFF1: Fuel Efficiency – Fuel burn per flight	6.07 Kg	AO-0319 SRAP = [2.65, 55.1] reduction kg of fuel per flight		
CAP3.2: Airport Capacity – Peak Runway Throughput (Segregated mode).	1.372%	AO-0319 SRAP = [-1.8%, 7.7%] increase in movements/hour		
CEF2: ATCO Productivity – Flights per ATCO -Hour on duty	0.267%	AO-0319 SRAP = [-1.8%, 7.7%] increase in movements/hour		
SAF1: Safety - Total number of fatal accidents and incidents with ATM Contribution per year	-0.12% MAC-TMA -0.22% RWY-Col -1.05% CFIT -0.24% WAKE FAP	NA		See Section 4.3.3 for Rationale

Table 28: Gap analysis Summary

⁷ Negative impacts are indicated in red.

⁸ 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).

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.sesariu.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.sesariu.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

1096	[18]PJ19.04.01 D4.5 Validation Targets (2018), Edition 01.00.00, April 2018
1097	https://stellar.sesarju.eu/servlet/dl/ShowDocumentContent?doc_id=6784461.13&att=attach
1098	ment&statEvent=Download
1099	[19]16.06.06-D68 Part 1 –SESAR Cost Benefit Analysis – Integrated Model
1100	[20]16.06.06-D51-SESAR_1 Business Case Consolidated_Deliverable-00.01.00 and CBA
1101	[21]Method to assess cost of European ATM improvements and technologies, EUROCONTROL
1102	(2014)
1103	[22]ATM Cost Breakdown Structure_ed02_2014
1104	[23]Standard Inputs for EUROCONTROL Cost Benefit Analyses
1105	[24]16.06.06_D26-08 ATM CBA Quality Checklist
1106	[25]16.06.06_D26_04_Guidelines_for_Producing_Benefit_and_Impact_Mechanisms
1107	Validation
1108	[26]03.00 D16 WP3 Engineering methodology
1109	[27]Transition VALS SESAR 2020 - Consolidated deliverable with contribution from Operational
1110	Federating Projects
1111	[28]European Operational Concept Validation Methodology (E-OCVM) - 3.0 [February 2010]
1112	System Engineering
1113	[29]SESAR Requirements and V&V guidelines
1114	Safety
1115	[30]SESAR, Safety Reference Material, Edition 4.0, April 2016
1116	https://stellar.sesarju.eu/jsp/project/qproject.jsp?objId=1795089.13&resetHistory=true&sta
1117	tInfo=Ogp&domainName=saas
1118	[31]SESAR, Guidance to Apply the Safety Reference Material, Edition 3.0, April 2016
1119	https://stellar.sesarju.eu/jsp/project/qproject.jsp?objId=1795102.13&resetHistory=true&sta
1120	tInfo=Ogp&domainName=saas
1121	[32]SESAR, Final Guidance Material to Execute Proof of Concept, Ed00.04.00, August 2015
1122	[33]Accident Incident Models – AIM, release 2017
1123	https://stellar.sesarju.eu/servlet/dl/ShowDocumentContent?doc_id=3658775.13&att=attach
1124	ment&statEvent=Download
1125	Human Performance
1126	[34]16.06.05 D 27 HP Reference Material D27

1127 [35]16.04.02 D04 e-HP Repository - Release note

1128 Environment Assessment

1129 [36]SESAR, Environment Reference Material, alias, “Environmental impact assessment as part of
1130 the global SESAR validation”, Project 16.06.03, Deliverable D26, 2014.

1131 [37]ICAO CAEP – “Guidance on Environmental Assessment of Proposed Air Traffic Management
1132 Operational Changes” document, Doc 10031.

1133 Security

1134 [38]16.06.02 D103 SESAR Security Ref Material Level

1135 [39]16.06.02 D137 Minimum Set of Security Controls (MSSCs).

1136 [40]16.06.02 D131 Security Database Application (CTRL_S)

1137 **5.1 Reference Documents**

1138 [41]PJ02-02 D2.1.04 SESAR PJ02-02 VALR, Edition 00.01.00

1139 [42]PJ02-02 VALP Part II – Safety Assessment Plan, 21 October 2019

1140 [43]PJ02-02 VALR Part II _ Safety Assessment Report, 29 November 2019

1141 [44]D4.3.002 - PJ.02-W2-14.3 SPR-INTEROP/OSED final Part I, Ed. 00.01.00, August 2022

1142

1143

1144

1145

1146

1147

1148

1149



1150