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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-W2-14.5, IGS-to-SRAP Increased Glide Slope to Second Runway Aiming Point, which consists of the extrapolation to ECAC wide level of the performance assessment results obtained through validation activities conducted for the concept.

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Table of Contents

List of Tables

List of Figures

1 Executive Summary

This document provides the Performance Assessment Report (PAR) for SESAR 2020 Wave 2 PJ.02-W2-14.5, Increased Glide Slope to 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-W2-14.5 solution develops the Enhanced Arrival Operations using Increased Glide Slope to Second Runway Aiming Point (IGS-to-SRAP) with the objectives 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 summarise the assessment outcomes per KPI (Table 1) and mandatory PI (Table 2) put them side-by side against Validation Targets in case of KPI from PJ19 [18]. The impact of the 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 Targets – Network Level (ECAC Wide)	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-0331 IGS-to-SRAP** = [2.65, 55.1] reduction kg of fuel per flight*	*Medium*
CAP3.2: Airport Capacity – Peak Runway Throughput (Segregated mode).	*1.372%*	*AO-0331 IGS-to-SRAP = [-1.8%, 7.7%] increase in movements/hour*	*Medium*
CEF2: ATCO Productivity – Flights per ATCO -Hour on duty	*0.267%*	*AO-0331 IGS-to-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-Col* *-1.05% CFIT* *-0.24% WAKE FAP*	*NA*	*Low*

Table 1: KPI Assessment Results Summary

[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-0331 IGS-to-SRAP*** = *[2.65, 55.1]* reduction kg CO_2 per flight	*Medium*
FEFF3: Reduction in average flight duration.	***AO-0331 IGS-to-SRAP*** = *[-0.06, 0.94]* reduction minutes per flight	*Medium*
NOI1: Relative noise scale	***AO-0331 IGS-to-SRAP*** = *[2]* For Airport with a large fraction of MEDIUM aircraft ***AO-0331 IGS-to-SRAP*** = *[1]* For Airport with a large fraction of HEAVY aircraft	*Medium*
NOI2: Size and location of noise contours	***AO-0331 IGS-to-SRAP 55db*** = *[-2.73, 0.92]* contour size evolution km2 ***AO-0331 IGS-to-SRAP 65db*** = *[-0.57, -0.5]* contour size evolution km2 ***AO-0331 IGS-to-SRAP 75db*** = *[-0.14, -0.07]* contour size evolution km2	*Medium*
NOI4: Number of people exposed to noise levels exceeding a given threshold	***AO-0331 IGS-to-SRAP 55db =*** [-16380, 5520] residents ***AO-0331 IGS-to-SRAP 65db =*** [-3420, -3000] residents ***AO-0331 IGS-to-SRAP 75db =*** [-840, -420] 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-0331 IGS-to-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*

185 **Table 2: Mandatory PIs Assessment Summary**

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2 Introduction

2.1 Purpose of the document

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

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

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222 ## 2.4 Glossary of terms

223 N/A

224 ## 2.5 Acronyms and Terminology

Term	Definition
A-IGS	Adaptive Increased Glide Slope
ANS	Air Navigation Service
ANSP	Air Navigation Service Provider
ATFM	Air Traffic Flow Management
ATM	Air Traffic Management
BAD	Benefits Assessment Date
BAER	Benefit Assessment Equipment Rate
CBA	Cost Benefit Analysis
CCDF	Complementary Cumulative Density Function
CFIT	Control Flight Into Terrain
CSPR-ST	Closely Spaced Parallel Runways using Staggered Thresholds
DB	Deployment Baseline
DOD	Detailed Operational Description
EAP	Enhanced Arrival Procedures
E-ATMS	European Air Traffic Management System
ECAC	European Civil Aviation Conference
FTS	Fast Time Simulation
GBAS	Ground Based Augmentation System
HP	Human Performance
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
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
PAR	Performance Assessment Report
PI	Performance Indicator
PRU	Performance Review Unit
QoS	Quality of Service
RMC	Rolling Moment Coefficient
RNP	Required Navigation Performance
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
TSE	Total System Error
WT on FAP	Wake Turbulence on Final Approach

Table 3: Acronyms and terminology

3 Solution Scope

3.1 Detailed Description of the Solution

PJ2-02 solution develops the following Enhanced Arrival Procedure with the objectives of reducing environmental impact, mainly noise, and when possible, improving capacity:

- Enhanced Arrival procedures using an Increased Glide Slope to a Second Runway Aiming Point (IGS-to-SRAP).

This procedure can be guided by GBAS, RNP.

That can be flown on top of any active procedure, only one Enhanced Procedure can be active, at a given time, in addition to the standard approach procedure.

3.2 Detailed Description of relationship with other Solutions

PJ02-02 is using a controller separation assistance tool based on the tool developed in PJ02-01, to help controller 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	PJ02-02 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.

PJ02-02 performed fourteen validation activities, three fast time simulations and three real time simulations. They are listed in the table below.

Exercise ID	Exercise Title	Release	Maturity	Status
F09	Contribute to the assessment of capacity and of the environmental impact of IGS-to-SRAP operations.	R9	V3	Finished
F12	IGS-to-SRAP	R9	V3	Finished
F13	Evaluation of benefits/drawbacks of IGS-to-SRAP.	R9	V3	Finished
R02	Increased Glide Slope to Second Runway Aiming Point (IGS-to-SRAP)	R9	V3	Finished
R03	Increased Glide Slope to Second Runway Aiming Point (IGS-to-SRAP)	R9	V3	Finished
R05	Runway Marking and Lighting for IGS-to-SRAP	R9	V3	Finished

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 three fast-time simulations, FTS9 were as well not considered for the following reasons:

- 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 two fast-time exercises, F12 and F13.

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

F12	AO-0331	The aim of this exercise is to assess environmental impacts in addition to runway and TMA throughput based on a traffic sample representative of London Heathrow airport.	• Runway capacity is increased (+2.5 to 4.5 mvts per hour) • The noise contours are shifted to the airport area • Fuel consumption is decreased with both concepts, more with IGS-to-SRAP than with IGS.
F13	AO-0331	Fast Time simulation to evaluate benefits/drawbacks in terms of Throughput, number of go-arounds, separation delivery accuracy and fuel burn IGS-to-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. • positive impact on fuel burn savings as the flight duration is reduced.

Table 6: Summary of Validation Results.

4.2 Conditions / Assumptions for Applicability

IGS-to-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 IGS-to-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 IGS-to-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 IGS-to-SRAP	10%	25%	50%		75%	100%	
Separation scheme			min	max		min	max
ICAO IGS-to-SRAP 45 m 1 inter alt	-3.9%	-7.0%	-19.6%	-5.1%	-3.5%	-1.3%	-0.8%
ICAO IGS-to-SRAP 45 m 2 inter alt	-3.7%	-6.7%	-19.6%	-4.8%	-3.2%	-1.3%	-0.4%
ICAO S IGS-to-RAP 60 m 1 inter alt	-3.5%	-6.7%	-19.6%	-4.9%	-3.2%	-0.9%	-0.4%
ICAO IGS-to-SRAP 60 m 2 inter alt	-2.8%	-5.0%	-19.5%	-2.8%	-1.0%	-0.6%	2.2%
ICAO IGS-to-SRAP 65 m 1 inter alt	-3.5%	-6.7%	-19.6%	-4.9%	-3.2%	-0.9%	-0.4%

ICAO IGS-to-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 IGS-to-SRAP runs

%age Medium on IGS-to-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 IGS-to-SRAP 45 m 1 inter alt	-4.5%	-7.6%	-21.0%	-5.5%	-4.2%	-2.9%	-1.3%
ICAO IGS-to-SRAP 45 m 2 inter alt	-4.3%	-7.3%	-21.0%	-5.2%	-3.8%	-2.9%	-0.7%
ICAO IGS-to-SRAP 60 m 1 inter alt	-4.1%	-7.3%	-20.9%	-5.3%	-3.8%	-2.6%	-0.9%
ICAO IGS-to-SRAP 60 m 2 inter alt	-3.5%	-5.7%	-20.8%	-3.2%	-1.6%	-2.2%	**1.9%**
ICAO IGS-to-SRAP 65 m 1 inter alt	-4.1%	-7.3%	-20.9%	-5.3%	-3.8%	-2.6%	-0.9%
ICAO IGS-to-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 IGS-to-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 – 0331 - Increased Glide Slope to a Second Runway Aiming Point (IGS-to-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 the IGS-to-SRAP 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 Encounter[5] 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"):

> **IGS-to-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 IGS-to-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):

> **IGS-to-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 IGS-to-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 IGS-to-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 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.

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[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)

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

A set of SACs, dedicated to the IGS-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 that concept.

<u>FINAL APPROACH PATH INTERCEPTED&FLOWN (encompassing safe landing & RWY vacation)</u>

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

IGS-to-SRAP-SAC#CFIT-1: The likelihood of "Controlled Flight Towards Terrain" on final approach segment during IGS-to-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):

IGGS-to-SRAP-SAC#CFIT-2: The likelihood of Flight towards terrain commanded by Pilot on final approach segment during IGS-to-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):

IGS-to-SRAP-SAC#CFIT-3: The likelihood of Flight towards terrain commanded by Airborne Systems on final approach segment during IGS-to-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):

IGS-to-SRAP-SAC#CFIT-4: The likelihood of Flight towards terrain commanded by ATC on final approach segment during IGS-to-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):

IGS-to-SRAP-SAC#CFIT-5: The likelihood of Flight towards terrain commanded by ANS on final approach segment during IGS-to-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):

IGS-to-SRAP-SAC#RWE-1: The likelihood of Runway excursion following stabilised touchdown in TDZ during IGS-to-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):

IGS-to-SRAP-SAC#RWE-2: The likelihood of Runway excursion following touchdown outside TDZ during IGS-to-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):

IGS-to-SRAP-SAC#RWE-3: The likelihood of Runway accident following unstable touchdown (e.g. hard landing) during IGS-to-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):

IGS-to-SRAP-SAC#RWE-4: The likelihood of Touchdown outside TDZ during IGS-to-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):

IGS-to-SRAP-SAC#RWE-5: The likelihood of Unstable touchdown (e.g. Hard landing) during IGS-to-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):

IGS-to-SRAP-SAC#RWE-6: The likelihood of Unstable approach during IGS-to-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 IGS-to-SRAP enhanced arrival procedure are applicable (see WE 7F.1 in AIM WT on Final Approach model and account for MRS minima):

IGS-to-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 IGS-to-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):

IGS-to-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 IGS-to-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 10/11in AIM WT accident on Final Approach model):

IGS-to-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 IGS-to-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):

IGS-to-SRAP-SAC#F1: The probability per approach of Imminent collision during interception and final approach shall be no greater in operations when IGS-to-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):

IGS-to-SRAP-SAC#F2: The probability per approach of Imminent infringement (radar separation) during interception and final approach shall be no greater in operations when IGS-to-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.

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):

> **IGS-to-SRAP-SAC#R-1:** The probability per approach of Runway Conflict during IGS-to-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 ac/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):

> **IGS-to-SRAP-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 AC/vehicle shall not increase during IGS-to-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 IGS-to-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 IGS-to-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 IGS-to-SRAP glide and the follower follows a lower glide, the wake separation minima are increased (Detailed results are provided in OSED 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 OSED Annex)

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

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

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

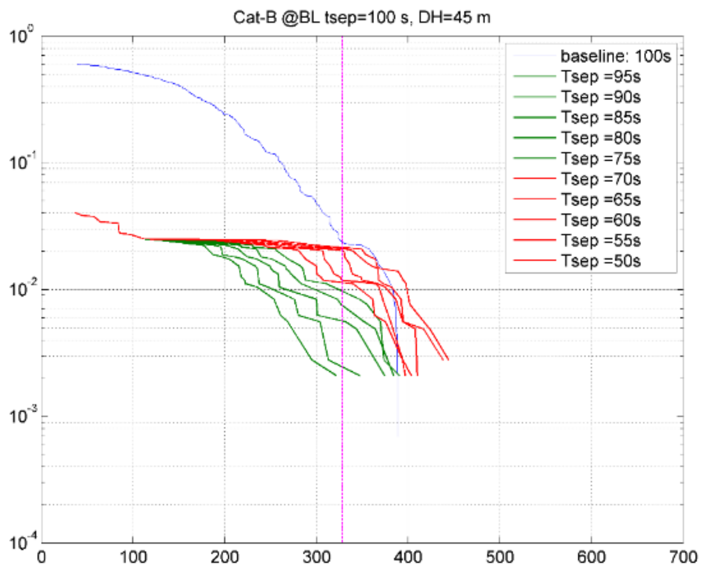
	Follower on CONVENTIONAL (LOWER)	Follower on IGS-to-SRAP

Leader on CONVENTIONAL (LOWER)	Baseline	Separation reduction
Leader on IGS-to-SRAP	Separation increase	Same as baseline

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

For In-Ground Effect (IGE) region, the allowed time separation reduction when operating IGS-to-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 an IGS-to-SRAP DH=45 m above the ILS with various separation reductions compared to the baseline time separation (100 s)



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On the contrary, for Out-of-Ground Effect (OGE) situation, when an aircraft on a lower glide follows an aircraft flying on an upper IGS-to-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 represents the absolute maximum acceptable RMC value OGE based on Flight simulator campaign (WISA). The maximum vortex strength guaranteeing RMC ≤ 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 the IGS-to-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 IGS-to-SRAP separation design indicated that such issue is not expected with IGS-to-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 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).

549

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 Increased Glide Slope to Second Runway Aiming Point (IGS-to-SRAP) concepts, 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 IGS-to-SRAP approach procedures 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 the IGS-to-SRAP procedures compared to the reference scenario from ATC perspective	IGS-to-SRAP-SAC#WT-F2, IGS-to-SRAP-SAC#WT-F4, IGS-to-SRAP--SAC#R-1	No safety related concerns were found in relation to the use of the ORD tool and the IGS-to-SRAP procedures. Safe standard controller practices are used when performing IGS-to-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 IGS-to-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 the IGS-to-SRAP procedure compared to the reference scenario	IGS-to-SRAP-SAC#WT-F2, IGS-to-SRAP-SAC#WT-F4	The results show that the use of the IGS-to-SRAP arrival procedure with ORD tool decrease 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 the IGS-to-SRAP procedure compared to the reference scenario	IGS-to-SRAP-SAC#R-1	
RTS03: RTS conducted by EUROCONTROL in the CDG airport environment to assess the application of the Increased Glide Slope to Second Runway Aiming Point (IGS-to-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 Increase Glide Slope to Secondary Aiming Point (IGS-to-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 the IGS-to-SRAP procedure compared to the reference scenario from ATC perspective	IGS-to-SRAP-SAC#WT-F2, IGS-to-SRAP-SAC#WT-F4, IGS-to-SRAP--SAC#R-1	
		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 the IGS-to-SRAP	IGS-to-SRAP-SAC#WT-F2, IGS-to-SRAP-SAC#WT-F4	

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		procedure 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 the IGS-to-SRAP procedure compared to the reference scenario	IGS-to-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.
RTS05 led by EUROCONTROL to assess IGS-to-SRAP runway aids from pilots point of view, via flight cockpit simulations using a high level professional Level D/Type 7 flight crew training simulator.	**OBJ-02.02-V3-VALP-SRAP.0203 / OBJ-02.02-V3-VALP-ITSR.0203** To confirm that IGS-to-SRAP does not negatively affect safety from the perspective of the crew	**CRT-02.02-V3-VALP-SRAP.0003-001 / CRT-02.02-V3-VALP-ITSR.0203-001** There is evidence that the level of operational safety is maintained and not negatively impacted under the IGS-to-SRAP procedure compared to the reference scenario, from the perspective of the crew	IGS-to-SRAP-SAC#WT-F2, IGS-to-SRAP-SAC#WT-F4, IGS-to-SRAP-SAC#R-1	A reduction in the perceived level of safety for IGS-to-SRAP was observed in lower visibility conditions. Pilots explained that this perceived reduction in safety was brought by the uncertainty caused by seeing only the first aiming point while having to land on the second. Additionally pilots stated that flying to the second runway aiming point with a steeper glide enhances the feeling of being too high when passing the first threshold despite the fact that the second PAPI gives the right indications. On the positive side, the steeper glide slope supports the pilot in identifying the second threshold and focusing on the aiming point.

550

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.

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4.4 Environment / Fuel Efficiency

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

4.4.1 Performance Mechanism

The Increased Glide Slope to Second Aiming Point (IGS-to-SRAP) concept 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 OSED Part I for more details.

From a wake point of view, the wake separations for the IGS-to-SRAP concept are only defined by the guaranteed altitude difference between the conventional glide and the IGS-to-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 IGS-to-SRAP glide.

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

- IGS-to-SRAP with 1060 m aiming point displacement and a 3.5 deg glide slope when navigating with RNAV on IGS-to-SRAP glide (TSE_{vert}=26 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 averaged flying time reduction compared to 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 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

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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

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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) 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:

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

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:

$$Fuel\ burn\ per\ flight = Fuel\ burn\ rate\ x\ 91.5\ min$$

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

Year	Minutes
2016	91.5
2015	91.3

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

Depending on percentage loading:

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

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

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:

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

All OIs have been assessed in the exercise separately as reported in the table below. A negative value indicates a saving in fuel emissions.

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

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.

4.4.3 Extrapolation to ECAC wide

The following PJ19 common assumptions have been used:

- High density airports traffic contribution to total airport traffic = 59.5%
- Arrivals traffic contribution to total traffic = 50%
- Average ECAC flight time = 90 minutes

- CO_2/Fuel ratio = 3.15

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

FEFF3, FEFF2 and FEFF1 for AO-0331 (IGS-To-SRAP)

FEFF3

1. Flight time reduction per arrival #1 = [0.25] min. This is the lowest benefit obtained assessing different traffic samples and different IGS-to-SRAP parameters, from FTS13 results.
2. Flight time reduction (FEFF3) at ECAC level #1 = 50% (arrivals traffic contribution) * 59.5% (high density airports traffic contribution) * 0.25 minutes (flight-time reduction per arrival #1) = 0.07 minutes per flight
3. Relative flight time reduction at ECAC level #1= 0.25 minutes (flight time reduction at ECAC level #1) / 90 minutes (average ECAC flight time) * 100 = 0.27%
4. Flight time reduction per arrival #2 = [3.16] min. This is the highest benefit obtained assessing different traffic samples and different IGS-to-SRAP parameters, from FTS13 results.
5. Flight time reduction (FEFF3) at ECAC level #2 = 50% (arrivals traffic contribution) * 59.5% (high density airports traffic contribution) * 3.16 minutes (flight-time reduction per arrival#2) = 0.94 minutes per flight
6. Relative flight time reduction at ECAC level #2= 0.94 minutes (flight time reduction at ECAC level) / 90 minutes (average ECAC flight time) * 100 = 1.04%

FEFF1

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

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

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

1. Fuel consumption reduction per arrival #1 = 0.25 (flight time reduction per arrival) #1 * 36.3 (fuel burn rate for arrival #1) = 9.07 kg/flight
2. Relative fuel consumption reduction #1 = 9.07 kg/flight (fuel consumption reduction on arrival #1) / 3321 kg (Average fuel burn per flight #1) * 100 = 0.27%

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

4. Fuel consumption reduction per arrival #2 = 3.16 (flight time reduction per arrival #2) * 59.1 (fuel burn rate for arrival #2)= 186.75 kg/flight
5. Relative fuel consumption reduction #2 = 186.75 kg/flight (fuel consumption reduction on arrival #2) / 5407 kg (Average fuel burn per flight #2) * 100= 3.45%

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

FEFF2

1. CO_2 emission reduction per arrival #1 = 9.07 (Fuel consumption reduction on arrival #1) * 3.15 (CO_2/Fuel Ratio) = 28.57 kg CO_2 per flight

2. Relative CO_2 emission reduction on arrival #1 = 28.57 (CO_2 emission reduction #1) / 3321 (Average Fuel burn per flight #1) / 3.15 (CO_2/Fuel ratio) * 100 = 0.27%

3. Relative CO2 emission reduction on arrival #1 (FEFF2) at ECAC level = 50% (arrivals traffic contribution) * 59.5% (high density airports traffic contribution)* x 0.27% (Relative CO2 emission reduction on arrival #1) = 0.08% = 2.65 kg CO_2/flight

4. CO_2 emission reduction on arrival #2 = 186.75 (Fuel consumption reduction on arrival #2) * 3.15 (CO_2/Fuel Ratio) = 588.2 kg CO_2 per flight

5. Relative CO_2 emission reduction on arrival #2 = 588.2 (CO_2 emission reduction #2) / 5407 (Average Fuel burn per flight #1) / 3.15 (CO_2/Fuel ratio) * 100= 3.45%

6. Relative CO2 emission reduction on arrival #2 (FEFF2) at ECAC level = 50% (arrivals traffic contribution) * 59.5% (high density airports traffic contribution)* x 3.45% (Relative CO2 emission reduction on arrival #1) = 1.02% = 55.15 kg CO_2/flight

KPIs / PIs	Unit	Calculation	Mandatory	Benefit in SESAR1 (if applicable)	Absolute expected performance benefit in SESAR2020	% expected performance benefit in SESAR2020
FEFF1 Actual Average fuel burn per flight	Kg fuel per movement	Total amount of actual fuel burn divided by the number of movements	YES	*NA*	***AO-0331 IGS-to-SRAP** = [2.65, 55.1]* reduction kg of fuel per flight	***AO-0331 IGS-to-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-0331 IGS-to-SRAP** = [2.65, 55.1]* reduction kg CO_2 per flight	***AO-0331 IGS-to-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-0331 IGS-to-SRAP** = [-0.06, 0.94]* reduction minutes per flight	***AO-0331 IGS-to-SRAP** = [0.27%, 1.04%]* reduction minutes per flight

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-0331 IGS-to-SRAP*** = *[2.65, 55.1]* reduction kg of fuel per flight	NA
FEFF2 Actual Average CO_2 Emission per flight	NA	NA	NA	***AO-0331 IGS-to-SRAP*** = *[2.65, 55.1]* reduction kg CO_2 per flight	NA
FEFF3 Reduction in average flight duration	NA	NA	NA	***AO-0331 IGS-to-SRAP*** = *[-0.06, 0.94]* reduction minutes per flight	NA

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 IGS-to-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.

4.5 Environment / Noise and Local Air Quality

4.5.1 Performance Mechanism

The Increased Glide Slope to Second Aiming Point (IGS-to-SRAP) concept:

The impact depends on the concept and on the traffic mix. For Noise benefits, one baseline and three test cases, illustrated in Figure 4 and 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 #2 corresponds to a scenario where all Medium and Light aircraft types follow a glide with an Increased-Glide Slope with 3.5 deg to a Second Runway Aiming Point (IGS-to-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.

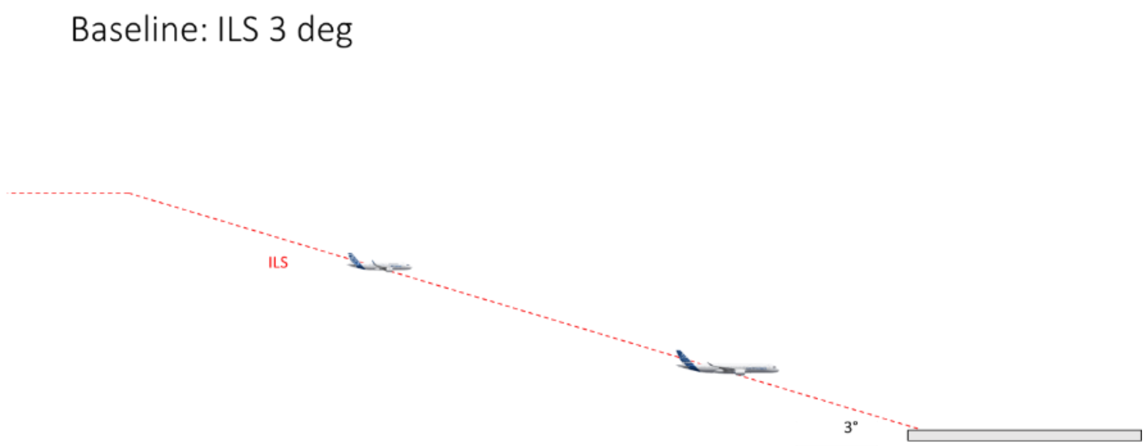

Figure 4: Baseline for noise assessment

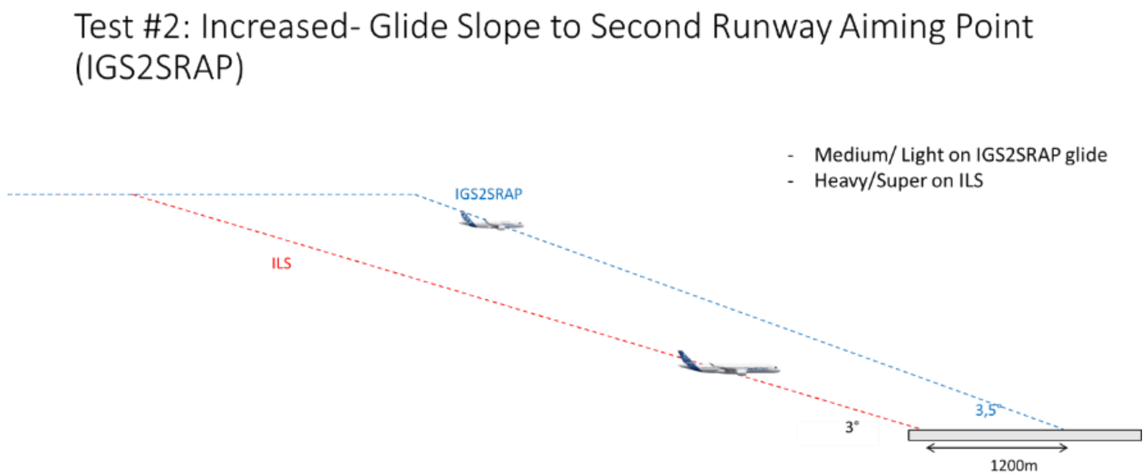

Figure 5: IGS-to-SRAP test case for noise assessment

Those scenarios are tested and compared using the EUROCONTROL IMPACT tool. 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 IGS-to-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 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 IGS-to-SRAP solution (noted *IGS2SRAP* in the following tables) contours (LDEN) are smaller than the baseline ones for all dB levels except for the 75dB. They are also shifted toward the runway (see Figure 7).

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

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

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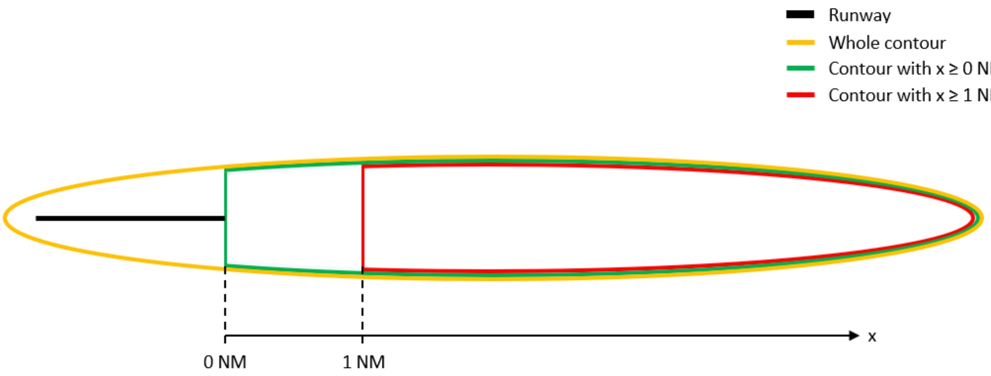

Figure 6: Contour definitions

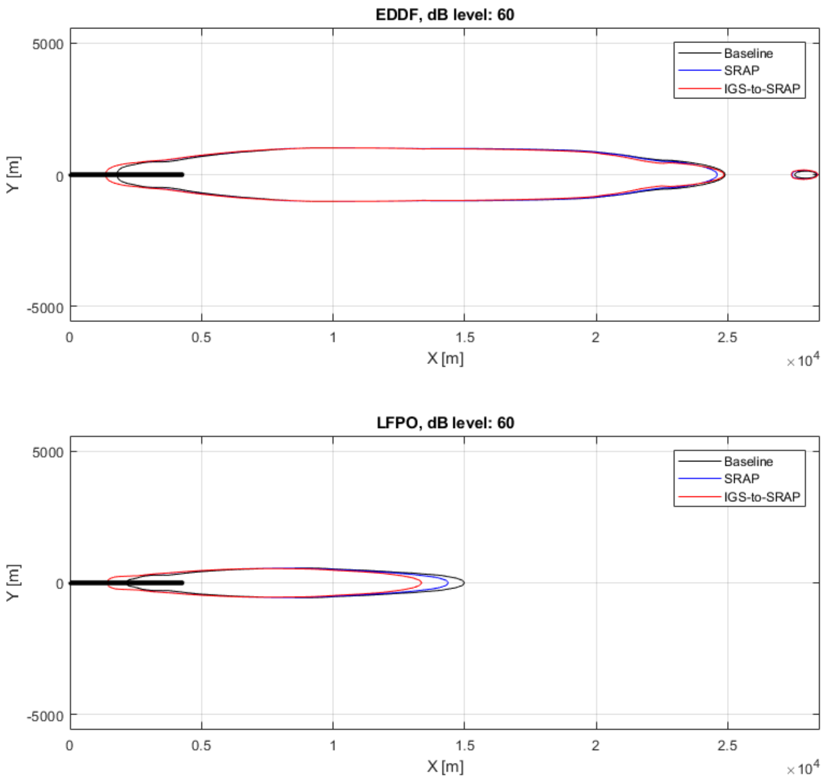

Figure 7: Baseline, IGS-to-SRAP contours (DEN) for EDDF and LFPO for the 60dB level

dB level	Airport	Baseline DEN Surface [km2]	IGS2SRAP Surface [km2]	IGS2SRAP gains [km2]	IGS2SRAP gains [%]
55	EGCC	32.49	31.27	-1.22	-3.8%
	EIDW	33.15	31.57	-1.58	-4.8%
	LFPO	28.55	27.54	-1.01	-3.5%
60	EGCC	12.62	11.98	-0.64	-5.1%
	EIDW	12.65	11.8	-0.85	-6.7%
	LFPO	10.71	9.93	-0.78	-7.3%
65	EGCC	4.68	4.56	-0.12	-2.6%
	EIDW	4.62	4.53	-0.09	-1.9%
	LFPO	3.84	3.68	-0.16	-4.2%
70	EGCC	1.61	1.56	-0.05	-3.1%
	EIDW	1.57	1.53	-0.04	-2.5%
	LFPO	1.24	1.19	-0.05	-4%
75	EGCC	0.48	0.5	+0.02	+4.2%
	EIDW	0.45	0.49	+0.04	+8.9%
	LFPO	0.36	0.39	+0.03	+8.3%
80	EGCC	0.13	0.13	0	
	EIDW	0.14	0.14	0	
	LFPO	0.1	0.08	-0.02	-20

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

dB level	Airport	Baseline DEN Surface [km2]	IGS2SRAP Surface [km2]	IGS2SRAP gains [km2]	IGS2SRAP gains [%]
55	EGCC	30.46	28.42	-2.04	-6.7%
	EIDW	31.34	28.61	-2.73	-8.7%
	LFPO	26.78	24.82	-1.96	-7.3%
60	EGCC	11.29	10.1	-1.19	-10.5%
	EIDW	11.48	9.86	-1.62	-14.1%
	LFPO	9.55	8.14	-1.41	-14.8%
65	EGCC	3.81	3.35	-0.46	-12.1%
	EIDW	3.86	3.28	-0.58	-15%
	LFPO	3.11	2.54	-0.57	-18.3%
70	EGCC	1.07	0.82	-0.25	-23.4%
	EIDW	1.09	0.77	-0.32	-29.4%
	LFPO	0.78	0.52	-0.26	-33.3%
75	EGCC	0.19	0.11	-0.08	-42.1%
	EIDW	0.19	0.09	-0.1	-52.6%
	LFPO	0.12	0.05	-0.07	-58.3%
80	EGCC	0.01	0	-0.01	-100%
	EIDW	0.01	0	-0.01	-100%
	LFPO	0.01	0	-0.01	-100%

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

dB level	Airport	Baseline DEN Surface [km2]	IGS2SRAP Surface [km2]	IGS2SRAP gains [km2]	IGS2SRAP gains [%]
55	EGCC	27.87	25.62	-2.25	-8.1%
	EIDW	28.72	25.71	-3.01	-10.5%
	LFPO	24.35	22.12	-2.23	-9.2%
60	EGCC	9.52	8.22	-1.3	-13.7%
	EIDW	9.69	7.91	-1.78	-18.4%
	LFPO	7.91	6.36	-1.55	-19.6%
65	EGCC	2.67	2.17	-0.5	-18.7%
	EIDW	2.7	2.08	-0.62	-23%
	LFPO	2.07	1.48	-0.59	-28.5%
70	EGCC	0.41	0.21	-0.2	-48.8%
	EIDW	0.42	0.16	-0.26	-61.9%
	LFPO	0.21	0.03	-0.18	-85.7%
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≥1NM from runway threshold for airports with a large fraction of MEDIUM aircraft, different dB levels

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 IGS-to-SRAP solution contours (LDEN) are only larger than the baseline ones for the 55dB and 80B levels. They are also shifted toward the runway.

When accounting for contours beginning at the runway threshold (or further upstream, see Table 19 and Table 20), contour surfaces related to the IGS-to-SRAP solution are seen to be smaller than the reference ones expect for the IGS-to-SRAP solutions 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 airports EDDF, EGLL and EHAM.

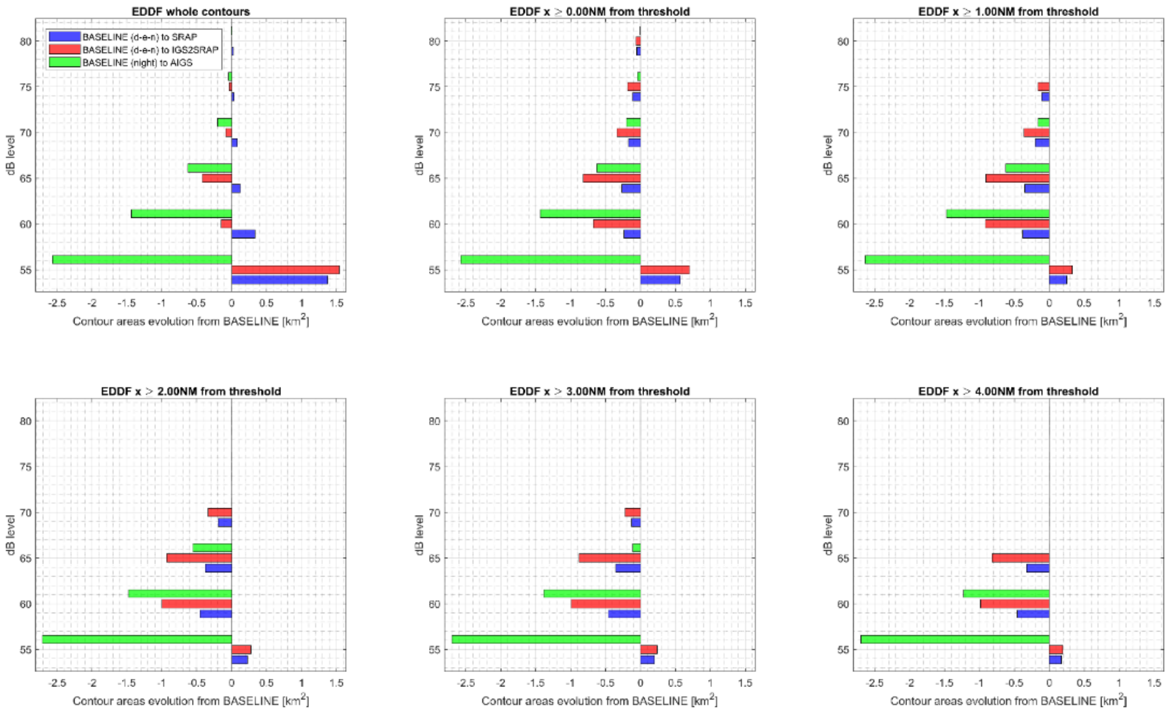

Figure 8: Comparison of contour surfaces for EDDF

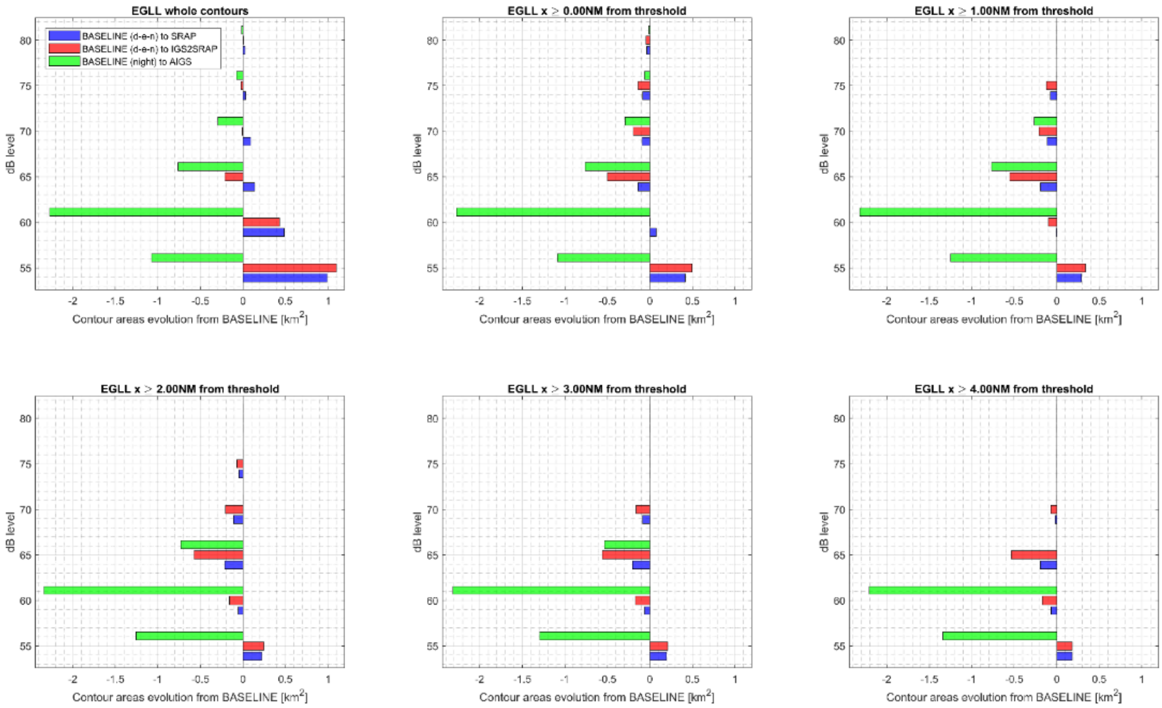

Figure 9: Comparison of contour surfaces for EGLL

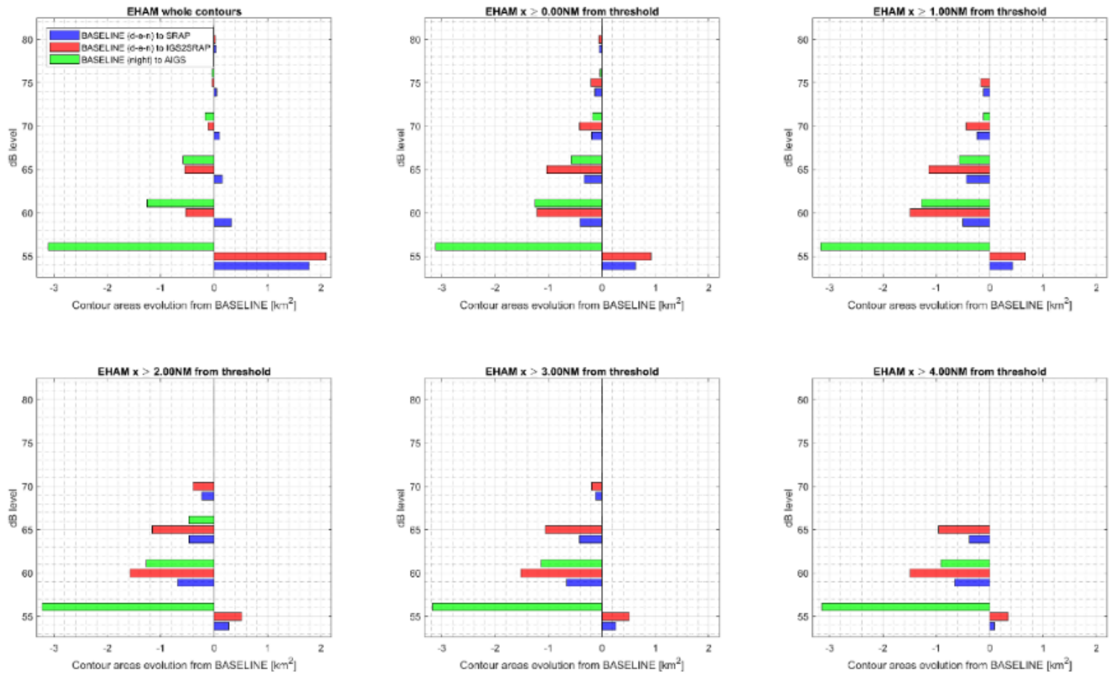

Figure 10: Comparison of contour surfaces for EHAM

dB level	Airport	Baseline DEN Surface [km2]	IGS2SRAP Surface [km2]	IGS2SRAP gains [km2]	IGS2SRAP gains [%]
55	EDDF	113.88	115.43	+1.55	+1.4%
	EHAM	101.48	103.58	+2.1	+2.1%
	EGLL	146.38	147.48	+1.1	+0.8%
60	EDDF	37.37	37.22	-0.15	-0.4%
	EHAM	33.8	33.27	-0.53	-1.6%
	EGLL	55.65	56.08	+0.43	+0.8%
65	EDDF	14.47	14.05	-0.42	-2.9%
	EHAM	12.93	12.38	-0.55	-4.3%
	EGLL	18.76	18.55	-0.21	-1.1%
70	EDDF	5.23	5.14	-0.09	-1.7%
	EHAM	4.62	4.51	-0.11	-2.4%
	EGLL	6.57	6.56	-0.01	-0.2%
75	EDDF	1.79	1.76	-0.03	-1.7%
	EHAM	1.55	1.51	-0.04	-2.6%
	EGLL	2.31	2.29	-0.02	-0.9%
80	EDDF	0.54	0.55	+0.01	+1.9%
	EHAM	0.44	0.46	+0.02	+4.5%
	EGLL	0.71	0.72	+0.01	+1.4%

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

dB level	Airport	Baseline DEN Surface [km2]	IGS2SRAP Surface [km2]	IGS2SRAP gains [km2]	IGS2SRAP gains [%]
55	EDDF	110.4	111.1	+0.7	+0.6%
	EHAM	98.42	99.34	+0.92	+0.9%
	EGLL	142.59	143.08	+0.49	+0.3%
60	EDDF	35.12	34.45	-0.67	-1.9%
	EHAM	31.77	30.55	-1.22	-3.8%
	EGLL	53.22	53.23	+0.01	+0%
65	EDDF	13	12.18	-0.82	-6.3%
	EHAM	11.6	10.56	-1.04	-9%
	EGLL	17.18	16.68	-0.5	-2.9%
70	EDDF	4.28	3.94	-0.34	-7.9%
	EHAM	3.77	3.35	-0.42	-11.1%
	EGLL	5.54	5.35	-0.19	-3.4%
75	EDDF	1.2	1.02	-0.18	-15%
	EHAM	1.02	0.82	-0.2	-19.6%
	EGLL	1.67	1.53	-0.14	-8.4%
80	EDDF	0.21	0.15	-0.06	-28.6%
	EHAM	0.16	0.1	-0.06	-37.5%
	EGLL	0.34	0.29	-0.05	-14.7%

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

833

dB level	Airport	Baseline DEN Surface [km2]	IGS2SRAP Surface [km2]	IGS2SRAP gains [km2]	IGS2SRAP gains [%]
55	EDDF	106.61	106.94	+0.33	+0.3%
	EHAM	94.54	95.22	+0.68	+0.7%
	EGLL	138.31	138.65	+0.34	+0.2%
60	EDDF	32.46	31.54	-0.92	-2.8%
	EHAM	29.17	27.68	-1.49	-5.1%
	EGLL	50.33	50.23	-0.1	-0.2%
65	EDDF	11.17	10.26	-0.91	-8.1%
	EHAM	9.83	8.69	-1.14	-11.6%
	EGLL	15.18	14.63	-0.55	-3.6%
70	EDDF	3.09	2.72	-0.37	-12%
	EHAM	2.63	2.19	-0.44	-16.7%
	EGLL	4.23	4.01	-0.22	-5.2%
75	EDDF	0.52	0.35	-0.17	-32.7%
	EHAM	0.38	0.21	-0.17	-44.7%
	EGLL	0.87	0.75	-0.12	-13.8%
80	EDDF	0	0	0	
	EHAM	0	0	0	
	EGLL	0	0	0	

834 **Table 20: Contour surfaces for x≥1NM from runway threshold for airports with large fraction of HEAVY aircraft, different dB levels**

Conclusions for NOI2

As the IGS-to-SRAP solution consists in a displacement of 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 $x \geq 0NM$ or $x \geq 1NM$, 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.

In addition to the runway threshold displacement for MEDIUM aircraft, the IGS-to-SRAP solution consists in an increased glide slope for those aircraft. The whole contours expansion observed for the IGS-to-SRAP solution for the low dB levels is therefore expected to be mitigated for all airports (either with large fraction 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 km² (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 large fraction of MEDIUM aircraft

One observes in Table 22 (contours accounted from the runway threshold) that for the lowest analysed noise level (55dB). Those reductions increase from -11760 to -16380 residents for the IGS-to-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 IGS-to-SRAP solution, still for the 55dB level.

dB level	Airport	Population inside Baseline DEN Surface [residents]	Population inside IGS2SRAP Surface [residents]	Change in population from baseline to IGS2SRAP [residents]
55	EGCC	194940	187620	-7320
	EIDW	198900	189420	-9480
	LFPO	171300	165240	-6060
60	EGCC	75720	71880	-3840
	EIDW	75900	70800	-5100
	LFPO	64260	59580	-4680
65	EGCC	28080	27360	-720
	EIDW	27720	27180	-540
	LFPO	23040	22080	-960
70	EGCC	9660	9360	-300
	EIDW	9420	9180	-240
	LFPO	7440	7140	-300
75	EGCC	2880	3000	+120
	EIDW	2700	2940	+240
	LFPO	2160	2340	+180
80	EGCC	780	780	0
	EIDW	840	840	0
	LFPO	600	480	-120

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

dB level	Airport	Population inside Baseline DEN Surface [residents]	Population inside IGS2SRAP Surface [residents]	Change in population from baseline to IGS2SRAP [residents]
55	EGCC	182760	170520	-12240
	EIDW	188040	171660	-16380
	LFPO	160680	148920	-11760
60	EGCC	67740	60600	-7140
	EIDW	68880	59160	-9720
	LFPO	57300	48840	-8460
65	EGCC	22860	20100	-2760
	EIDW	23160	19680	-3480
	LFPO	18660	15240	-3420
70	EGCC	6420	4920	-1500
	EIDW	6540	4620	-1920
	LFPO	4680	3120	-1560
75	EGCC	1140	660	-480
	EIDW	1140	540	-600
	LFPO	720	300	-420
80	EGCC	60	0	-60
	EIDW	60	0	-60
	LFPO	60	0	-60

880 **Table 22: Population associated to contours with x≥0NM for airports with large fraction of MEDIUM aircraft**

dB level	Airport	Population inside Baseline DEN Surface [residents]	Population inside IGS2SRAP Surface [residents]	Change in population from baseline to IGS2SRAP [residents]
55	EGCC	167220	153720	-13500
	EIDW	172320	154260	-18060
	LFPO	146100	132720	-13380
60	EGCC	57120	49320	-7800
	EIDW	58140	47460	-10680
	LFPO	47460	38160	-9300
65	EGCC	16020	13020	-3000
	EIDW	16200	12480	-3720
	LFPO	12420	8880	-3540
70	EGCC	2460	1260	-1200
	EIDW	2520	960	-1560
	LFPO	1260	180	-1080
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

881 **Table 23: Population associated to contours with x≥1NM for airports with a large fraction of MEDIUM aircraft**

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 from +2940 to +5520 persons for the IGS-to-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 +60 to -7320 persons for the IGS-to-SRAP solution (with contours starting at the runway threshold). When looking at contours beginning at 1NM from the runway threshold, those reductions increase from -600 to -8940 persons for the IGS-to-SRAP solution.

dB level	Airport	Population inside Baseline DEN Surface [residents]	Population inside IGS2SRAP Surface [residents]	Change in population from baseline to IGS2SRAP [residents]
55	EDDF	683280	692580	+9300
	EHAM	608880	621480	+12600
	EGLL	878280	884880	+6600
60	EDDF	224220	223320	-900
	EHAM	202800	199620	-3180
	EGLL	333900	336480	+2580
65	EDDF	86820	84300	-2520
	EHAM	77580	74280	-3300
	EGLL	112560	111300	-1260
70	EDDF	31380	30840	-540
	EHAM	27720	27060	-660
	EGLL	39420	39360	-60
75	EDDF	10740	10560	-180
	EHAM	9300	9060	-240
	EGLL	13860	13740	-120
80	EDDF	3240	3300	+60
	EHAM	2640	2760	+120
	EGLL	4260	4320	+60

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

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dB level	Airport	Population inside Baseline DEN Surface [residents]	Population inside IGS2SRAP Surface [residents]	Change in population from baseline to IGS2SRAP [residents]
55	EDDF	662400	666600	+4200
	EHAM	590520	596040	+5520
	EGLL	855540	858480	+2940
60	EDDF	210720	206700	-4020
	EHAM	190620	183300	-7320
	EGLL	319320	319380	+60
65	EDDF	78000	73080	-4920
	EHAM	69600	63360	-6240
	EGLL	103080	100080	-3000
70	EDDF	25680	23640	-2040
	EHAM	22620	20100	-2520
	EGLL	33240	32100	-1140
75	EDDF	7200	6120	-1080
	EHAM	6120	4920	-1200
	EGLL	10020	9180	-840
80	EDDF	1260	900	-360
	EHAM	960	600	-360
	EGLL	2040	1740	-300

895 **Table 25: Population associated to contours with x≥0NM for airports with a large fraction of HEAVY aircraft**

dB level	Airport	Population inside Baseline DEN Surface [residents]	Population inside IGS2SRAP Surface [residents]	Change in population from baseline to IGS2SRAP [residents]
55	EDDF	639660	641640	+1980
	EHAM	567240	571320	+4080
	EGLL	829860	831900	+2040
60	EDDF	194760	189240	-5520
	EHAM	175020	166080	-8940
	EGLL	301980	301380	-600
65	EDDF	67020	61560	-5460
	EHAM	58980	52140	-6840
	EGLL	91080	87780	-3300
70	EDDF	18540	16320	-2220
	EHAM	15780	13140	-2640
	EGLL	25380	24060	-1320
75	EDDF	3120	2100	-1020
	EHAM	2280	1260	-1020
	EGLL	5220	4500	-720
80	EDDF	0	0	0
	EHAM	0	0	0
	EGLL	0	0	0

896 **Table 26: Population associated to contours with x≥1NM for airports with a large fraction of HEAVY aircraft**

Conclusion for NOI4

Contours accounting from the runway threshold (x ≥ 0NM) or from a certain distance from it (x ≥ 1NM), 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 ≥ 0NM and x ≥ 1NM) show reductions in the number of affected residents, going up to 18000 residents, for the IGS-to-SRAP solution.

For airports with 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 8900 residents for the IGS-to-SRAP solution for the 60dB level, for contours beginning at 1NM from the runway threshold.

NOI1

Based on the 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 large fraction of MEDIUM aircraft	Airport with large fraction of HEAVY aircraft
IGS-to-SRAP (compared to LDEN baseline)	2	1

Table 27: Relative scale of benefits associated to the solution

Conclusion for NOI1

For airports with a large fraction of HEAVY aircraft, small increases of contour surfaces are observed for the IGS-to-SRAP solution (for whole contours, see Table 18). When looking at contours beginning at 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 IGS-to-SRAP solution, for airports with a large fraction of HEAVY aircraft, has been given classification **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 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*	***AO-0331 IGS-to-SRAP*** *= [2]* For Airport with a large fraction of MEDIUM aircraft ***AO-0331 IGS-to-SRAP*** *= [1]* 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*	***AO-0331 IGS-to-SRAP 55db*** *= [-2.73, 0.92]* ***AO-0331 IGS-to-SRAP 65db*** *= [-0.57, -0.5]* ***AO-0331 IGS-to-SRAP 75db*** *= [-0.14, -0.07]* reduction km2	***AO-0331 IGS-to-SRAP 55db*** *= [-8.7%, 0.9%]* ***AO-0331 IGS-to-SRAP 65db*** *= [-18.3%, -2.9%]* ***AO-0331 IGS-to-SRAP 75db*** *= [-8.4%, 58.3%]* 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*	***AO-0331 IGS-to-SRAP 55db*** *= [-16380, 5520]* ***AO-0331 IGS-to-SRAP 65db*** *= [-3420, -3000]* ***AO-0331 IGS-to-SRAP 75db*** *= [-840, -420]* residents	***AO-0331 IGS-to-SRAP 55db*** *= [-8.71%, 0.93%]* ***AO-0331 IGS-to-SRAP 65db*** *= [-18.3%, -2.91%]* ***AO-0331 IGS-to-SRAP 75db*** *= [-8.4%, 58.3%]* residents[%]

PIs	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/m3 for each pollutant	Measurement to be performed within LTO cycle. NOx: Nitrogen oxides, including nitrogen dioxide (NO2) and nitrogen oxide (NO); VOC: Volatile organic compounds (including non-methane hydrocarbons (NMHC)); CO: Carbon monoxide; PM: Particulate matter (fraction size PM2.5 and PM10); SOx: Sulphur oxides. Recommended tools: Open-ALAQS	YES for Airport OE Solutions relative to LTO (=>below 3000ft)	*NA*		

928

4.5.3 Extrapolation to ECAC wide

There is no ECAC wide extrapolation required for this KPI.

Discussion of Assessment Result

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

4.5.5 Additional Comments and Notes

No further comments.

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4.6 Airspace Capacity (Throughput / Airspace Volume & Time)

NA

4.7 Airport Capacity (Runway Throughput Flights/Hour)

4.7.1 Performance Mechanism

The Increased Glide Slope to Second Aiming Point (IGS-to-SRAP) concept, depending on the way it is operated, impacts the wake separation between aircraft, see the BIM in the OSED Part I for more details.

From a wake point of view, the wake separations for the IGS-to-SRAP concept are only defined by the guaranteed altitude difference between the conventional glide and the IGS-to-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 IGS-to-SRAP glide.

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

- IGS-to-SRAP with 1060 m aiming point displacement and a 3.5 deg glide slope when navigating with RNAV on IGS-to-SRAP glide (TSE_{vert}=26 m) or

4.7.2 Assessment Data (Exercises and Expectations)

The results are extracted from the FTS12 and FTS13 exercises. In particularly FTS12 looked at the IGS-to-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:
IGS-to-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 – IGS-to-SRAP parameter	Traffic mix				
	S5H0	S5H10	S5H20	S5H30	S5H40
ICAO IGS-to-SRAP 45 1 alt	-1,8%	-0,2%	1,2%	1,8%	1,9%
ICAO IGS-to-SRAP 45 2 alt	-1,8%	0,0%	1,8%	2,8%	2,7%
ICAO IGS-to-SRAP 60 1 alt	-1,7%	-0,1%	1,3%	1,8%	2,0%
ICAO IGS-to-SRAP 60 2 alt	-1,4%	1,4%	3,8%	4,8%	5,0%
ICAO IGS-to-SRAP 65 1 alt	-1,7%	-0,1%	1,3%	1,8%	2,0%
ICAO IGS-to-SRAP 65 2 alt	-0,6%	3,2%	6,6%	7,7%	8,0%

CAP4:

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

AO-0331 IGS-to-SRAP = [-281, 1116] increase in flights/year

KPIs / PIs	Unit	Calculation	Mandatory	Benefit in SESAR1 (if applicable)	Absolute expected performance benefit in SESAR2020	% expected performance benefit in SESAR2020
CAP3 Peak Runway Throughput (Mixed mode)	% and Flight per hour	% and also total number of movements per one runway per one hour for specific traffic mix and density (in mixed mode RWY operations). The percentage change is measured against the maximum observed throughput during peak demand hours in the mixed-mode RWY operations airports group.	YES	*NA*	*NA*	*NA*
CAP3.1 Peak Departure throughput per hour (Segregated mode)	% and Flight per hour	% and also total number of departures per one runway per one hour for specific traffic mix and density (in segregated mode of operations). The percentage change is measured against the maximum observed throughput during peak demand hours in the segregated-mode RWY operations airports group.	YES	*NA*	*NA*	*NA*

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)	% and Flight per hour	% and also total number of arrivals per one runway per one hour for specific traffic mix and density (in segregated mode of operations). The percentage change is measured against the maximum observed throughput during peak demand hours in the segregated-mode RWY operations airports group.	YES	*NA*	***AO-0331 IGS-to-SRAP*** *= [-0.77, 3.06] increase in movements/hour*	***AO-0331 IGS-to-SRAP*** *= [-1.8%, 7.7%] increase in movements/hour*
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.	*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?*	**AO-0331 IGS-to-SRAP** = [-281, 1116] increase in flights/year	***AO-0331 IGS-to-SRAP*** *= [-1.8%, 7.7%]* increase in flights/year

4.7.3 Extrapolation to ECAC wide

There is no ECAC wide extrapolation required for this KPI.

4.7.4 Discussion of Assessment Result

These results meet and exceed the performance targets defined from PJ19 that were 1.372% increase in capacity when 3 of the OIs of the solution are applied.

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 IGS-to-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 in different combination.

	Traffic mix				
Wake Scheme – OI – IGS-to-SRAP parameter	S5H0	S5H10	S5H20	S5H30	S5H40
RECATPWS IGS-to-SRAP 45 1 alt	0,8%	5,7%	9,3%	12,2%	14,7%
RECATPWS IGS-to-SRAP 45 2 alt	0,8%	5,7%	9,5%	12,4%	14,9%
RECATPWS IGS-to-SRAP 60 1 alt	0,8%	5,8%	9,4%	12,3%	14,8%
RECATPWS IGS-to-SRAP 60 2 alt	1,2%	6,0%	10,3%	13,3%	15,6%
RECATPWS IGS-to-SRAP 65 1 alt	0,8%	5,8%	9,4%	12,3%	14,8%
RECATPWS IGS-to-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 Predictability (Flight Duration Variability, against RBT)

NA

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

NA

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

NA

4.12 Flexibility

NA

4.13 Cost Efficiency

4.13.1 Performance Mechanism

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

4.13.2 Assessment Data (Exercises and Expectations)

As per Capacity KPI above.

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. For details on the FTS results see the VALR [41].

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

ICAO IGS-to-SRAP 60 2 alt	-1,4%	1,4%	3,8%	4,8%	5,0%
ICAO IGS-to-SRAP 65 1 alt	-1,7%	-0,1%	1,3%	1,8%	2,0%
ICAO IGS-to-SRAP 65 2 alt	-0,6%	3,2%	6,6%	7,7%	8,0%

4.13.3 Extrapolation to ECAC wide

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

KPIs / PIs	Unit	Calculation	Mandatory	Benefit in SESAR1 (if applicable)	Absolute expected performance benefit in SESAR2020	% expected performance benefit in SESAR2020
CEF2[6] 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-0331 IGS-to-SRAP*** *= [-0.77, 3.06] increase in movements/hour*	***AO-0331 IGS-to-SRAP*** *= [-1.8%, 7.7%] increase in movements/hour*

4.13.4 Discussion of Assessment Result

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

4.13.5 Additional Comments and Notes

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

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4.14 Airspace User Cost Efficiency

NA

4.15 Security

NA

4.16 Human Performance

4.16.1 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**
		HP4.1 User acceptability of the proposed solution	Covered
		HP4.2 Feasibility in relation to changes in competence requirements	Not covered

PIs	Activities & Metrics	Second level indicators	Covered
HP4 Feasibility with regard to HP-related transition factors		**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

4.16.2Extrapolation to ECAC wide

There is no ECAC wide extrapolation required for this KPI.

4.16.3Open 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

4.16.4Concept interaction

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

4.16.5 Most important HP issues

PIs	Most important issue of the solution	Most important issues due to solution interdependencies
HP1 Consistency of human role with respect to human capabilities and limitations	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. 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 IGS-to-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 IGS-to-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' habit 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 an IGS-to-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		

4.16.6Additional Comments and Notes

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

4.17 Other PIs

NA

4.18 Gap Analysis

KPI	Validation Targets – Network Level (ECAC Wide)	Performance Benefits Expectations at Network Level (ECAC Wide or Local depending on the KPI)[7]	Rationale[8]
FEFF1: Fuel Efficiency – Fuel burn per flight	*6.07 Kg*	*AO-0331 IGS-to-SRAP = [2.65, 55.1] reduction kg of fuel per flight*	
CAP3.2: Airport Capacity – Peak Runway Throughput (Segregated mode).	*1.372%*	*AO-0331 IGS-to-SRAP = [-1.8%, 7.7%] increase in movements/hour*	
CEF2: ATCO Productivity – Flights per ATCO -Hour on duty	*0.267%*	*AO-0331 IGS-to-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.sesarju.eu/servlet/dl/ShowDocumentContent?doc_id=1669873.13&att=attachment&statEvent=Download

[6] B05 Data Collection and Repository Cycle 2015

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

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