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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-W2-14.3, Increased Second Glide Slope, which consists of the extrapolation to ECAC wide level of the performance assessment results obtained through validation activities conducted for the concepts in SESAR 2020 Wave 1 PJ02-02 scope.

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1 Executive Summary

This document provides the Performance Assessment Report (PAR) for SESAR 2020 Wave 2 PJ.02-W2-14.3, Increased Second Glide Slope Enhanced Arrival Procedures (ISGS).

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

Description

PJ.02-W2-14.3 solution develops the Enhanced Arrival Operations using an Increased Second Glide Slope 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 summarises the assessment outcomes per KPI (Table 1) and mandatory PI (Table 2) puts them side-by side against Validation Targets in case of KPI from PJ19 [18]. The impact of a Solution on the performances are described in Benefit Impact Mechanism. All the KPI and mandatory PI from the Benefit Mechanism the Solution potentially affects, have to be assessed via validation results, expert judgment etc.

There are three cases:

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

KPI	Validation 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-0320 ISGS*** *= [-1.99, -14.5] reduction kg of fuel per flight*	*Medium*
CAP3.2: Airport Capacity – Peak Runway Throughput (Segregated mode).	*1.372%*	***AO-0320 ISGS*** *= [-4.4%, -3.2%] increase in movements/hour*	*Medium*
CEF2: ATCO Productivity – Flights per ATCO -Hour on duty	*0.267%*	***AO-0320 ISGS*** *= [-4.4%, -3.2%] 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*

185 **Table 1: KPI Assessment Results Summary**

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[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-0320 ISGS*** = *[-1.99, -14.5]* reduction kg CO_2 per flight	*Medium*
FEFF3: Reduction in average flight duration.	***AO-0320 ISGS*** = *[-0.66, -0.25]* reduction minutes per flight	*Medium*
NOI1: Relative noise scale	***AO-0320 ISGS*** = *[0-2]* For Airport with large fraction of MEDIUM aircraft ***AO-0320 ISGS*** = *[0-2]* For Airport with large fraction of HEAVY aircraft	*Medium*
NOI2: Size and location of noise contours	***AO-0320 ISGS 55db*** = *[-0.8, 0]* contour size evolution km2 ***AO-0320 ISGS 65db*** = *[-0.15, 0]* contour size evolution km2 ***AO-0320 ISGS 75db*** = *[-0.03, 0]* contour size evolution km2	*Medium*
NOI4: Number of people exposed to noise levels exceeding a given threshold	***AO-0320 ISGS 55db*** = [-6540, 0] residents ***AO-0320 ISGS 65db*** = [-3420, 0] residents ***AO-0320 ISGS 75db*** = [-1740, 0] residents	*Medium*

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[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]
LAQ1: Geographic distribution of pollutant concentrations	*X (local)*	*X*
CAP4: Un-accommodated traffic reduction	**AO-0320 ISGS** = [-590, -474] 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***	*NA*

Mandatory PI	Performance Benefits Expectations at Network Level (ECAC Wide or Local depending on the KPI)[3]	Confidence in Results[4]
	HP4.5 *Feasibility in terms of changes in training needs with regard to its contents, duration and modality.* ***Covered***	

186 **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.

2.4 Glossary of terms

N/A

2.5 Acronyms and Terminology

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

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

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

227 **Table 3: Acronyms and terminology**

3 Solution Scope

3.1 Detailed Description of the Solution

PJ.02-W2-14.3 solution develops the following Enhanced Arrival procedures using Increased Second Glide Slope (ISGS) with the objectives of reducing environmental impact, mainly noise, and when possible, improving capacity.

This procedure can be guided by GBAS, RNP.

PJ.02-W2-14.3 will be active, in addition to the standard approach procedure.

3.2 Detailed Description of relationship with other Solutions

PJ.02-W2-14.3 is using a controller separation assistance tool based on the tool developed in SESAR 2020 W1 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	PJ.02-W2-14.3 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 glide towards the same runway, are complex and linked to the same wake vortex categories. Therefore, the tool from PJ02-01 is a basis of what is needed in PJ02-02 where more tables have to be applied according to which aircraft is on which glide slope.

Table 4: Relationships with other Solutions

4 Solution Performance Assessment

4.1 Assessment Sources and Summary of Validation Exercise Performance Results

No previous Validation Exercises (pre-SESAR2020, etc.) are relevant for this assessment. No performance assessment has been performed in SESAR 2020 W2 for solution PJ.02-W2-14.3.

SESAR 2020 W1 PJ02-02 performed fourteen validation activities, five fast time simulations and nine real time simulations. They are listed in the table below. In the following tables, ISGS shall be read as ISGS, because the solution name has been changed in SESAR 2020 W2.

Exercise ID	Exercise Title	Release	Maturity	Status
R01	Increased Glide Slope (ISGS)	R9	V3	Finished
R11	Assessment of ISGS function integration in Airbus aircraft cockpit and avionics and operational use	R9	V3	Finished
R14	Real Time Simulation on ISGS operation from airborne perspective.	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.

Main data used to develop the Performance Assessment Report come from two fast-time exercises, F12 and F13, as F06 report was not available when the PAR was developed.

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

Exercise	OI Step	Exercise scenario & scope	Performance Results
F12	AO-0320	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 ISGS.
F13	AO-0320	Fast Time simulation to evaluate benefits/drawbacks in terms of Throughput, number of go-arounds, separation delivery accuracy and fuel burn ISGS.	• ISGS has a positive impact on fuel burn savings as the flight duration is reduced. • ISGS reduces the noise area size thus reducing noise impact in the airports surroundings.

Table 6: Summary of Validation Results.

4.2 Conditions / Assumptions for Applicability

4.2.1 Applicability of ISGS

As ISGS procedures lead to a capacity decrease when used in traffic-constrained environment, their use should not be envisaged in such environments during peak hours. Throughput loss depends on the percentage of Medium aircraft able to fly ISGS.

Table 7 gives the maximum throughput decrease compared to baseline, **with** a controller separation assistance tool, for different percentage of medium aircraft flying ISGS, for ICAO separations. Results for other separations schemes (RECAT-EU, RECAT-EU PWS) are available in [41], section 19.3.2.

%age Medium on ISGS	**10%**	**25%**	**50%**		**75%**	**100%**	
Separation scheme			**min**	**max**		**min**	**max**
ICAO ISGS	-5.2%	-11.2%	-20.1%	-10.4%	-9.1%	-6.6%	-2.5%

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

Table 8 gives the maximum throughput decrease compared to baseline, **without** a controller separation assistance tool, for different percentage of medium aircraft flying ISGS.

%age Medium on ISGS	**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 ISGS	-5.8%	-11.8%	-21.5%	-10.9%	-9.7%	-7.0%	-4.1%

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

The benefits of ISGS are more on noise reduction, so their use at night, when traffic is lower, or in not constrained airports, should give a benefit to people living in airports surroundings.

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 – 0320 - Enhanced Arrival procedures using Increased Second Glide Slope (ISGS)

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 operation, 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 arrival following a departure in Mixed mode on same runway or on Dependent or CSPRs.

A SAC dedicated to the ISGS 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"):

> **ISGS-SAC#WT-1:** The probability per approach of wake turbulence encounter of a given severity for a given traffic pair for <u>any type of operations/RWY configuration in which that pair of aircraft can be found</u> spaced on Final Approach segment at the WT minima adapted in order to <u>account for the applied X[6] concept</u> 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):

> **ISGS-SAC#WT-F1:** The probability per approach of imminent wake encounter under unmanaged under-separation on Final Approach for <u>any type of operations/RWY configuration in which a pair of aircraft can be found</u> shall be no greater in operations with applicable WT minima adapted in order to <u>account for the applied ISGS concept</u> 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 ISGS-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

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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)

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

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

A set of SACs, dedicated to the ISGS 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 operation in each concept.

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

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

> **ISGS-SAC#CFIT-1:** The likelihood of “Controlled Flight Towards Terrain” on final approach segment during ISGS 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):

> **ISGS-SAC#CFIT-2:** The likelihood of Flight towards terrain commanded by Pilot on final approach segment during ISGS 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):

> **ISGS-SAC#CFIT-3:** The likelihood of Flight towards terrain commanded by Airborne Systems on final approach segment during ISGS 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):

> **ISGS-SAC#CFIT-4:** The likelihood of Flight towards terrain commanded by ATC on final approach segment during ISGS 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):

> **ISGS-SAC#CFIT-5:** The likelihood of Flight towards terrain commanded by ANS on final approach segment during ISGS 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):

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

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

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

ISGS-SAC#RWE-4: The likelihood of Touchdown outside TDZ during ISGS 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):

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

ISGS-SAC#RWE-6: The likelihood of Unstable approach during ISGS 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

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

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

> **ISGS-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 ISGS 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):

> **ISGS-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 X 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):

> **ISGS-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 ISGS 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):

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

> **ISGS-SAC#F2:** The probability per approach of Imminent infringement (radar separation) during interception and final approach shall be no greater in operations when ISGS 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):

ISGS-SAC#R-1: The probability per approach of Runway Conflict during ISGS 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):

ISGS-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 ISGS 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 ISGS 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 ISGS), 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 ISGS 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 ISGS concepts in the following subsections.

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

For ISGS operations, see Table 9, given the very low altitude difference between the two glides at low altitude (i.e. in IGE region), the separation minima are unchanged for leader on conventional glide and follower on ISGS glide. For leader on ISGS 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 ISGS
Leader on CONVENTIONAL (LOWER)	Baseline	Same as baseline
Leader on ISGS	Separation increase	Same as baseline

Table 9: Wake separation minima modification for operation of ISGS in combination with conventional ILS procedure

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).

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Exercise ID, Name, Objective	Exercise Validation objective	Success criterion	Safety Criteria coverage	Validation results & Level of safety evidence
RTS01: RTS conducted by EUROCONTROL in the CDG airport environment to assess the application of the Increased Glide Slope (ISGS) concept on the Paris Charles de Gaulle (CDG) airport and with an approach environment. This simulation was performed under a single runway environment (arrivals only) on runway 27R.	**OBJ-02.02-V3-VALP-ISGS.0103** To confirm that Increased Glide Slope (ISGS) approach procedures do not negatively affect safety from ATC perspective	**CRT-OBJ-02.02-V3-VALP-ISGS.0103-001** There is evidence that the level of operational safety is maintained and not negatively impacted with the ISGS procedures compared to the reference scenario from ATC perspective.	ISGS-SAC#WT-F2, ISGS-SAC#WT-F4, ISGS-SAC#R-1	Safe standard controller practices were used when performing ISGS with ORD tool. Controller feedback and observations, based on expert judgment, indicate there is no increase in potential human errors with safety implications due to the introduction of ISGS 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) No safety related concerns were found in relation to the use of the ORD tool and the ISGS arrival procedures
		CRT-OBJ-02.02-V3-VALP-ISGS.0103-002 The probability of aircraft being under-separated and therefore experiencing a wake encounter is not increased under ISGS procedures compared to the reference scenario.	ISGS-SAC#WT-F2, ISGS-SAC#WT-F4	The results show that the number of major and small under-separated a/c on the final approach is reduced under ISGS conditions with the ORD tool, as compared to current day operations. The number of separation infringements on the base leg is not higher under ISGS with the ORD tool.
		CRT-OBJ-02.02-V3-VALP-ISGS.0103-003 The probability of a go-around due to inadequate consideration of ROT	ISGS-SAC#R-1	The number of occurrences of spacing management by APP ATCO without considering ROT constraint- involving transfer to TWR with aircraft beyond the ROT indicator

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		constraint is not increased under ISGS procedures compared to the reference scenario		is not higher under ISGS with the ORD compared to the reference scenario.
RTS011 led by Airbus to address the ISGS concept from airborne perspective. The exercise is performed in Airbus Aircraft integration simulator as a single event, i.e. without integrating an ATM traffic environment but with a pseudo-controller (which is not controlling traffic) that allows simulating voice communications with the pilot.	**OBJ-02.02-V3-VALP-ISGS.0203** To confirm ISGS does not negatively affect safety from the perspective of the crew	**CRT-02.02-V3-VALP-ISGS.0203-001** There is evidence that the level of operational safety is maintained and not negatively impacted under ISGS procedures compared to the reference scenario from the perspective of the crew.	ISGS-SAC#WT-F2, ISGS-SAC#WT-F4, ISGS-SAC#R-1	It was concluded that pilots would need manual flare assistance for flying glide-slopes above 3.5 degrees (due to increased vertical speed and a change in the visual references). Flight Crew assistance to manage aircraft energy was also considered necessary to perform increase glide slope approaches. However, this might not be necessary for all aircraft and the need for such assistance should be considered on a case by case study (e.g. small business jets might not need assistance to manage aircraft energy for steep approaches).
		CRT-02.02-V3-VALP-ISGS.0203-002 Flight crew initiate the flare at the right moment during ISGS approach in order to prevent hard landing.	ISGS-SAC#WT-F2, ISGS-SAC#WT-F4	
		CRT-02.02-V3-VALP-ISGS.0203-003 Stabilization criteria are reached when pilot applies applicable SOPs.	ISGS-SAC#R-1	
RTS14	**OBJ-02.02-V3-VALP-ISGS.0203** To confirm ISGS does not negatively	**CRT-02.02-V3-VALP-ISGS.0203-001** There is evidence that the level of operational safety is maintained and not	ISGS-SAC#WT-F2, ISGS-SAC#WT-F4,	ISGS approach operations were only exposed with both energy management and flare assistant enablers.

	affect safety from the perspective of the crew	negatively impacted under ISGS procedures compared to the reference scenario from the perspective of the crew.	ISGS-SAC#R-1	Pilots' feedback regarding the safety impact suggested that audio flare assistant and the energy management aid were desirable to maintain the level of operational safety for ISGS approach operations with a glideslope above 3,5°.
		CRT-02.02-V3-VALP-ISGS.0203-002 Flight crew initiate the flare at the right moment during ISGS approach in order to prevent hard landing.	ISGS-SAC#WT-F2, ISGS-SAC#WT-F4	Manual flare assistance function participated to the safety to perform ISGS approach operation. However, ISGS approaches operations were not exposed without this enabler.
		CRT-02.02-V3-VALP-ISGS.0203-003 Stabilization criteria are reached when pilot applies applicable SOPs.	ISGS-SAC#R-1	Energy Management made easier the pilots' decision-making in some cases, providing them with useful information concerning the energy of the aircraft. The function quickly informed and assisted them for the anticipation of future actions. While some algorithm fine-tuning is still needed, the added value of the function itself is clearly identified.

4.3.3 Extrapolation to ECAC wide

The results obtained from the validation activities are for the moment limited to the specific set of aerodrome environments the concepts have been simulated in. This is in terms of layout and configuration (CDG airport - either single runway segregated arrivals operations or closely spaced parallel runways in mix mode) as well as in terms of traffic (as per the traffic in medium and large airports with Medium/High Complexity TMAs).

These results could be extrapolated to similar aerodromes in ECAC, but not enough evidence is available to extrapolate this statement to the rest of aerodromes in other categories. The number of aerodromes to which this Solution could be applied while ensuring the level of safety is maintained needs then to be defined.

4.3.4 Discussion of Assessment Result

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

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

With regard to abnormal and degraded mode of operations:

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

4.3.5 Additional Comments and Notes

No additional comments.

4.4 Environment / Fuel Efficiency

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

4.4.1 Performance Mechanism

The Increased Second Glide Slope (ISGS) 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 ISGS concept are only defined by the guaranteed altitude difference between the conventional glide and the ISGS 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 ISGS glide.

4.4.2 Assessment Data (Exercises and Expectations)

Fuel Efficiency benefits due to the application of operational concepts addressed by PJ02.02 have been identified taking into account:

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

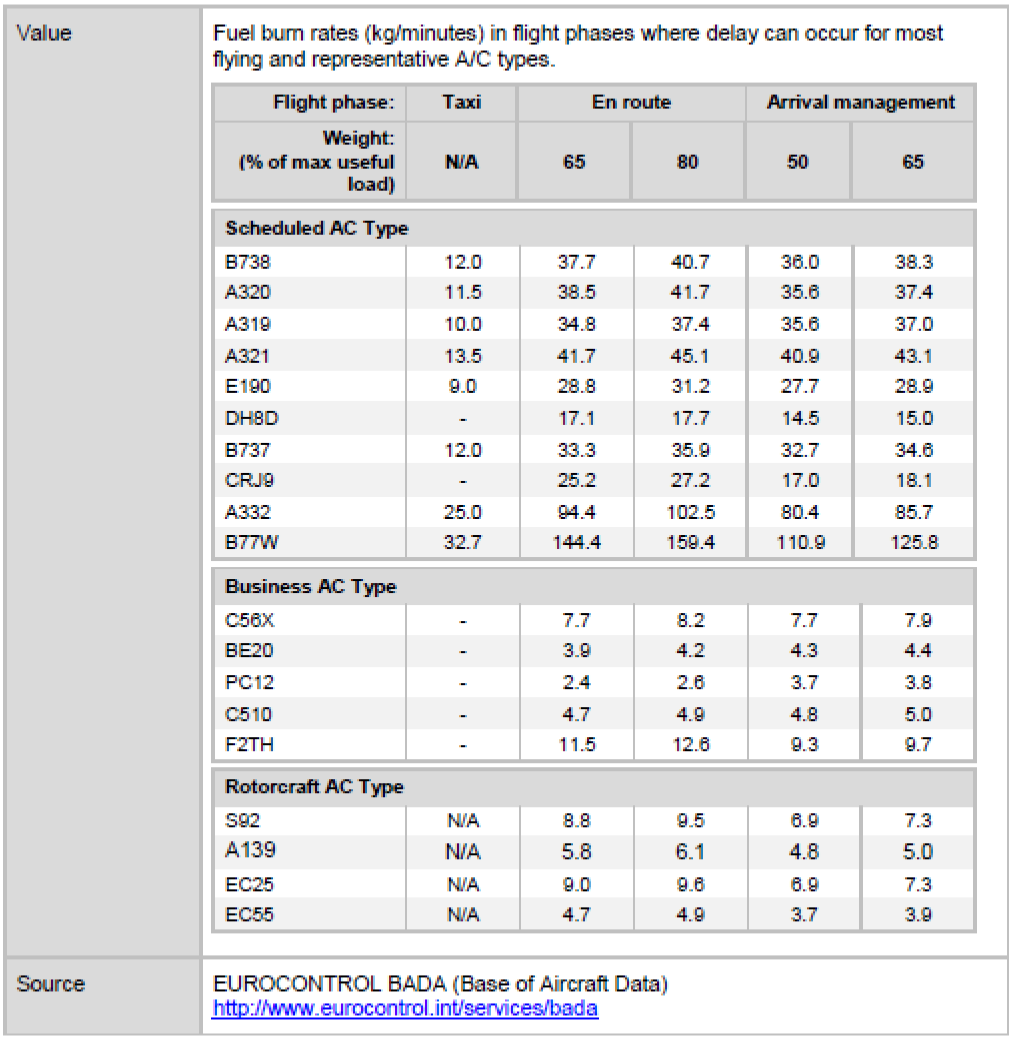
Fuel efficiency has been assessed in FTS12 and FTS13. See VALR for details about the exercise.

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

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

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

The relationship between the averaged flying time reduction compared to reference and fuel burn savings is then established using assumptions found in [36]. In particular, the fuel burn rates for arrival management per RECAT category is obtained as an average of the value provided for several aircraft (see Figure 1). The value for Cat-A and Cat-C aircraft types are obtained from Cat-B value weighted by the differences in averaged MLW per category, see Table 10. Two scenarios are considered: aircraft weight at 50 % of mx useful load and aircraft weight at 65% of max useful load. Table 10 also provided the mean fuel burn rate for each traffic sample obtained as the average weighted by the traffic mix of each traffic sample. As expected, traffic samples with a higher fraction of heavy aircraft types show larger fuel burn rates.



Value

Fuel burn rates (kg/minutes) in flight phases where delay can occur for most flying and representative A/C types.

Flight phase:	Taxi	En route		Arrival management	
Weight: (% of max useful load)	N/A	65	80	50	65
Scheduled AC Type					
B738	12.0	37.7	40.7	36.0	38.3
A320	11.5	38.5	41.7	35.6	37.4
A319	10.0	34.8	37.4	35.6	37.0
A321	13.5	41.7	45.1	40.9	43.1
E190	9.0	28.8	31.2	27.7	28.9
DH8D	-	17.1	17.7	14.5	15.0
B737	12.0	33.3	35.9	32.7	34.6
CRJ9	-	25.2	27.2	17.0	18.1
A332	25.0	94.4	102.5	80.4	85.7
B77W	32.7	144.4	159.4	110.9	125.8
Business AC Type					
C56X	-	7.7	8.2	7.7	7.9
BE20	-	3.9	4.2	4.3	4.4
PC12	-	2.4	2.6	3.7	3.8
C510	-	4.7	4.9	4.8	5.0
F2TH	-	11.5	12.6	9.3	9.7
Rotorcraft AC Type					
S92	N/A	8.8	9.5	6.9	7.3
A139	N/A	5.8	6.1	4.8	5.0
EC25	N/A	9.0	9.6	6.9	7.3
EC55	N/A	4.7	4.9	3.7	3.9

Source

EUROCONTROL BADA (Base of Aircraft Data)
http://www.eurocontrol.int/services/bada

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

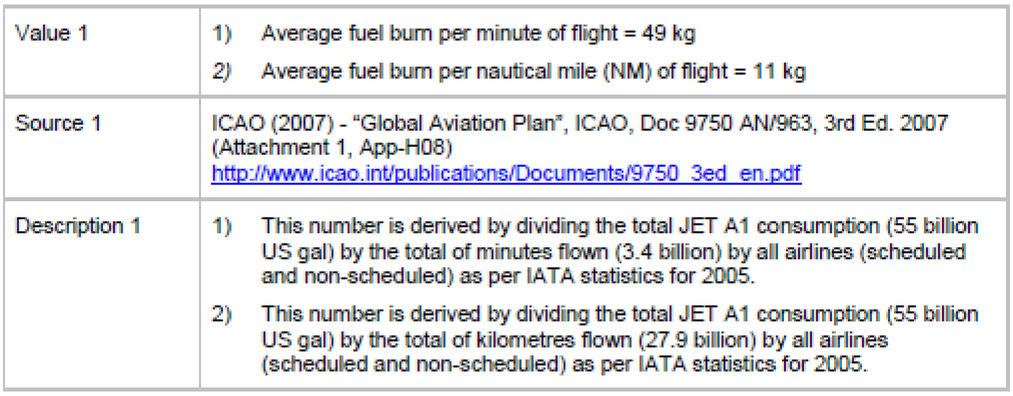
	fuel burn rate arrival [kg/min] 50 % max useful load	fuel burn rate arrival [kg/min] 65 % max useful load
Cat-A	162.6*	179.8*
Cat-B	95.7	105.8
Cat-C	61.1*	67.5*
Cat-D	36.2	38.1
Cat-E	19.7	20.7
Cat-F	6.0	6.2

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

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

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

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



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

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

Note that this average depends on the aircraft traffic mix. (Eurocontrol, January 2018) 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:

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

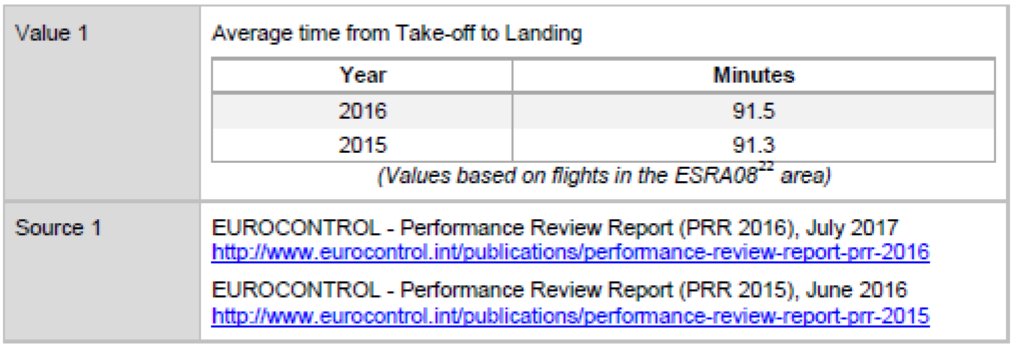
With the traffic mixes described, the obtained fuel burn rates for all phases of flight are detailed in Table 11.

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

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

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:

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

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

Wake Scheme – OI – ISGS parameter	Traffic mix				
	S5H0	S5H10	S5H20	S5H30	S5H40
ISGS ICAO	0,2%	0,6%	0,6%	0,4%	0,8%

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-0320 (ISGS)

FEFF3

1. Flight time reduction per arrival #1 = [-0.22] min. This is the lowest minus obtained assessing different traffic samples and different ISGS parameters, from FTS13 results.
2. Flight time reduction (FEFF3) at ECAC level #1 = 50% (arrivals traffic contribution) * 59.5% (high density airports traffic contribution) * -0.22 minutes (flight-time reduction per arrival #1) = -0.06 minutes per flight
3. Relative flight time reduction at ECAC level #1= -0.22 minutes (flight time reduction at ECAC level #1) / 90 minutes (average ECAC flight time) * 100 = -0.24%
4. Flight time reduction per arrival #2 = [-0.86] min. This is the highest minus obtained assessing different traffic samples and different ISGS parameters, from FTS13 results.
5. Flight time reduction (FEFF3) at ECAC level #2 = 50% (arrivals traffic contribution) * 59.5% (high density airports traffic contribution) * -0.86 minutes (flight-time reduction per arrival#2) = -0.25 minutes per flight
6. Relative flight time reduction at ECAC level #2= -0.25 minutes (flight time reduction at ECAC level) / 90 minutes (average ECAC flight time) * 100 = -0.27%

FEFF1

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

For the computations below the respective fuel burn rate for the minimum and maximum flight time increase (ISGS increases separations and flying time) from the FTS13 results for 50% loading are used.

1. Fuel consumption reduction per arrival #1 = -0.22 (flight time reduction per arrival) #1 * 36.3 (fuel burn rate for arrival #1) = -7.7 kg/flight
2. Relative fuel consumption reduction #1 = -7.7 kg/flight (fuel consumption reduction on arrival #1) / 3321 kg (Average fuel burn per flight #1) * 100 = -0.23%
3. Fuel consumption reduction (FEFF1) at ECAC level #1 = 50% (arrivals traffic contribution) * 59.5% (high density airports traffic contribution) * -0.23% (relative fuel consumption reduction #1) = -0.06% = -1.99 kg/flight
4. Fuel consumption reduction per arrival #2 = -0.86 (flight time reduction per arrival #2) * 59.1 (fuel burn rate for arrival #2)= -50.82 kg/flight
5. Relative fuel consumption reduction #2 = -50.82 kg/flight (fuel consumption reduction on arrival #2) / 5407 kg (Average fuel burn per flight #2) * 100= -0.93%
6. Fuel consumption reduction (FEFF1) at ECAC level #2 = 50% (arrivals traffic contribution) * 59.5% (high density airports traffic contribution) * -0.93% (relative fuel consumption reduction #1) = -0.27% = -14.5 kg/flight

FEFF2

1. CO_2 emission reduction per arrival #1 = -7.7 (Fuel consumption reduction on arrival #1) * 3.15 (CO_2/Fuel Ratio) = -24.25 kg CO_2 per flight

2. Relative CO_2 emission reduction on arrival #1 = -24.25 (CO_2 emission reduction #1) / 3321 (Average Fuel burn per flight #1) / 3.15 (CO_2/Fuel ratio) * 100 = -0.23%

3. Relative CO2 emission reduction on arrival #1 (FEFF2) at ECAC level = 50% (arrivals traffic contribution) * 59.5% (high density airports traffic contribution)* x -0.23% (Relative CO2 emission reduction on arrival #1) = 0.06% = 1.99 kg CO_2/flight

4. CO_2 emission reduction on arrival #2 = -50.82 (Fuel consumption reduction on arrival #2) * 3.15 (CO_2/Fuel Ratio) = -160 kg CO_2 per flight

5. Relative CO_2 emission reduction on arrival #2 = 160 (CO_2 emission reduction #2) / 5407 (Average Fuel burn per flight #1) / 3.15 (CO_2/Fuel ratio) * 100= -0.93%

6. Relative CO2 emission reduction on arrival #2 (FEFF2) at ECAC level = 50% (arrivals traffic contribution) * 59.5% (high density airports traffic contribution)* x -0.93% (Relative CO2 emission reduction on arrival #1) = -0.27% = -14.15 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-0320 ISGS*** *= [-1.99, -14.5]* reduction kg of fuel per flight	***AO-0320 ISGS*** *= [-0.06%, -0.27%]* 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-0320 ISGS*** *= [-1.99, -14.5]* reduction kg CO_2 per flight	***AO-0320 ISGS*** *= [-0.06%, -0.27%]* reduction kg of fuel 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-0320 ISGS*** *= [-0.66, -0.25]* reduction minutes per flight	***AO-0320 ISGS*** *= [-0.24%, --0.27%]* 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-0320 ISGS*** = *[-1.99, -14.5]* reduction kg of fuel per flight	NA
FEFF2 Actual Average CO_2 Emission per flight	NA	NA	NA	***AO-0320 ISGS*** = *[-1.99, -14.5]* reduction kg CO_2 per flight	NA
FEFF3 Reduction in average flight duration	NA	NA	NA	***AO-0320 ISGS*** = *[-0.66, -0.25]* 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. Note that the operations of ISGS, as only leading to separation increases, leads, as expected, to increase of flying time and fuel emissions; those two concepts are focused on providing noise benefits.

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 airports, 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 ISGS glide, runway occupancy time, glide length, runway layout, airport infrastructure, etc.

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

4.4.5 Additional Comments and Notes

NA

4.5 Environment / Noise and Local Air Quality

4.5.1 Performance Mechanism

The Increased Glide Slope (ISGS) concept:

The impact depends on the concept and on the traffic mix. For Noise benefits, one baseline and one 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 #3 corresponds to a scenario where all Lower Medium (RECAT CAT-E and CAT-F) and Light aircraft types follow a glide with an Increased-Glide Slope (ISGS) of 4 deg whereas all other types follow a glide with an ISGS of 3.5 deg both with an interception at 4000 ft.

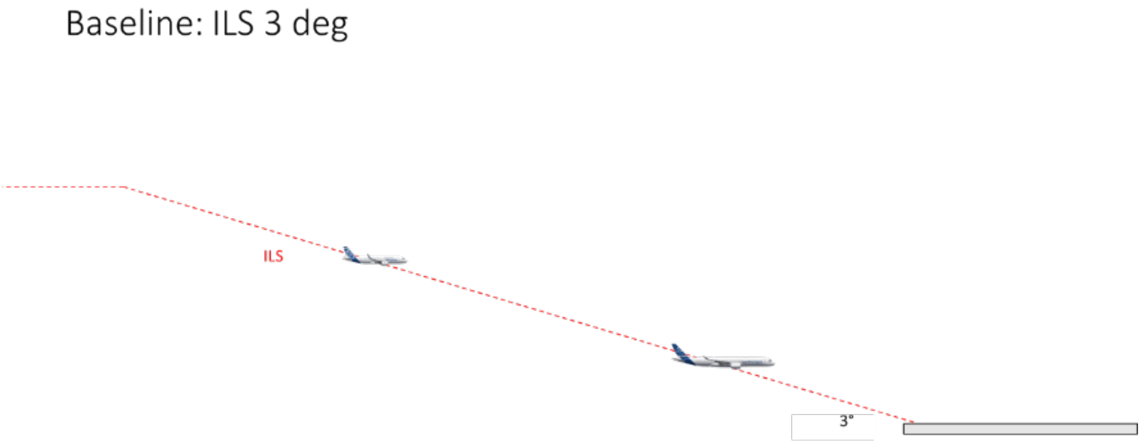


Figure 4: Baseline for noise assessment

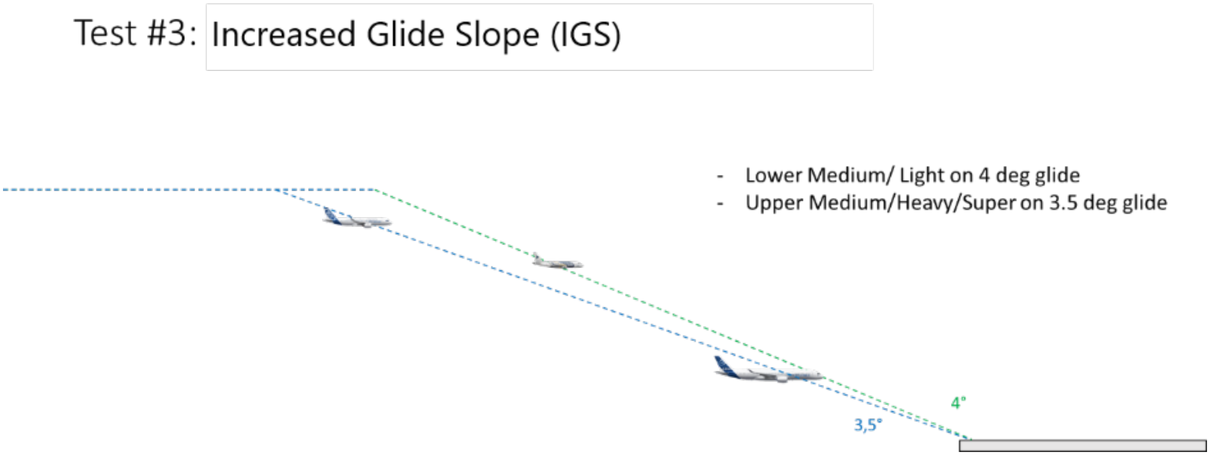


Figure 5: ISGS test case for noise assessment

Those scenarios are tested and compared using the IMPACT tool of EUROCONTROL. The inputs and outputs of this analysis are here presented. For the inputs, two main data were required: the traffic mix observed at each airport (providing the amount of flights operating on each glide for each scenario) and the approach speed profile followed by each aircraft type (directly affecting its noise footprint and used by the IMPACT tool).

4.5.2 Assessment Data (Exercises and Expectations)

Traffic data processing

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

For each airport, the average number of each aircraft type is counted considering that time period:

- 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 ISGS contours were compared to those obtained with the ILS during the NIGHT period.

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 5 and Table 15) shows that:

- The contours related to the ISGS solution (NIGHT) are smaller than the baseline ones (NIGHT) for all dB levels and not shifted toward the runway (see Figure 6).

When accounting for contours beginning at the runway threshold (with x ≥ 0NM or x ≥ 1NM, see Figure 5), results (see Table 16 and Table 17) show that contour surfaces related to the ISGS solution are smaller than the reference ones. The noise contours in the area away from the runway are thus smaller.

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

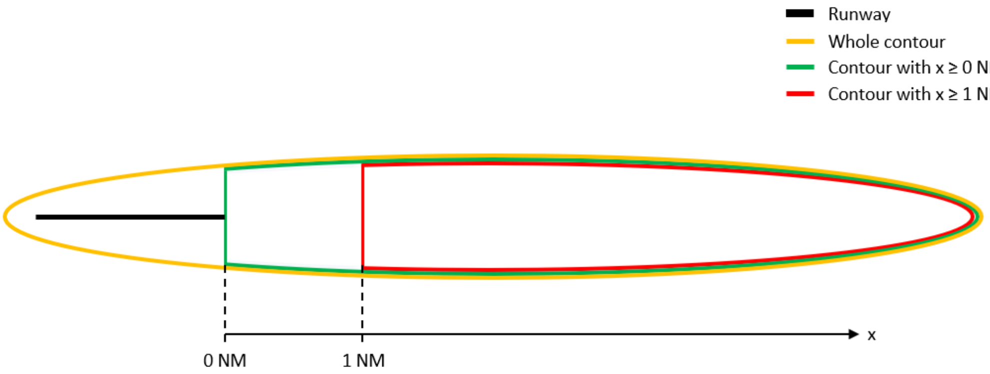


Figure 6: Contour definitions

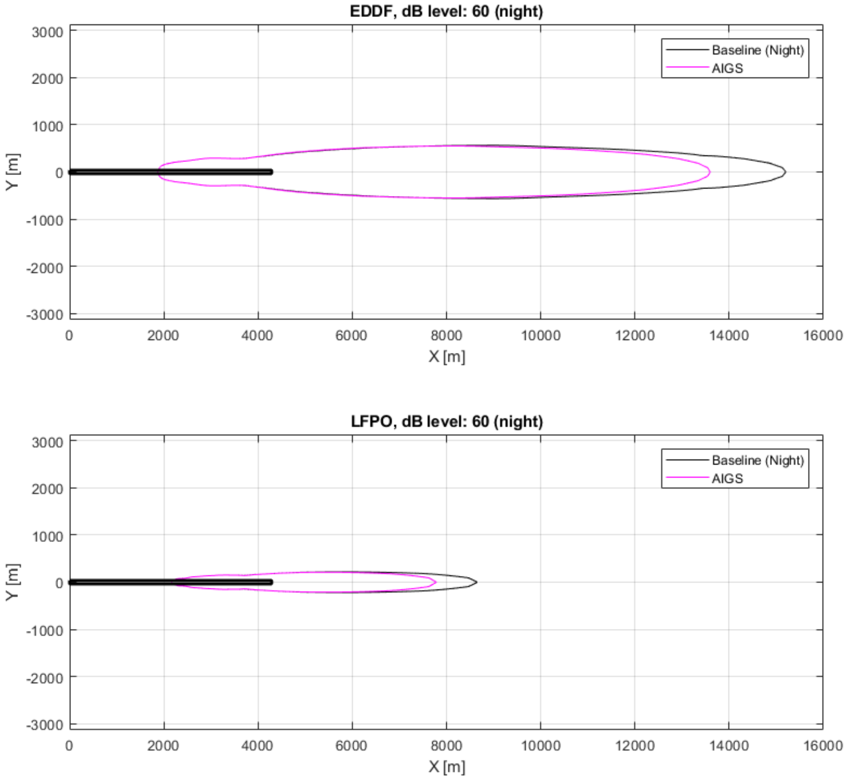


Figure 7: Baseline (Night) and ISGS contours for EDDF and LFPO for the 60dB level

dB level	Airport	Baseline Night surface [km2]	ISGS Surface [km2]	ISGS gains [km2]	ISGS gains [%]
55	EGCC	8.25	7.19	-1.06	-12.8%
	EIDW	7.69	6.69	-1	-13%
	LFPO	6.21	5.41	-0.8	-12.9%
60	EGCC	3.13	2.61	-0.52	-16.6%
	EIDW	2.97	2.43	-0.54	-18.2%
	LFPO	2.19	1.82	-0.37	-16.9%
65	EGCC	1	0.84	-0.16	-16%
	EIDW	0.9	0.74	-0.16	-17.8%
	LFPO	0.66	0.56	-0.1	-15.2%
70	EGCC	0.3	0.26	-0.04	-13.3%
	EIDW	0.26	0.23	-0.03	-11.5%
	LFPO	0.2	0.18	-0.02	-10%
75	EGCC	0.06	0.05	-0.01	-16.7%
	EIDW	0.06	0.05	-0.01	-16.7%
	LFPO	0.02	0.02	0	0%
80	EGCC	0	0	0	
	EIDW	0	0	0	
	LFPO	0	0	0	

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

dB level	Airport	Baseline Night surface [km2]	ISGS Surface [km2]	ISGS gains [km2]	ISGS gains [%]
55	EGCC	7.11	6.05	-1.06	-14.9%
	EIDW	6.73	5.73	-1	-14.9%
	LFPO	5.27	4.47	-0.8	-15.2%
60	EGCC	2.41	1.89	-0.52	-21.6%
	EIDW	2.36	1.82	-0.54	-22.9%
	LFPO	1.6	1.24	-0.36	-22.5%
65	EGCC	0.56	0.41	-0.15	-26.8%
	EIDW	0.53	0.38	-0.15	-28.3%
	LFPO	0.32	0.23	-0.09	-28.1%
70	EGCC	0.07	0.04	-0.03	-42.9%
	EIDW	0.07	0.04	-0.03	-42.9%
	LFPO	0.03	0.02	-0.01	-33.3%
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	

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

dB level	Airport	Baseline Night surface [km2]	ISGS Surface [km2]	ISGS gains [km2]	ISGS gains [%]
55	EGCC	5.63	4.55	-1.08	-19.2%
	EIDW	5.25	4.24	-1.01	-19.2%
	LFPO	3.97	3.16	-0.81	-20.4%
60	EGCC	1.48	0.97	-0.51	-34.5%
	EIDW	1.44	0.91	-0.53	-36.8%
	LFPO	0.83	0.48	-0.35	-42.2%
65	EGCC	0.08	0	-0.08	-100%
	EIDW	0.06	0	-0.06	-100%
	LFPO	0	0	0	
70	EGCC	0	0	0	
	EIDW	0	0	0	
	LFPO	0	0	0	
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	

768 **Table 17: Contour surfaces for x≥1NM from runway threshold for airports with 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 contour surfaces related to the ISGS solution (NIGHT) are smaller than the baseline ones (NIGHT).

When accounting for contours beginning at the runway threshold (or further upstream, see Table 19 and Table 20), contour surfaces related to the ISGS solution (compared to NIGHT baseline) are seen to be smaller than the reference ones. This increase is related to the fact that the noise impact on the glide is governed by Heavy traffic on the ILS.

Figure 7, Figure 8 and Figure 9 respectively show the evolution of different contour surfaces for the airports EDDF, EGLL and EHAM.

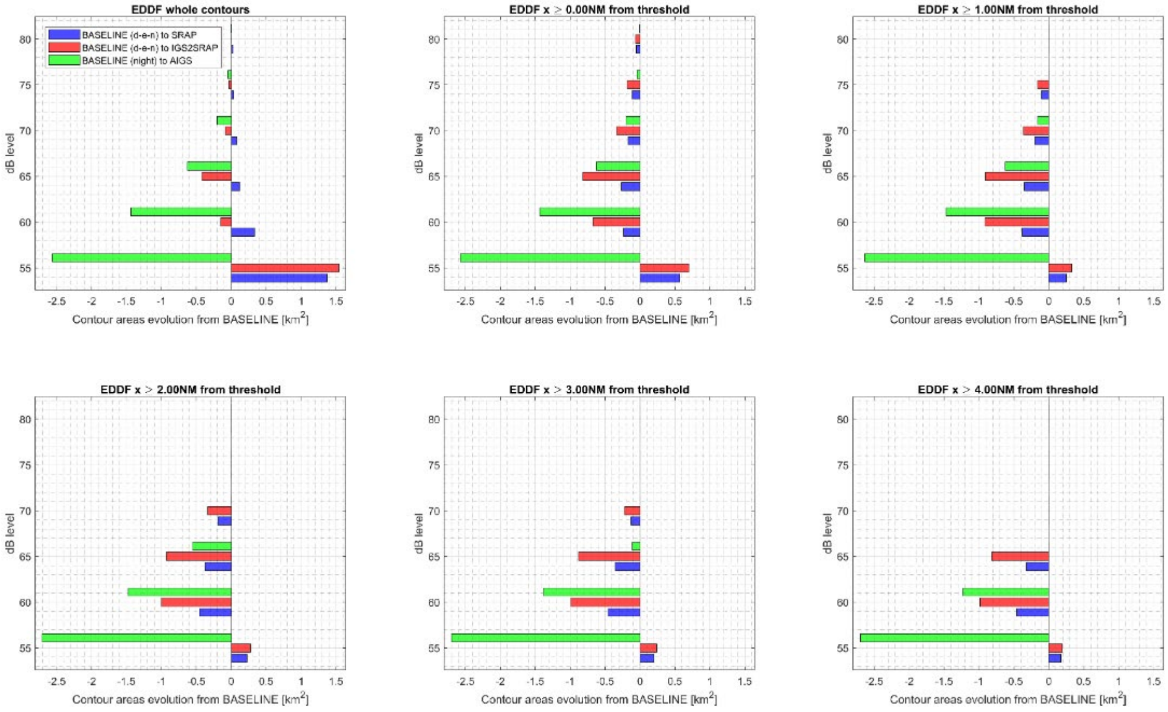


Figure 8: Comparison of contour surfaces for EDDF

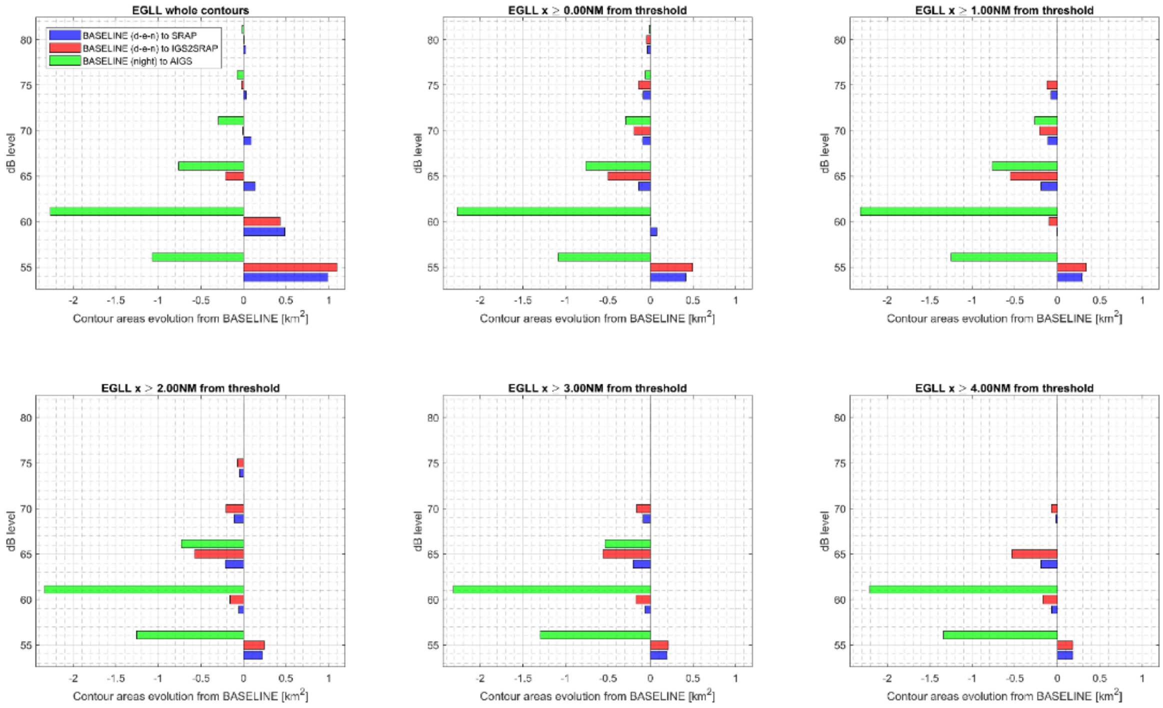


Figure 9: Comparison of contour surfaces for EGLL

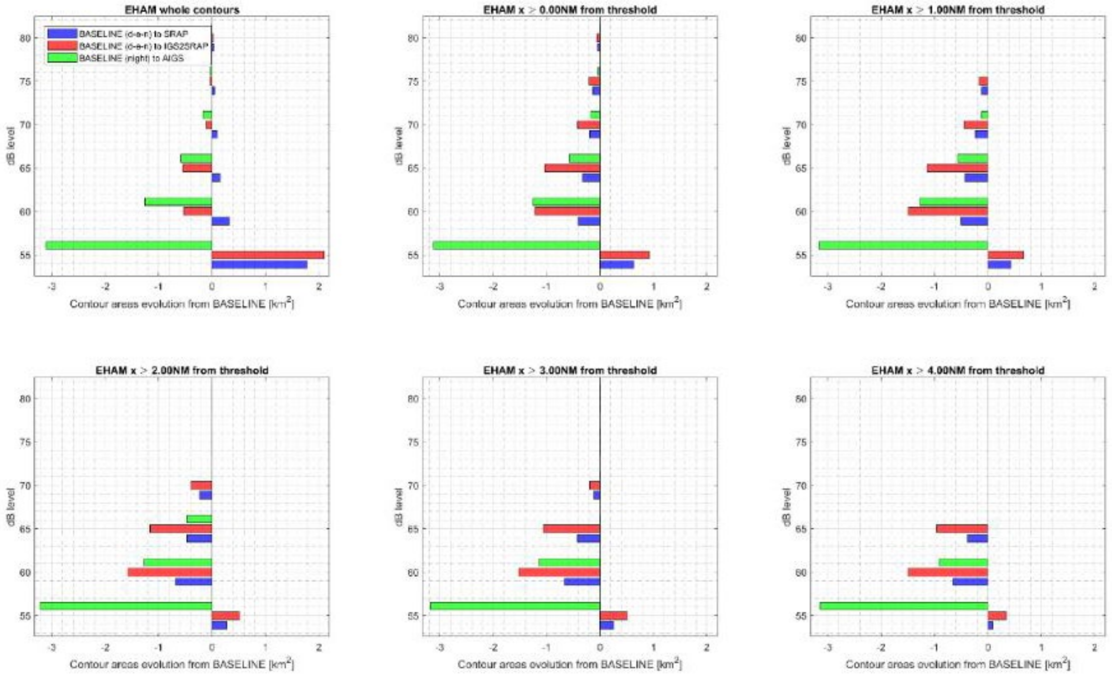


Figure 10: Comparison of contour surfaces for EHAM

dB level	Airport	Baseline Night surface [km2]	ISGS Surface [km2]	ISGS gains [km2]	ISGS gains [%]
55	EDDF	29.19	26.62	-2.57	-8.8%
	EHAM	25.67	22.57	-3.1	-12.1%
	EGLL	43.03	41.96	-1.07	-2.5%
60	EDDF	11.22	9.79	-1.43	-12.7%
	EHAM	9.37	8.12	-1.25	-13.3%
	EGLL	15.59	13.32	-2.27	-14.6%
65	EDDF	4.09	3.47	-0.62	-15.2%
	EHAM	3.44	2.86	-0.58	-16.9%
	EGLL	5.48	4.72	-0.76	-13.9%
70	EDDF	1.34	1.14	-0.2	-14.9%
	EHAM	1.07	0.9	-0.17	-15.9%
	EGLL	1.85	1.56	-0.29	-15.7%
75	EDDF	0.4	0.36	-0.04	-10%
	EHAM	0.31	0.27	-0.04	-12.9%
	EGLL	0.56	0.49	-0.07	-12.5%
80	EDDF	0.1	0.09	-0.01	-10%
	EHAM	0.06	0.05	-0.01	-16.7%
	EGLL	0.16	0.15	-0.01	-6.3%

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

dB level	Airport	Baseline Night surface [km2]	ISGS Surface [km2]	ISGS gains [km2]	ISGS gains [%]
55	EDDF	27.16	24.58	-2.58	-9.5%
	EHAM	23.88	20.77	-3.11	-13%
	EGLL	40.78	39.69	-1.09	-2.7%
60	EDDF	9.9	8.46	-1.44	-14.5%
	EHAM	8.2	6.95	-1.25	-15.2%
	EGLL	14.11	11.84	-2.27	-16.1%
65	EDDF	3.24	2.62	-0.62	-19.1%
	EHAM	2.7	2.13	-0.57	-21.1%
	EGLL	4.53	3.76	-0.77	-17%
70	EDDF	0.82	0.62	-0.2	-24.4%
	EHAM	0.63	0.46	-0.17	-27%
	EGLL	1.25	0.96	-0.29	-23.2%
75	EDDF	0.12	0.08	-0.04	-33.3%
	EHAM	0.08	0.05	-0.03	-37.5%
	EGLL	0.23	0.17	-0.06	-26.1%
80	EDDF	0	0	0	
	EHAM	0	0	0	
	EGLL	0.02	0.01	-0.01	-50%

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

dB level	Airport	Baseline Night surface [km2]	ISGS Surface [km2]	ISGS gains [km2]	ISGS gains [%]
55	EDDF	24.73	22.09	-2.64	-10.7%
	EHAM	21.56	18.39	-3.17	-14.7%
	EGLL	38.16	36.91	-1.25	-3.3%
60	EDDF	8.25	6.78	-1.47	-17.8%
	EHAM	6.65	5.37	-1.28	-19.2%
	EGLL	12.26	9.95	-2.31	-18.8%
65	EDDF	2.19	1.57	-0.62	-28.3%
	EHAM	1.73	1.16	-0.57	-32.9%
	EGLL	3.32	2.55	-0.77	-23.2%
70	EDDF	0.24	0.08	-0.16	-66.7%
	EHAM	0.12	0.01	-0.11	-91.7%
	EGLL	0.55	0.29	-0.26	-47.3%
75	EDDF	0	0	0	
	EHAM	0	0	0	
	EGLL	0	0	0	
80	EDDF	0	0	0	
	EHAM	0	0	0	
	EGLL	0	0	0	

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

Conclusions for NOI2

The ISGS solution presents contour surface reductions for all airports and all dB levels, independently of the contour definition (whole or from the runway threshold). Those reductions are even more emphasised for the contours accounted from the runway threshold (see Table 15 to 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 10 and Figure 11). Therefore, results of Table 22, Table 23, Table 25 and Table 26 are those of interest in this section.

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

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

Airports with a large fraction of MEDIUM aircraft

Regarding the ISGS solution, one observes a reduction of affected people going from -4800 to -6360 residents for the 55dB level, when accounting for contours beginning at the runway threshold. Similar reductions are observed for contours beginning at 1NM from the runway threshold.

dB level	Airport	Population inside Baseline Night surface [residents]	Population inside ISGS Surface [residents]	Change in population from baseline (NIGHT) to ISGS [residents]
55	EGCC	49500	43140	-6360
	EIDW	46140	40140	-6000
	LFPO	37260	32460	-4800
60	EGCC	18780	15660	-3120
	EIDW	17820	14580	-3240
	LFPO	13140	10920	-2220
65	EGCC	6000	5040	-960
	EIDW	5400	4440	-960
	LFPO	3960	3360	-600
70	EGCC	1800	1560	-240
	EIDW	1560	1380	-180
	LFPO	1200	1080	-120
75	EGCC	360	300	-60
	EIDW	360	300	-60
	LFPO	120	120	0
80	EGCC	0	0	0
	EIDW	0	0	0
	LFPO	0	0	0

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

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dB level	Airport	Population inside Baseline Night surface [residents]	Population inside ISGS Surface [residents]	Change in population from baseline (NIGHT) to ISGS [residents]
55	EGCC	42660	36300	-6360
	EIDW	40380	34380	-6000
	LFPO	31620	26820	-4800
60	EGCC	14460	11340	-3120
	EIDW	14160	10920	-3240
	LFPO	9600	7440	-2160
65	EGCC	3360	2460	-900
	EIDW	3180	2280	-900
	LFPO	1920	1380	-540
70	EGCC	420	240	-180
	EIDW	420	240	-180
	LFPO	180	120	-60
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

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

dB level	Airport	Population inside Baseline Night surface [residents]	Population inside ISGS Surface [residents]	Change in population from baseline (NIGHT) to ISGS [residents]
55	EGCC	33780	27300	-6480
	EIDW	31500	25440	-6060
	LFPO	23820	18960	-4860
60	EGCC	8880	5820	-3060
	EIDW	8640	5460	-3180
	LFPO	4980	2880	-2100
65	EGCC	480	0	-480
	EIDW	360	0	-360
	LFPO	0	0	0
70	EGCC	0	0	0
	EIDW	0	0	0
	LFPO	0	0	0
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

819 **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

Regarding the ISGS solution, one observes reductions in affected population varying from -6540 to -18660 residents for the 55dB level, when analysing contours beginning at the runway threshold. When looking at contours starting at 1NM from runway threshold, those reductions accentuate from -7500 up to -19020 residents, for the same dB level.

dB level	Airport	Population inside Baseline Night surface [residents]	Population inside ISGS Surface [residents]	Change in population from baseline (NIGHT) to ISGS [residents]
55	EDDF	175140	159720	-15420
	EHAM	154020	135420	-18600
	EGLL	258180	251760	-6420
60	EDDF	67320	58740	-8580
	EHAM	56220	48720	-7500
	EGLL	93540	79920	-13620
65	EDDF	24540	20820	-3720
	EHAM	20640	17160	-3480
	EGLL	32880	28320	-4560
70	EDDF	8040	6840	-1200
	EHAM	6420	5400	-1020
	EGLL	11100	9360	-1740
75	EDDF	2400	2160	-240
	EHAM	1860	1620	-240
	EGLL	3360	2940	-420
80	EDDF	600	540	-60
	EHAM	360	300	-60
	EGLL	960	900	-60

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

dB level	Airport	Population inside Baseline Night surface [residents]	Population inside ISGS Surface [residents]	Change in population from baseline NIGHT) to ISGS [residents]
55	EDDF	162960	147480	-15480
	EHAM	143280	124620	-18660
	EGLL	244680	238140	-6540
60	EDDF	59400	50760	-8640
	EHAM	49200	41700	-7500
	EGLL	84660	71040	-13620
65	EDDF	19440	15720	-3720
	EHAM	16200	12780	-3420
	EGLL	27180	22560	-4620
70	EDDF	4920	3720	-1200
	EHAM	3780	2760	-1020
	EGLL	7500	5760	-1740
75	EDDF	720	480	-240
	EHAM	480	300	-180
	EGLL	1380	1020	-360
80	EDDF	0	0	0
	EHAM	0	0	0
	EGLL	120	60	-60

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

dB level	Airport	Population inside Baseline Night surface [residents]	Population inside ISGS Surface [residents]	Change in population from baseline (NIGHT) to ISGS [residents]
55	EDDF	148380	132540	-15840
	EHAM	129360	110340	-19020
	EGLL	228960	221460	-7500
60	EDDF	49500	40680	-8820
	EHAM	39900	32220	-7680
	EGLL	73560	59700	-13860
65	EDDF	13140	9420	-3720
	EHAM	10380	6960	-3420
	EGLL	19920	15300	-4620
70	EDDF	1440	480	-960
	EHAM	720	60	-660
	EGLL	3300	1740	-1560
75	EDDF	0	0	0
	EHAM	0	0	0
	EGLL	0	0	0
80	EDDF	0	0	0
	EHAM	0	0	0
	EGLL	0	0	0

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

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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 10 and Figure 11).

For all airports and all noise levels, the ISGS solution offers large reductions in the number of exposed residents, going from over 6000 to over 18000 people (respectively for airports with a large fraction of MEDIUM and HEAVY aircraft, for the 55dB level).

NOI1

Based on results of Performance Indicators **NOI2** and **NOI4**, a qualitative assessment of the analysed ISGS 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 ISGS 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
ISGS **(compared to NIGHT baseline)**	**2**	**2**

Table 27: Relative scale of benefits associated to different solutions

Conclusion for NOI1

The ISGS solution presents, for both types of airports, major contour surface reductions (looking at whole contours or only at those beginning at the runway threshold). For this reason, the ISGS solution has been given a classification **2** for both types of airports.

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-0320 ISGS*** *= [0-2]* For Airports with a large fraction of MEDIUM aircraft ***AO-0320 ISGS*** *= [0-2]* For Airports 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-0320 ISGS 55db*** *= [-0.8, 0]* ***AO-0320 ISGS 65db*** *= [-0.15, 0]* ***AO-0320 ISGS 75db*** *= [-0.03, 0]* reduction km2	***AO-0320 ISGS 55db*** *= [-15.2%, 0%]* ***AO-0320 ISGS 65db*** *= [-28.3%, 0%]* ***AO-0320 ISGS 75db*** *= [-42.9%, 0%]* 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-0320 ISGS 55db*** *= [-6540, 0]* ***AO-0320 ISGS 65db*** *= [-3420, 0]* ***AO-0320 ISGS 75db*** *= [-1740, 0]* residents	***AO-0320 ISGS 55db*** *= [-3.48%, 0%]* ***AO-0320 ISGS 65db*** *= [-4.91%, 0%]* ***AO-0320 ISGS 75db*** *= [-5.23%, 0%]* 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*		

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.

4.6 Airspace Capacity (Throughput / Airspace Volume & Time)

NA

4.7 Airport Capacity (Runway Throughput Flights/Hour)

4.7.1 Performance Mechanism

The Increased Second Glide Slope concept depending on the way it is operated impacts the wake separation between aircraft, see the BIM in the OSED Part I [44]for more details.

4.7.2 Assessment Data (Exercises and Expectations)

The results are extracted from the FTS13 exercises.

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.

In FTS13 different traffic samples have been assessed for the solution scenarios 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 used for the KPI analysis. For details on the FTS results see the VALR.

Wake Scheme – OI – ISGS parameter	Traffic mix				
	S5H0	S5H10	S5H20	S5H30	S5H40
ISGS ICAO	-3,2%	-4,4%	-4,6%	-4,2%	-4,4%

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-0320 ISGS = [-590, -474] 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	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**
		percentage change is measured against the maximum observed throughput during peak demand hours in the mixed-mode RWY operations airports group.				
CAP3.1 Peak Departure throughput per hour (Segregated mode)	% and Flight per hour	% and also total number of departures per one runway per one hour for specific traffic mix and density (in segregated mode of operations). The percentage change is measured against the maximum observed throughput during peak demand hours in the segregated-mode RWY operations airports group.	YES	*NA*	*NA*	*NA*
CAP3.2 Peak Arrival throughput per hour (Segregated mode)	% and Flight per hour	% and also total number of arrivals per one runway per one hour for specific traffic mix and density (in segregated mode of operations). The percentage change is measured against the maximum observed throughput during peak demand hours in the segregated-mode RWY operations airports group.	YES	*NA*	***AO-0320 ISGS*** *= [-1.7, -1.3] increase in movements/hour*	***AO-0320 ISGS*** *= [-4.4%, -3.2%] 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	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*	**AO-0320 ISGS** = [-590, -474] increase in flights/year	***AO-0320 ISGS*** *= [-4.4%, -3.2%]* 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
		the assessment of the runway throughput we provide with and without the solutions and STATFOR data.		*performance comes in addition to SESAR1 or replace it?*		

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. Note that the operations of ISGS, as only leading to separation increases, lead, as expected, to capacity decrease; this concept focuses on providing noise benefits. The losses related to ISGS are lower when combined with a more "refined" separation scheme as RECAT-Pairwise, some results of the combined PJ02.02 and PJ02.01 benefits are presented in the next paragraph.

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 ISGS glide, runway occupancy time, glide length, runway layout, airport infrastructure, etc.

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

4.7.5 Additional Comments and Notes

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

Wake Scheme – OI – ISGS parameter	Traffic mix				
	S5H0	S5H10	S5H20	S5H30	S5H40
ISGS RECATPWS	0,0%	3,8%	6,3%	9,1%	10,9%

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

NA

4.9 Flight times

NA

4.10Predictability (Flight Duration Variability, against RBT)

NA

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

NA

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

NA

4.13 Flexibility

NA

4.14Cost Efficiency

4.14.1Performance Mechanism

The Increased Second Glide Slope 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.

4.14.2Assessment Data (Exercises and Expectations)

As per Capacity KPI above.

In FTS13 different traffic samples have been assessed for the solution scenarios 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].

	Traffic mix				
Wake Scheme – OI – ISGS parameter	S5H0	S5H10	S5H20	S5H30	S5H40
ISGS ICAO	-3,2%	-4,4%	-4,6%	-4,2%	-4,4%

4.14.4Extrapolation to ECAC wide

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

KPIs / PIs	**Unit**	**Calculation**	**Mandatory**	**Benefit in SESAR1 (if applicable)**	**Absolute expected performance benefit in SESAR2020**	**% expected performance benefit in SESAR2020**
CEF2[7] 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-0320 ISGS*** *= [-1.7, -1.3] increase in movements/hour*	***AO-0320 ISGS*** *= [-4.4%, -3.2%] increase in movements/hour*

4.14.5 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 the ISGS concept is applied, see VALR for details.

4.14.6 Additional Comments and Notes

No further comments.

4.15 Airspace User Cost Efficiency

NA

4.16 Security

NA

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[7] 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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4.17 Human Performance

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4.17.1 HP arguments, activities and metrics

PIs	Activities & Metrics	Second level indicators	Covered
HP1 Consistency of human role with respect to human capabilities and limitations		**HP1.1** Clarity and completeness of role and responsibilities of human actors	Not covered
		HP1.2 Adequacy of operating methods (procedures) in supporting human performance	**Covered**
		HP1.3 Capability of human actors to achieve their tasks in a timely manner, with limited error rate and acceptable workload level	**Covered**
HP2 Suitability of technical system in supporting the tasks of human actors		**HP2.1** Adequacy of allocation of tasks between the human and the machine (i.e. level of automation).	**Covered**
		HP2.2 Adequacy of technical systems in supporting Human Performance with respect to timeliness of system responses and accuracy of information provided	Covered
		HP2.3 Adequacy of the human machine interface in supporting the human in carrying out their tasks.	Covered
HP3 Adequacy of team structure and team communication in supporting the human actors		**HP3.1** Adequacy of team composition in terms of identified roles	**Not covered**
		HP3.2 Adequacy of task allocation among human actors	**Not covered**
		HP3.3 Adequacy of team communication with regard to information type, technical enablers and impact on situation awareness/workload	**Covered**
HP4 Feasibility with regard to HP-related transition factors		**HP4.1** User acceptability of the proposed solution	Covered
		HP4.2 Feasibility in relation to changes in competence requirements	Not covered
		HP4.3 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

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4.17.2Extrapolation to ECAC wide

There is no ECAC wide extrapolation required for this KPI.

4.17.3Open 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

4.17.4 Concept 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.

4.17.5 Most important HP issues

PIs	Most important issues 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 ISGS 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 ISGS could impact the use of these other cockpit functions if they	

PIs	Most important issues of the solution	Most important issues due to solution interdependencies
	are not well interfaced from an operational and HMI point of view.	
	Increasing the slope may challenge pilots' habits regarding approach procedure: new perception of the runway, new tasks to accomplish, etc. which may be more mentally demanding than for conventional approaches leading therefore to potential additional workload	
HP2 Suitability of technical system in supporting the tasks of human actors	Aircraft performance and the system ability to fly an ISGS 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		

4.17.6 Additional 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.

4.18 Other PIs

NA

4.19 Gap Analysis

KPI	**Validation Targets – Network Level (ECAC Wide)**	**Performance Benefits Expectations at Network Level (ECAC Wide or Local depending on the KPI)[8]**	**Rationale[9]**
FEFF1: Fuel Efficiency – Fuel burn per flight	*6.07 Kg*	*AO-0320 ISGS = [-1.99, -14.5] reduction kg of fuel per flight*	
CAP3.2: Airport Capacity – Peak Runway Throughput (Segregated mode).	*1.372%*	*AO-0320 ISGS = [-4.4%, -3.2%] increase in movements/hour*	
CEF2: ATCO Productivity – Flights per ATCO -Hour on duty	*0.267%*	*AO-0320 ISGS = [-4.4%, -3.2%] 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

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[8] Negative impacts are indicated in red.

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

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

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