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AART

AIRPORT AIRSIDE AND RUNWAY THROUGHPUT

This CBA 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 provides the Cost Benefit Analysis (CBA) at V3 level for **PJ.02-W2-14.3 – Increased Second Glide Slope (ISGS)**, which is an Enhanced Arrival Procedure (EAP). The associated OI Step is AO-0320: Enhanced approach operations using an increased second glide slope (ISGS).

This deliverable includes the quantification and monetisation of costs and benefits associated to the implementation of the ISGS procedure at relevant airports across ECAC.

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1 Executive Summary

This document[1] provides the V3 Cost Benefit Analysis (CBA) for SESAR Solution **PJ.02-W2-14.3: Increased Second Glide Slope (ISGS)**, which is an Enhanced Arrival Operation (EAO) that uses a steeper second glide slope to the runway threshold.

The Solution has validated to V3 level the Operational Improvement Step (OI Step) AO-0320: Enhanced approach operations using an increased second glide slope (ISGS). The CBA focuses on the **deployment** of the Solution at ECAC[2]-level and is not limited to the scope of the validation activities.

Benefits

The Solution will provide the following benefits during off-peak periods as the validation activities showed that deploying ISGS during peak periods results in a reduction of airport capacity.

The expected ISGS **benefits** that are monetised in the CBA are:

- Reduced environmental impact from **Noise Reduction** below the final approach in off-peak periods from the aircraft using the ISGS

  The noise benefits are based on the reduction in size of noise contours around the airport when implementing ISGS; this translates to a reduction in aircraft noise exposure for impacted residents.

- Improvements in **Fuel Efficiency** (reduced fuel burn and CO_2 emissions) and **Time Efficiency** in off-peak periods where ISGS enables an optimisation of the arrival flight profile for the aircraft types that can use it, which leads to a reduction in their arrival flying time for those on the ISGS.

An airport will choose to deploy an increased second glide slope to a runway threshold to reduce the noise impact of arrival aircraft, especially at night, on local residents.

Deployment is included for 32 capacity-constrained airports[3] from the Very Large and Large operating environment categories (SESAR 2020 Airport Classification Scheme). These airports have been identified as potential candidates to deploy ISGS for noise related reasons. Other airports, from any category, that have a high population density under the final approach could deploy the solution and benefit from the noise reduction, however, the associated costs and benefits are not included in this CBA.

CBA Results

The **Net Present Value (NPV) of 509 M€** reflects that the benefits from deploying this Solution are expected to exceed the costs of deploying and operating it. Confidence in the fuel and time efficiency benefits is medium as they are based on Fast Time Simulation results. Confidence in the noise results is low to medium as they generalise the benefits calculated from the noise simulations produced in the Wave 1 Solution PJ.02-02 'Enhanced Arrival Procedures'.

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[1] The opinions expressed herein reflect the authors' view only. Under no circumstances shall the SESAR 3 Joint Undertaking be responsible for any use that may be made of the information contained herein.

[2] European Civil Aviation Conference

[3] The airport names are not provided as they were chosen based on criteria and have made no commitment to deploy.

The NPV has been calculated with an 8% discount rate over the period 2022 to 2043, with PJ.02-W2-14.3 being deployed between 2025 and 2030 and with benefits starting to be realised from late 2026. The payback year is 2027, which reflects when the cumulative net benefits will exceed the costs.

The sensitivity analysis shows that even if the costs doubled and the benefits set to their low values, the deployment, as described in the CBA Solution Scenario, would still have a positive NPV of 133 M€.

Costs

On the cost side the deployment of ISGS will require ANSPs[4] and Airport Operators to invest.

- ANSP costs are based on tools or procedures to provide approach controllers with the ability to assign approach procedures and for aerodrome (TWR) controllers to know what has been assigned, including the associated training, and meeting the regulatory provisions
- Airport Operator costs relate to installing a second PAPI (precision approach path indicator) for the ISGS

  Noting that the CBA includes the cost for one additional PAPI per candidate airport so if an airport were to deploy ISGS at multiple runway ends then these costs would increase.

Some of the enablers required for this Solution will also enable other Solutions; however, the full enabler costs have been included in this CBA as a conservative approach.

While not included in the CBA, approach guidance is required for the operation of ISGS. This can be RNP (Required Navigation Performance), SBAS (Satellite Based Augmentation System) or GBAS (Ground Based Augmentation System). RNAV (Required Vertical Navigation Performance) guidance is also considered because it is anticipated that in 2025 most aircraft will be able to follow RNAV procedures, whereas only 25% of the fleet is expected to be GBAS-equipped.

Recommendations and next steps

PJ.02-W2-14.3: Increased Second Glide Slope (ISGS) is a solution that an airport could choose to deploy if they face noise issues around the airport during off-peak periods, especially at night. However, each airport needs to assess if this Solution is the best way to meet their operational needs and they should develop their own CBA based on their specific infrastructure, operations, layout, etc. to assess the scale of their potential benefits. They should also review related solutions, such as PJ.02-W2-14.2 Second Runway Aiming Point and PJ.02-W2-14.5 Increased Glide Slope to Second Runway Aiming Point, which can also offer capacity benefits during peak hours, to ensure they deploy the most appropriate solution for their needs.

[4] It is assumed that air traffic control (ATC) systems located at airports are owned by the ANSPs that provide the service; ANSPs are therefore assigned the relevant upgrade costs of these systems in the CBA. In reality the situation will differ across airports as some airports may own the systems.

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2 Introduction

2.1 Purpose of the document

This document provides the Cost Benefit Analysis (CBA) for SESAR Solution **PJ.02-W2-14.3 Increased Second Glide Slope (ISGS)**, which is an Enhanced Arrival Procedure (EAP) that has been validated to V3 level. The CBA looks at the **affordability of deploying the ISGS solution** with respect to its expected benefits.

This V3 CBA considers the impacts, benefits and costs of deploying the solution at ECAC-level. It includes the Net Present Value (NPV) for the Solution and per impacted stakeholder group, as well as a sensitivity analysis to identify the most critical variables to the value of the project.

2.2 Scope

Deploying ISGS will result in two glides slopes being active simultaneously to a single runway threshold. The aircraft flying on the higher slope should generate less noise under the final approach.

Deploying an Increased Second Glide Slope is expected to provide benefits in terms of:

- Reduced environmental impact from **Noise Reduction** below the final approach in off-peak periods for aircraft using the ISGS
- Improvements in **Fuel Efficiency** (reduced fuel burn and CO_2 emissions) and **Time Efficiency** in off-peak periods where ISGS enables an optimisation of the arrival flight profile for the aircraft types that can use it, which leads to a reduction in their arrival flying time for those on the ISGS.

This PJ.02-W2-14.3 V3 CBA provides the costs and benefits of the ISGS Solution Operational Improvement Step (OI Step AO-0320) and associated enablers; see section 3.2. It considers the standalone deployment of the Solution, i.e. independently from any other SESAR Solution(s). This means that the costs of any enablers that also enabler other solutions are fully included here.

The CBA covers the period from 2022 to 2043. The Solution is assumed to be available to deploy from 2025, with initial benefits starting in late 2026 and full benefits from 2030. The CBA includes 32 airports, from the Very Large and Large categories [10], which have been identified as candidates for deployment. Airports in other categories, especially Medium, could also benefit from noise reduction. The scale of an airport's benefits will depend on the population density around the airport. The associated costs and benefits for these other airports are not included in this CBA.

2.3 Intended readership

The intended readership for this document includes:

- PJ.02-W2-14.3 project members
- PJ.02 Increased Runway and Airport Throughput – Other Solution partners
- PJ.19 – who provides inputs such as the assumptions and who will consolidate the CBA results (where required by PJ.20)
- PJ.20, in its role of Master Plan Maintenance project
- PJ.22 - System Engineering Data Management Framework (SE-DMF)
- SESAR Programme Management

- Stakeholders (ANSPs and airports) interested in deploying this solution
- Airspace Users (Scheduled Airlines, Business Aviation) interested in the deployment of this solution

2.4 Structure of the document

This report is structured as follows:

- Section 1 provides the executive summary
- Section 2 provides the scope, intended readership, structure, background, glossary of terms and acronyms
- Section 3 presents the objectives and scope of this CBA, including a description of the ISGS Solution, information on the main stakeholders and descriptions of the CBA scenarios
- Section 4 describes the benefits and how they are monetised as well as a view on the overall contribution to Key Performance Indicators (KPIs)
- Section 5 details the costs along with the cost approach per stakeholder group and the associated assumptions
- Section 6 includes the CBA model and information on the sources of data used to feed it
- Section 7 provides the CBA results
- Section 8 includes sensitivity
- Section 9 includes recommendations and next steps
- Section 10 includes the references and applicable documents.
- The appendices provide a visual representation of the solution concept, the rationale for using an 8% discount rate and the mapping between ATM Master Plan Performance Ambition KPAs (Key Performance Areas) and SESAR 2020 Performance Framework KPAs, Focus Areas and KPIs.

2.5 Background

The PJ.02-W2-14.3 ISGS solution builds on the PJ.02-02 Solution “Enhanced Arrival Procedures” from SESAR 2020 Wave 1. PJ.02-02 considered a group of five Enhanced Arrival Procedures (EAP). In Wave 2 each EAP has been defined as a separate Solution:

- **PJ.02-W2-14.1** (AO-0308) Closely Spaced Parallel Runways optimised operations using Staggered Thresholds (CSPR-ST) – *frozen in Wave 2*
- **PJ.02-W2-14.2** (AO-0319) Enhanced Arrival procedures using Second Runway Aiming Points (SRAP)
- **PJ.02-W2-14.3** (AO-0320) Enhanced Arrival procedures using Increased Glide Slope (ISGS) – focus of this CBA
- **PJ.02-W2-14.4** (AO-0321) Enhanced Arrival procedures using Adaptive Increased Glide Slope (A-IGS) - *frozen in Wave 2*
- **PJ.02-W2-14.5** (AO-0331) Enhanced Arrival Procedure using an Increased Second Glide Slope to a Second Runway Aiming Point (IGS-to-SRAP)

As each Solution is separate, they each have a stand-alone CBA (PJ.02-W2-14.2 SRAP, PJ.02-W2-14.3 ISGS and PJ.02-W2-14.5 ISGS-to-SRAP) developed from the PJ.02-02 CBA deliverable [18] from Wave

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1 that included a consolidated analysis for the five EAP concepts. The CBA is based on nominal conditions and so the non-nominal validation exercises performed in SESAR 2020 Wave 2 have not provided additional inputs for this CBA.

The PJ.02-02 Solution built on validation work produced during SESAR 1 for projects:

- P06.08.08 D07 – Enhanced Arrival Procedures Enabled by GBAS - OSED Consolidation [14] and,
- P06.08.05 D04 – Operational Service and Environment Definition (OSED) Displaced Thresholds [15].

2.6 Glossary of terms

Term	Definition	Source of the definition
Benefit	A Benefit is the positive value of the return on investment for (some or all) stakeholders.	SESAR 16.06.06 - Methods to Assess Costs and Monetise Benefits for CBAs (D26, Edition 00.02.02, July 2016)
Benefit and Impact Mechanism	A Benefit and Impact Mechanisms a cause-effect description of the positive and negative impacts of the Solution proposed by the project	SESAR 16.06.06 – Guidelines for Producing benefit and Impact Mechanisms (D26_04, Edition 03.00.00)
Business Case	A Business Case is a tool for decision-makers, it aims to provide them with the information they need to make a fully informed decision on whether funding should be provided and/or whether an investment should proceed. A Business Case is much more than just a financial analysis as it also includes quantitative and qualitative arguments on performance and transversal activities that are key to determining the value of the project.	SESAR 16.06.06, SESAR Business Case Example – Remote Tower, D48, Edition 00.01.02, 06/05/14
Cash Flow	Cash flow is the difference between the cash inflows and outflows related to the project during the time horizon in which they occur.	SESAR 16.06.06 - ATM CBA for Beginners, D26-01, October 2014
Cost	A Cost is the monetary value of an investment used up to produce or acquire the benefit.	SESAR 16.06.06 - Methods to Assess Costs and Monetise Benefits for CBAs (D26, Edition 00.02.02, July 2016)
Cost Benefit Analysis	A Cost Benefit Analysis is a process of quantifying in economic terms the costs and benefits of a project or a program over a certain period, and those of its alternatives (within the same period), in order to have a single scale of comparison for unbiased evaluation. A CBA is a neutral financial tool that helps decision makers to compare an investment with other possible investments and/or to make a choice between different options / scenarios and to select the one that offers the best value for money while considering all the key criteria for the decision.	SESAR 16.06.06, SESAR Business Case Example – Remote Tower, D48, Edition 00.01.02, 06/05/141

Cost mechanisms	Cost mechanisms are a description of the potential costs of the project broken down into relevant cost categories (e.g. investment, operating).	SESAR 16.06.06, ATM CBA for Beginners, D26-01, October 2014
Discount Rate	Discount Rate is a way to capture the time value of money. This is a percentage that represents the increase in the amount of money needed or estimated to keep the same value as one year ago.	SESAR 16.06.06, ATM CBA for Beginners, D26-01, October 2014
Initial Operational Capability	Initial Operational Capability is the state archives when a capability is available in its minimum usefully deployable form. In other words, it identifies the start of benefits and the benefit ramp-up period.	16.06.06-D68-New CBA Model and Method 2015-Part1 of 2
Inflation	Inflation is a rise in the general level of prices of goods and services in an economy over a period of time.	SESAR 16.06.06, ATM CBA for Beginners, D26-01, October 2014
Net Present Value (NPV)	Net Present Value (NPV) is the sum of all discounted cash inflows and outflows during the time horizon period.	SESAR 16.06.06, ATM CBA for Beginners, D26-01, October 2014
Sensitivity Analysis	Sensitivity refers to the impact one given input to the model has on the overall NPV.	SESAR 16.06.06, ATM CBA for Beginners, D26-01, October 2014
Stakeholders	Stakeholders are organizations and entities who will have to pay for or will be impacted by the project directly or indirectly.	SESAR 16.06.06, ATM CBA for Beginners, D26-01, October 2014
Time Horizon	Time horizon refers to a definite period during which all cost and benefits related to a given project occur.	SESAR 16.06.06, ATM CBA for Beginners, D26-01, October 2014
Time Value of Money	Time Value of Money means that the same (nominal) amount of money received at different points in time has different value	SESAR 16.06.06, ATM CBA for Beginners, D26-01, October 2014
Wake Turbulence	Wake turbulence is a function of an aircraft producing lift, resulting in the formation of two counter-rotating vortices trailing behind the aircraft. Wake turbulence from generating aircraft can affect encountering aircraft due to the strength, duration, and direction of the vortices.	PJ.02-01 partners
Wake Vortex	Wake vortex is a circular pattern of rotating air left behind a wing as it generates lift.	PJ.02-01 partners

Table 1: Glossary of terms

2.7 List of Acronyms

Acronym	Definition
ACC	Area Control Centre
AART	Airport Airside and Runway Throughput
AERO	Aerodrome
A-IGS	Adaptive Increased Glide Slope

Acronym	Definition
ANS	Air navigation services
ANSP	Air Navigation Service Provider
AO	Airport Operator
APP	Approach Centre
APT	Airport
APV-Baro	Approach Procedures with Vertical Guidance (using barometric altitude info)
APV-SBAS	Approach Procedures with Vertical Guidance (using barometric altitude info)
ATC	Air Traffic Control
ATCO	Air Traffic Controller
ATM	Air Traffic Management
ATS	Air Traffic Services
AU	Airspace User
AUC	Airspace User Costs
BA	Business Aviation
BIM	Benefit and Impact Mechanisms
CAP	Capacity
CAPEX[5]	Capital Expenditure
CBA	Cost Benefit Analysis
CEF	Cost Effectiveness
CMC	Civil Military Coordination
CO_2	Carbon dioxide
CP1	Common Project 1
CSPR-ST	Closely Spaced Parallel Runways - Staggered Thresholds
db	decibel
DS	Data Set
EAO	Enhanced Arrival Operations
EAP	Enhanced Arrival Procedures
EATM	European ATM (Portal, database, dataset)
EATMA	European ATM Architecture
EC	European Commission
ECAC	European Civil Aviation Conference
EN	Enabler
ENV	Environment (KPA)

[5] Note that the term CAPEX has been used in the CBA Report to indicate all the investments (pre-implementation and implementation costs).

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Acronym	Definition
ER	En-route
EU	European Union
EUR	Euro
EUROCONTROL	European Organisation for the Safety of Air Navigation
FAP	Final Approach Point
FEFF	Fuel Efficiency
FLX	Flexibility
FOC	Final Operating Capability / Flight Operations Centre
G2G	Gate to Gate
GAT	General Air Traffic
GBAS	Ground-Based Augmentation System
H	High complexity (En-route/Terminal Airspace classification)
H2020	Horizon 2020
HC	High complexity (airport)
HP	Human Performance
HUM	Human (enabler)
ICAO	International Civil Aviation Organization
IGS	Increased Glide Slope
IGS-to-SRAP	Increased Glide Slope to a Second Runway Aiming Point
ILS	Instrument Landing System
INTEROP	Interoperability
IOC	Initial Operating Capability
IR	Industrial Research
ISGS	Increased Second Glide Slope
IT	Information Technology
KG (kg)	Kilogram
KM	Kilometre
KPA	Key Performance Area
KPI	Key Performance Indicator
L	Large (Airport classification) / Low complexity (En-route/Terminal Airspace classification)
LC	Low complexity (airport)
Lden	Day-evening-night noise level
M	Medium (Airport classification) / Medium complexity (En-route/Terminal Airspace classification)
M€	Millions of euros
NM	Network Manager / Nautical Mile

Acronym	Definition
NOI	Noise
NPV	Net Present Value
NSA	National Supervisory Authority
O	Optional (enabler)
OE	Operating Environment
OI	Operational Improvement
OPEX	Operating Expenditure (Considers Changes in Operating Costs)
ORD	Optimised Runway Delivery (Tool)
OSED	Operational Service and Environment Definition
PAGAR	Performance Assessment And Gap Analysis Report
PAPI	Precision Approach Path Indicator
PAR	Performance Assessment Report
PAX	Passengers
PI	Performance Indicator
PJ	Project
PRD	Predictability
PUN	Punctuality
R	Required (enabler)
R&D	Research and Development
RECAT	Wake Turbulence Re-categorisation
REG	Regulation (enabler)
RES	Resilience
RNAV	Area Navigation
RNP	Required Navigation Performance
S	Small (Airport classification)
S3JU	SESAR3 Joint Undertaking
SA	Scheduled Aviation
SAF	Safety
SBAS	Satellite-based Augmentation Systems
SEC	Security
SESAR	Single European Sky ATM Research Programme
SJU	SESAR Joint Undertaking
SOL	Solution
SPR	Safety and Performance Requirements
SRAP	Second Runway Aiming Point (SRAP)
STATFOR	EUROCONTROL Statistics and Forecasts Service

Acronym	Definition
STD	Standardisation (enabler)
sWP	Sub-Work Package
TEFF	Time Efficiency (KPA)
TMA	Terminal Manoeuvring Area
V3	Pre-industrial development and integration stage of the Concept Lifecycle Model (E-OCVM)
VH	Very High complexity (En-route/Terminal Airspace classification)
VL	Very Large (Airport classification)
VLD	Very Large Demonstration
VT	Validation Target
W1	SESAR 2020 Wave 1
W2	SESAR 2020 Wave 2
WHO	World Health Organisation
WP	Work Package

291 **Table 2: List of acronyms**

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3 Objectives and scope of the CBA

3.1 Problem addressed by the solution

One problem, currently faced by many airports is the noise impact of aircraft flying ILS (Instrument Landing System) approaches, especially during the night. This noise impact is a major limitation that constrains the operations at some airports because most airports provide straight-in ILS precision approaches on a standard 3-degree glide slope. Such an approach obliges aircraft to fly low close to the airport, which is generally over built-up, often residential, areas. The aircraft are not always able to follow trajectories that allow optimum flap settings and engine thrust for both fuel consumption and noise.

An Increased Second Glide Slope can help address this problem as aircraft on the ISGS remain higher for longer which will reduce the noise below the final approach.

3.2 SESAR Solution description

The Solution description in EATMA (DS23 draft) is:

> This solution introduces an increased second glide slope (ISGS) as a new concept of enhanced approach operations. ISGS helps reduce the environmental impact by the use of two glide slopes active simultaneously.
> By doing so, the environmental impact should be reduced as aircraft flying on the higher slope should generate less noise.

The following description is based on the Solution description from the OSED, section 3.1 [21].

An Increased Second Glide Slope (ISGS) will allow inbound aircraft to reduce their noise footprint (environmental benefit). ISGS procedures are published approaches which feature a glide slope between the "standard" published one (commonly 3 degrees) and 4.49 degrees (limit above which steep approach concept applies) in order to provide a significant reduction in ground noise level (order of magnitude: -3 dBA in approach between 15 NM and 4 NM from runway threshold); see Appendix A. The increased final glide slope (published as an alternate final procedure) can be captured before the Final Approach Point (FAP) at any time during the approach phase with the ISGS procedure.

ISGS is expected to reduce noise around the airport during off-peak periods and was validated for operations during the night using only standard procedures. The reason ISGS is only proposed for off-peak periods is that for some aircraft pairs the separation needs to be increased, which reduces runway throughput. This increase in separation is a function of the traffic mix, the sequence, the glide slope allocation, and the local standard separation minima applied at the airport. For some aircraft pairs the separation increase is 'limited' while for others it is 'very significant' which relates to the level of impact on the runway throughput. It is worth noting that a separation delivery tool (ORD) could limit that runway throughput reduction, but not enough to consider using ISGS in peak periods.

All this means that it is likely to be much more efficient, applicable and beneficial to use ISGS during off-peak, especially night, operations when the traffic pressure allows for runway throughput reduction and the noise constraints are the highest. Under these conditions, a separation delivery tool (ORD) is not needed since a conservative separation can be applied because of the low traffic pressure.

It should be noted that, although that ISGS concept is primarily based on mixed usage of the slopes, airports could implement ISGS operations for noise purpose considering that there are periods of the day during which all or almost all incoming traffic may be able to fly the ISGS approach procedure, hence having no negative impact on capacity since consecutive approaches on ISGS can be separated by standard wake minima, avoiding increased wake separation during these periods. However, this

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will only be possible if all the traffic during that period will be able to fly the ISGS, and that will depend on the published ISGS slope and on whether the traffic capability and equipage levels are compatible with the navigation guidance used for the ISGS procedure (e.g. GBAS and/or SBAS and/or RNP Baro-VNAV).

Table 3 provides the OI Step associated with ISGS.

SESAR Solution ID	OI Steps ref.	OI Steps definition
PJ.02-W2-14.3	**AO-0320**	Enhanced Approach Operations using Increased Second Glide Slope (ISGS)

Table 3: SESAR Solution PJ.02-W2-14.3 OI step

Costs and benefits are both calculated on the assumption that all required enablers are deployed by the relevant stakeholders. Optional enablers are not included in the cost assessment, although they are provided in Table 4 for completeness.

Enabler [6] ref.	Enabler definition	Applicable stakeholders
AERODROME-ATC-102 (R)	Aerodrome ATC system to support final approach operations (distinguish approach procedures)	Air Navigation Service Provider - Civil ATS Aerodrome Service Provider - Military ATS Aerodrome Service Provider
AIRPORT-53 (R)	PAPI for ISGS approach procedures	Airport Operator - Civil APT operator - Military APT operator
APP ATC 170 (R)	Approach ATC system upgraded to support approach procedure assignment	Air Navigation Service Provider - Civil ATS Approach Service Provider - Military ATS Approach Service Provider
HUM-022 (R)	Flight Crew training for ISGS approach	Airspace User - Civil Scheduled Aviation - Civil Business Aviation-Fixed Wing - Civil General Aviation - Military Transport - Military Fighter - Military Light Aircraft
HUM-032 (R)	ATC training for ISGS approach	Air Navigation Service Provider - Civil ATS Aerodrome Service Provider - Civil ATS Approach Service Provider - Military ATS Aerodrome Service Provider - Military ATS Approach Service Provider
A/C-86 (O)	On-board assistance to aircraft energy management	Airspace User - Civil Scheduled Aviation - Civil Business Aviation-Fixed Wing - Civil General Aviation - Military Transport - Military Fighter - Military Light Aircraft

[6] This includes System, Procedural and Human Enablers

A/C-87 (O)	On-board assistance to flare	Airspace User - Civil Scheduled Aviation - Civil Business Aviation-Fixed Wing - Civil General Aviation - Military Transport - Military Fighter - Military Light Aircraft
AERODROME-ATC-71 (O)	Aerodrome ATC System to support ISGS operations (separation delivery)	Air Navigation Service Provider - Civil ATS Aerodrome Service Provider - Military ATS Aerodrome Service Provider
APP ATC 114 (O)	Approach ATC System to support ISGS operations (separation delivery)	Air Navigation Service Provider - Civil ATS Approach Service Provider - Military ATS Approach Service Provider

Table 4: AO-0320 related Enablers

The institutional enablers, REG-0530 and STD-113, listed in the Wave 1 PJ.02-02 CBA, have been allocated to system and human enablers in the more recent datasets. They are listed in Table 6 to give a link to the Wave 1 PJ02-02 CBA.

Enabler ref.	Enabler definition	Applicable stakeholders
REG-0530 Allocated to HUM-032 (R), AERODROME-ATC-71 (O), APP ATC 114 (O)	Regulatory provisions for Increased Second Glide Slope operations (ISGS)	Institutional enabler - unassigned in DS23 draft
STD-113 Allocated to HUM-022 (R), HUM-032 (R), AIRPORT-53 (R)	Update of EASA/ICAO regulatory frameworks for new visual ground aids (ISGS)	Institutional enabler - unassigned in DS23 draft

Table 5: AO-0320 Institutional Enablers

For PJ.02-W2-14.3, REG-0530 and STD-113 need to be in place before the solution can become operational.

- For REG-0530, the regulatory provisions (produced by the competent regulatory authority) relate to wake separation minima when applying Increased Second Glide Slope (ISGS) procedures. These regulatory provisions consist of a minimum arrival separation table expressed in distance or/and time depending on the aircraft type/category and procedure respectively used by leader and follower (ISGS / normal ILS approach).

  "Regulatory provisions" refers here to advice from the regulatory authorities on the acceptability of a safety case supporting an ATM rule modification.

- For STD-113 the introduction of the Increased Second Glide Slope concept, will require updates to both:
  - EASA Aerodrome regulation 139/2014 acceptable mean of compliance (AMC)
  - ICAO Annex 14

relating to visual ground aids (second PAPI installation for the same runway threshold).

3.3 Objectives of the CBA

This V3 Cost Benefit Analysis helps to build an assessment of whether PJ.02-W2-14.3 is worth deploying from an economic perspective for the involved stakeholders.

The objective is to provide an assessment of the costs and benefits of deploying increased second glide slopes (ISGS) at the 32 airports that have been included in the ECAC-level CBA Solution Scenario. These airports are not named in the CBA to avoid the implication that those airports have made any commitment to deploy PJ.02-W2-14.3.

This CBA assesses whether the benefits of the deployed Solution are expected to exceed the costs over the CBA time horizon (up to 2043). It does this using discounted cash flow analysis which provides the Net Present Value (NPV) for the Solution and per stakeholder group. As there is a positive NPV, the break-even year and payback period are provided; respectively, these are the year from which the benefits will cover the costs incurred and the number of years from the start of the project before this occurs.

The CBA results are also explored through a sensitivity analysis to assess the impact on the NPV of changes to the input values, e.g. a doubling of the costs or a halving of the benefits.

As the CBA provides results at ECAC-level it does not provide sufficient detail to support individual deployment decisions that must take into account the local environment/situation (e.g. current operational systems, their lifespan(s), replacement timing, etc.). However, interested parties can take the mechanisms and inputs used here and refine them for their local CBAs, if appropriate.

3.4 Stakeholders identification

The CBA results are presented at solution level and individually from the viewpoint of each impacted stakeholder group, i.e. those that need to invest and those who will receive benefits from the Solution.

In summary the key stakeholders for PJ.02-W2-14.3 are:

- ANSPs providing approach (APP) and tower (AERO) services at the deploying airports
- Airport Operators at the deploying airports
- Airspace Users[7] who operate at the deploying airports
- Society focused on the inhabitants living around the deploying airports

Table 6 describes how each stakeholder is impacted by the ISGS solution in terms of costs and benefits.

Note that the key inputs for the PJ.02-W2-14.3 CBA come from the ISGS related data from SESAR 2020 Wave 1 PJ.02-02 as no additional performance data will be produced by the Wave 2 validation activities. Cost data was originally provided by PJ.02-02 members and has been reviewed in Wave 2 with Airport Operator costs being updated.

Stakeholder	Type of stakeholder and/or applicable sub-OE	Type of Impact	Involvement in the CBA task	Quantitative results available in the CBA
ANSPs	ATCOs, Terminal Airspace (APP) and Tower Control	Benefits: no benefits Costs: implementation of the controller tools and procedures to provide approach controllers with the ability to assign approach procedures and for	PJ.02 partners providing cost inputs	Costs

[7] Note that the terminology used to describe AU stakeholders in the CBA differs from that associated with Enablers in the dataset. This is due to costing being provided for different types of aircraft regardless of the operations they perform.

Stakeholder	Type of stakeholder and/or applicable sub-OE	Type of Impact	Involvement in the CBA task	Quantitative results available in the CBA
	Centres (AERO)	aerodrome (TWR) controllers to know what has been assigned, also includes the associated training		
Airport Operators	Very Large and Large Airports	Benefits: Noise reduction in the areas close to the airport could reduce capacity restrictions due to noise (during off-peak periods, especially at night) allowing an improved quality of service to AUs Costs: investments are needed for the PAPI (Precision Approach Path Indicator) for the ISGS	No involvement	Costs
Network Manager	Network for NM	Benefits: no benefits Costs: no costs as there are no changes to NM systems or operations	No involvement	No costs or benefits
Airspace Users: Scheduled Airlines (Mainline and Regional) / Business Aviation	Flight Crew, Safety Department	Benefits: time efficiency and fuel efficiency associated optimised arrival profiles for aircraft that use the ISGS. Where applicable, AU less likely to incur fines related to noise infringements. Costs: no costs included as using a steeper glide slope is included in current flight crew training	No involvement	Benefits
Regulation Authority **-** Approve new operations	National Supervisory Authority (NSA) / Ministry of Transport	Benefits: no benefits Costs: no costs for regulatory authorities, the cost for regulation drafting are taken into account in the ANSP costs	No involvement	Stakeholder not included in the CBA No costs or benefits
Society	Communities around airports	Benefits: Communities around airports are interested in environmental benefits, especially noise reduction, coming from the implementation of the ISGS solution Costs: no costs	No involvement	Noise reduction benefits

Table 6: SESAR Solution PJ.02-W2-14.3 CBA Stakeholders and impacts

3.5 CBA Scenarios and Assumptions

This section describes the scenarios that are compared in the CBA. The comparison is between the CBA Reference scenario (where the Solution is not deployed - the orange box in Figure 1) and the Solution scenario (reflecting the proposed deployment of the Solution at applicable locations across ECAC - the green box in Figure 1). The CBA uses a delta approach where the focus is on the costs and benefits associated with the ECAC-level deployment of the solution, i.e., with the changes from the CBA Reference Scenario.

Defining the CBA Reference Scenario has proven to be very challenging for many Solutions because of the assumptions that need to be made regarding the 'ongoing deployments' (blue arrow in Figure 1). To avoid being blocked by this issue this V3 CBA is currently based more on the difference between the current situation (2022) and the CBA Solution Scenario.

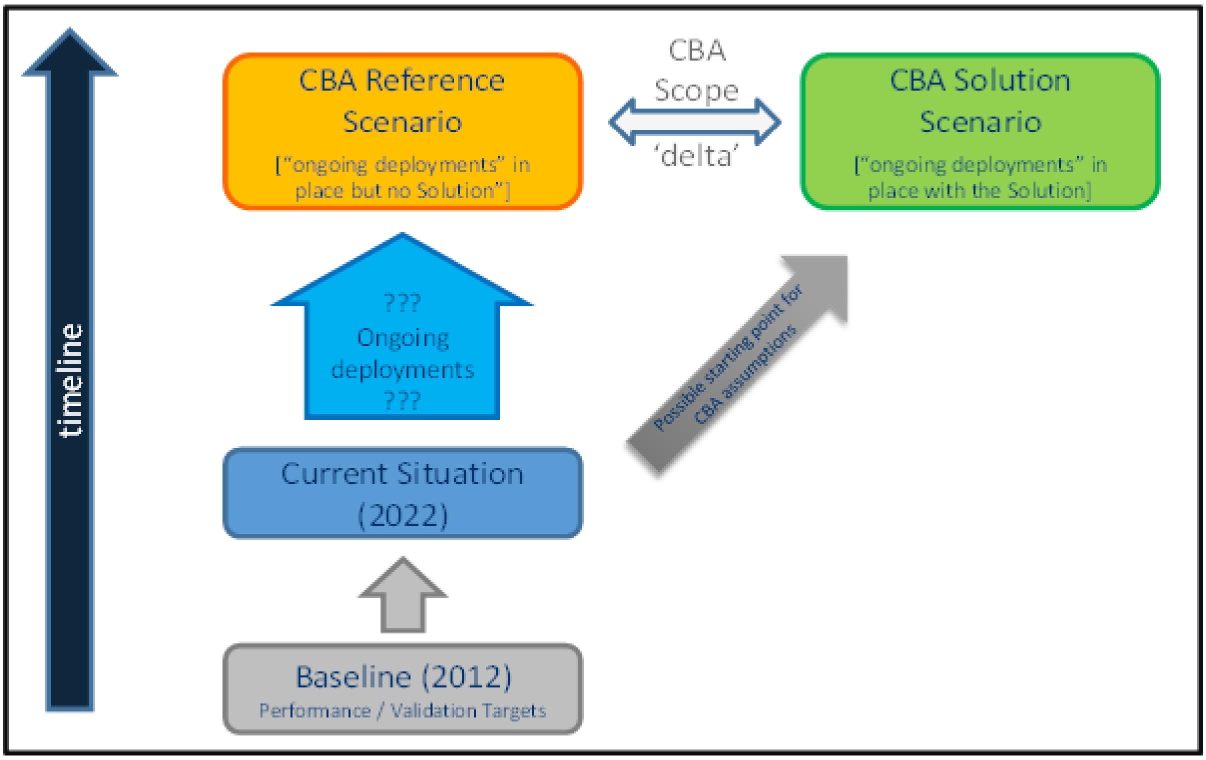

Figure 1: Scenario Overview

3.5.1 CBA Reference Scenario

The CBA Reference Scenario reflects the future situation where ISGS is not deployed.

It is assumed that any relevant Common Project 1 (CP1) elements have been deployed at applicable airports in line with the SESAR Deployment Programme planning.

For the wake turbulence schemes, the current operational environment is assumed in the CBA Reference Scenario i.e. RECAT-EU[8] and ICAO[9] (3 categories+A380). Relevant benefits are assessed from this starting point.

3.5.2 CBA Solution Scenario

The deployment of the Solution involves the implementation of the enablers listed in section 3.2, which include:

- a PAPI for the increased glide slope (Airport-53 (R))

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[8] RECAT-EU: European Wake Turbulence Categorisation and Separation Minima on Approach and Departure (applicable scheme at Charles de Gaulle and London Heathrow)

[9] ICAO Wake Turbulence Scheme https://www.skybrary.aero/index.php/ICAO_Wake_Turbulence_Category (applicable scheme at all other airports)

- A controller tool to support final approach operations (Aerodrome-ATC-102 (R), APP ATC 170 (R))
- ATCO training (HUM-032 (R))
- Flight crew training (HUM-022 (R))

The 32 candidate airports included in the CBA Solution Scenario are assumed to deploy ISGS to achieve the noise reduction benefits. The airports come from the Very Large and Large airport categories [10]. Airports in other categories, especially Medium, could also benefit from noise reduction. The scale of an airport's benefits will depend on the population density around the airport. The associated costs and benefits for these other airports are not included in this CBA.

The main cost and benefit inputs for the PJ.02-W2-14.3 CBA are taken from the SESAR 2020 Wave 1 PJ.02-02 CBA [18]. For the benefits there is no additional performance data from the Wave 2 validation activities. The Performance Assessment Report [22] was developed from the Wave 1 PAR [17] and assesses the achievement of the solution based on the Wave 1 PJ19.04 common assumptions. It includes some results aggregated to ECAC-level. The cost data was originally provided by PJ.02-02 members and has been reviewed in Wave 2 with Airport Operator costs being updated for Airport-53 (PAPI).

CBA timeline

The CBA covers the period from 2022 to 2043 as defined by PJ19.04; this mean that Net Present Value is calculated by discounting the cash-flows back to 2022 (the end of Wave 2).

The table below lists the key dates used in the CBA and Figure 2 shows them over a timeline.

Dates	ISGS
Start of deployment date: the start of investments for the first deployment location	**2025**
End of deployment date: the end of the investments for the final deployment location, same as FOC	**2030**
Initial Operating Capability (IOC): the time when the first benefits occur following the *minimum deployment* necessary to provide them. Costs continue after this date as further deployment occurs at other locations.	**Late 2026**
Final Operating Capability (FOC): Maximum benefits from the *full deployment*[10] of the Solution at applicable locations. Investment costs are considered to end[11] here although any operating cost impacts would continue.	**2030**

Table 7: CBA Investment and Benefit Dates

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

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

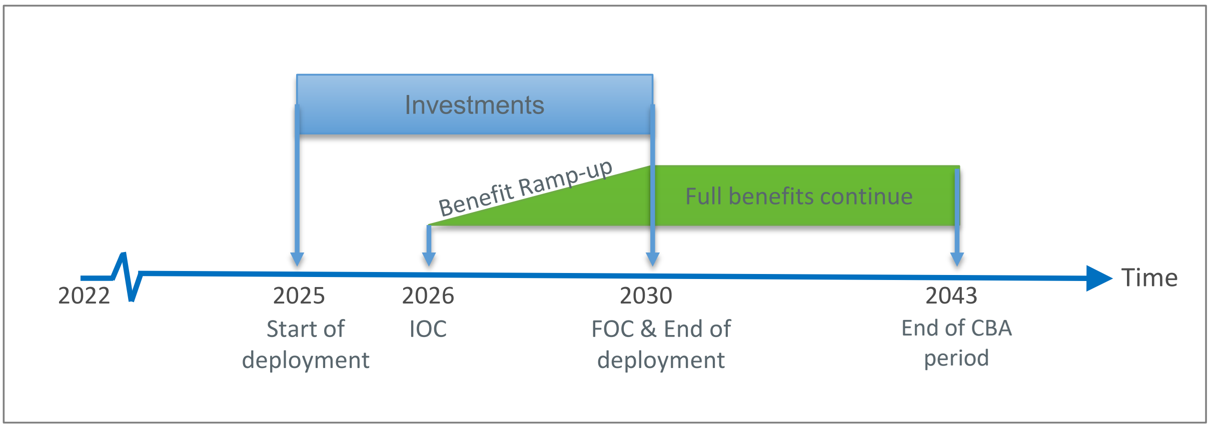

Figure 2: Overview of CBA Dates

Figure 2 shows that:

- Investment costs are spread linearly between the Start and End of Deployment dates.
- Benefits ramp-up linearly between IOC and FOC and then continue up to the end of the CBA period.
- Operating cost impacts (increases or decreases) would also start at IOC and ramp-up linearly to FOC before continuing for the rest of the CBA duration.

3.5.3 Assumptions

Costs and benefits have been computed from fast-time validation exercise results, partners' contributions and average values taken from the PJ.19.04 Common Assumptions for extrapolation to ECAC-Level.

As it is not feasible to identify exact costs for each airport separately, the costs have been estimated assuming that they would be of same order of magnitude, implying that all targeted airports will support the same kind of costs.

4 Benefits

The main objective of solution 14.3 ISGS is **reducing the aircraft noise footprint** during the arrival and approach procedures.

The solution Performance Assessment Report (PAR, [22]) shows that the solution (a) improves fuel efficiency (FEFF1), time efficiency (TEFF1), and airport noise (NOI2), whereas (b) reduces the airport capacity (CAP3.2) and ATCO productivity (CEF2) due to increased separation minima between aircraft. In also extrapolates the local performance gain (calculated based on a fast-time simulation) to ECAC-level assuming that the solution will impact all the traffic occurring at “high-density airports” (SESAR 1 classification).

However, ATC would only apply the solution during off-peak periods, when airports do not require the maximum runway throughput. This provides the noise reductions without reducing the number of arrivals (since there is spare capacity).

To align with the Wave 2 common assumptions, this CBA re-calculates the extrapolation, introducing two changes in comparison with the PAR:

- The CBA assumes implementation in Very Large and Large airports (SESAR2020 Wave 2 Classification), instead of “high-density airports”; and
- The CBA considers that the solution only applies during off-peak periods. Therefore, there is no impact on runway throughput or ATCO productivity (since the airport has spare capacity).

Table 8 shows the local benefits the CBA applies to the off-peak periods at Very Large and Large airports.

Performance gain	KPI	Low value	High value
Fuel savings	FEFF1	-7.99 kg fuel per arrival	-50.83 kg fuel per arrival
Flight time savings	TEFF1	-0.22 minutes per arrival	-0.86 minutes per arrival
Noise reduction	NOI2 – 55dB contour	-	-0.80 km^2 per airport
	NOI2 – 65dB contour	-	-0.15 km^2 per airport
	NOI2 – 75dB contour	-	-0.03 km^2 per airport

Table 8: Solution PJ.02-W2-14.3 ISGS local benefits

4.1 Benefit Monetisation Mechanisms

4.1.1 Extrapolation assumptions

Table 9 shows the SESAR Common Assumptions [11] that the CBA uses to extrapolate ISGS local benefits to the off-peak periods at Very Large and Large airports.

Item	ID	Value	Unit

Contribution to total En-Route traffic from Very Large airports	APT-VL-2035	0.71	Movements per ECAC flight[12]
Contribution to total En-Route traffic from Large airports	APT-L-2035	0.21	Movements per ECAC flight
Contribution to total En-Route traffic from Very Large airports during peak traffic	APT-PC-VL-2035	0.47	Movements per ECAC flight
Contribution to total En-Route traffic from Large airports during peak traffic	APT-PC-L-2035	0.15	Movements per ECAC flight
Percentage of arrivals per TMA movement	M-0012	50%	%
Average ECAC flight time	T-0010	1.7	hours
Average fuel burn per flight	F-0001	5280	Kg per flight
Peak operating time at high density airport	M-0011	11	Hours per day

Table 9: SESAR Common Assumptions (Annex 1, v5, 17-10-2019)

The percentage of ECAC traffic that benefits from the solution is calculated as follows:

- Traffic at VL and L airports: $0.71 + 0.21 = 0.92$ movements per ECAC flight
- Peak traffic at VL and L airports: $0.47 + 0.15 = 0.62$ movements per ECAC flight
- Off-peak traffic at VL and L airports: $0.92 - 0.62 = 0.30$ movements per ECAC flight
- Off-peak arrivals at VL and L airports: $0.30 \cdot 50\% = 15\%$ of the ECAC flights

Therefore, the FEFF1 and TEFF1 local benefits are multiplied by 15% to calculate the ECAC-wide performance gain. The NOI2 benefit calculation follows a different approach (see section 4.1.3).

4.1.2 Fuel Efficiency (FEFF1)

The CBA considers the average local performance gain to calculate the FEFF1 extrapolation to the ECAC:

- Average local FEFF1 gain: -29.41 kg per arrival
- ECAC FEFF1 gain (absolute): $-29.41 \text{ kg per arrival} \cdot 15\% = -4.44 \text{ kg per flight}$
- ECAC FEFF1 gain (relative): $-4.44\text{kg} / 5280\text{kg} = -0.08\%$

The CBA monetises the Fuel Efficiency as the value of the savings in fuel (FEFF1) and, consequently, in CO_2 (ENV1). Figure 3 shows the CBA monetisation mechanism for Fuel Efficiency.

[12] For Airports the traffic contribution to total traffic handled per sub-OE category is the sum of annual movements at each specific sub-OE within the same category divided by the annual IFR ECAC flights, because the volume of arrival and departure traffic is best considered in number of movements. The sum of all sub-OE traffic contributions of the TMA and airport OEs, respectively, is less than 2 movements per flight because of flights departing to or arriving from outside ECAC.

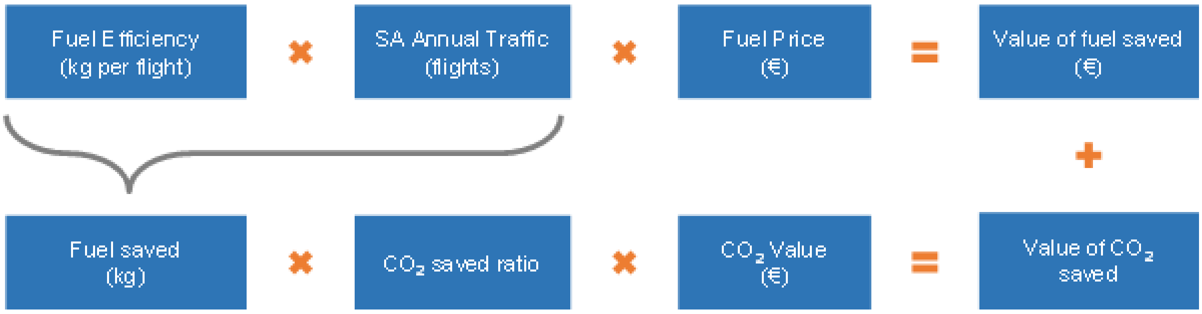

Figure 3: Fuel Efficiency and CO2 Monetisation Mechanisms

4.1.3 Time Efficiency (TEFF1)

The Time Efficiency savings refer to a reduction in the average flying time (minutes/flight) for each aircraft. Again, the CBA considers the average local performance gain to calculate the TEFF1 extrapolation to the ECAC:

- Average local TEFF1 gain: -0.54 minutes per arrival
- ECAC TEFF1 gain (absolute): $-0.54 \text{ minutes per arrival} \cdot 15\% = -0.08 \text{ minutes per flight}$
- ECAC TEFF1 gain (relative): $-0.08 \text{ min} \,/\, (1.7 \text{ hours} \cdot 60 \text{ min}) = -0.08\%$

The CBA model monetises time efficiency only as strategic delay savings, to avoid double counting benefits with the flight efficiency gain (fuel and emissions).

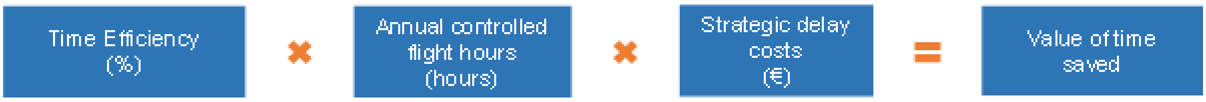

Figure 4: Time Efficiency Monetisation Mechanism

4.1.4 Noise Reduction (NOI2)

Whilst the increase in traffic volume results in higher noise levels, the increase in urbanisation results in a higher number of people experiencing disutility due to noise. Communities around airports are interested in environmental benefits, especially noise, coming from the implementation of the ISGS solution. In general, noise can be defined as unwanted sounds of varying duration, intensity or other quality that causes physical or psychological harm to humans.

The PAR [22] calculates the noise benefits as the reduction in the size of the noise contours (NOI2) around the airport area when the ISGS solution is applied. The CBA considers the average reduction in this noise contour and then multiplies it by (i) the average population density and (ii) the value of noise per person.

Since the PAR calculates the change in noise contour area per decibel band, the CBA estimates the cost of noise per decibel band too.

The population density is the average of the cities where the Very Large and Large airports are located, which results in 4,788 inhabitants per square kilometre[13].

The cost of noise (EU28 averages) is extracted from the Handbook[14] on the external costs of transport Version 2019 [19], which takes into account only health and annoyance costs. Section 7 refers to these benefits as Societal Benefits.

Noise (Lden)	Annoyance	Health	Total	Unit
50-54 dB(A)	34	5	39	EUR per dB per person per year
55-59 dB(A)	68	6	74	
60-64 dB(A)	68	9	77	
65-69 dB(A)	129	12	141	
70-74 dB(A)	129	16	145	
≥75 dB(A)	129	21	150	

Table 10: Environmental price of traffic noise for EU28
(CE Delft- Handbook on the external costs of transport Version 2019)

Annoyance represents the disturbance individuals experience when they are exposed to traffic noise. It can hinder people from performing certain activities, which may lead to a variety of negative responses, including irritation, disappointment, anxiety, exhaustion and sleep disturbance (WHO, 2011). Sleep disturbance is not considered a separate component in this value to avoid potential double counting. If one is asked about their annoyance they are inclined to also take into account the effects of sleep disturbance; therefore sleep disturbance is assumed to be included in the annoyance.

Concerning *health*, exposure to noise results in several health endpoints due to prolonged and frequent exposure to transport noise. According to the CE Delft report, "t*hese health endpoints can take a multitude of forms. Health endpoints for which significant evidence is available are ischaemic heart disease, stroke, dementia and hypertension. For health endpoints not mentioned in the list above, e.g. breast cancer and depression, only fragmented evidence is available. Therefore, these costs are not included in the noise costs estimated in this study. For the same reason, productivity losses (e.g. loss of concentration) and environmental impacts of traffic noise (e.g. harmful effects on wildlife) are not covered. Finally, direct material damages as a result of vibrations are not included in the costs of noise in this study, as the vibrations are not necessarily an effect of noise, but rather an external effect on its own."*

Further benefits related to reduced noise taxes have not been included in this CBA due to limited, thus not exhaustive, information concerning noise taxation around the ECAC area airports.

The following tables translate the solution noise benefit (NOI2) intro avoided "cost of noise" for the population living in the airports' cities.

Noise (Lden)	Area reduction (km^2)	Population density (hab/km^2)	Population reduction (inhabitants)
75 dB(A)	0.015	4,788	72
65 dB(A)	0.075	4,788	359
55 dB(A)	0.400	4,788	1,915

Table 11: Reduction in population impacted by noise per airport

[13] European Commission, Urban Centre Database UCDB R2019A, Population density value in 2015.

[14] CE Delft (on behalf of the European Commission).

Noise (Lden)	Population reduction (inhabitants)	Noise cost (EUR per person per year)[15]	Noise cost (EUR per year)
75 dB(A)	72	150	10,773
65 dB(A)	359	141	50,635
55 dB(A)	1,915	74	141,731
		Total per year	**203,140**

Table 12: Avoided cost of noise per airport

The CBA considers that 32 Very Large and Large airports benefit from the ISGS procedures in terms of reduction of noise. Therefore:

- Noise cost savings (ECAC): $203{,}140€ \text{ per airport} \cdot 32 \text{ airports} = 6.5 \text{ M€ per year}$

However, the PAR results are expressed using the Lden metric, which calculates the *"noise level based on energy equivalent noise level (Leq) over a whole day…"*[16]. The CBA assumes that ATC only applies the solution ISGS during off-peak periods and thus it does not bring a noise reduction during the "whole day". Therefore, the previous calculation is corrected by:

- Off-peak time at Very Large and Large airports: $24\text{hr} - 11\text{hr} = 13 \text{ hours per day}$
- Off-peak time-share at Very Large and Large airports: $13/24 = 54\%$
- Off-peak noise cost savings (ECAC): $6.5 \text{ M€} \cdot 54\% = €3.5 \text{ M€ per year}$

Finally, Figure 5 shows the noise monetisation mechanism applied in the CBA model.

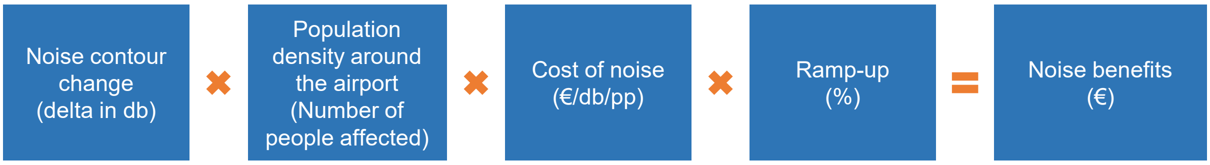

Figure 5: Noise reduction Monetisation Mechanism

4.1.5 Summary of benefits

Table 13 summarises the benefit inputs for the CBA model, which have been calculated based on the solution Performance Assessment Report (PAR, [22]):

Performance gain	KPI	CBA input (ECAC)
Fuel savings	**FEFF1** *(ENV1)*	**-4.44kg of fuel per flight** *(-13.97kg of CO_2 per flight)*
Flight time savings	**TEFF1**	**-0.08%** *(-0.08min per flight)*
Noise reduction	**NOI2**	**3.5 M€ per year** *(aggregated benefit for 32 Very Large and Large airports)*

Table 13: Solution PJ.02-W2-14.3 ISGS ECAC-wide benefits

[15] Considering only 1dB reduction per person. This is a conservative assumption since the PAR provides the noise footprints every 10dB.

[16] European Environment Agency: Lden Day-evening-night level

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Performance Framework KPA[1]	Focus Area	KPI/PI from the Performance Framework	Unit	Metric for the CBA	Unit	Total benefits from IOC to 2043
Cost Efficiency	ANS Cost efficiency	**CEF2** Flights per ATCO-Hour on duty	Nb	ATCO employment Cost change	€/year	No Validation Target
				Support Staff Employment Cost Change	€/year	No Validation Target
				Non-staff Operating Costs Change	€/year	No Validation Target
		CEF3 Technology cost per flight	EUR / flight	G2G ANS cost changes related to technology and equipment	€/year	No Validation Target
	Airspace User Cost efficiency	**AUC3** Direct operating costs for an airspace user	EUR / flight	Impact on direct costs related to the aeroplane and passengers. Examples: fuel, staff expenses, passenger service costs, maintenance and repairs, navigation charges, strategic delay, landing fees, catering	€/year	No Validation Target
		AUC4 Indirect operating costs for an airspace user	EUR / flight	Impact on operating costs that do not relate to a specific flight. Examples: parking charges, crew and cabin salary, handling prices at Base Stations	€/year	No Validation Target
		AUC5 Overhead costs for an airspace user	EUR / flight	Impact on overhead costs. Examples: dispatchers, training, IT infrastructure, sales.	€/year	No Validation Target

[1] For information, the mapping to the Performance Ambition KPAs (used in the ATM Master Plan) is available in the Appendix C

Performance Framework KPA[1]	Focus Area	KPI/PI from the Performance Framework	Unit	Metric for the CBA	Unit	Total benefits from IOC to 2043
Capacity	Airspace capacity	**CAP1** TMA throughput, in challenging airspace, per unit time	% and # movements	Tactical delay cost (avoided-; additional +)	€/year	No validation target
			% and # movements	Strategic delay cost (avoided-; additional +)	€/year	No Validation Target
		CAP2 En-route throughput, in challenging airspace, per unit time	% and # movements	Tactical delay cost (avoided-; additional +)	€/year	No Validation Target
			% and # movements	Strategic delay cost (avoided-; additional +)	€/year	No Validation Target
	Airport capacity	**CAP3** Peak Runway Throughput	% and # movements	Value of additional flights	€/year	No Validation Target
	Resilience	**RES4a** Minutes of delays	Minutes	Tactical delay cost (avoided-; additional +)	€/year	No Validation Target
		RES4b Cancellations	% and # movements	Cost of cancellations	€/year	No Validation Target
		Diversions	% and # movements	Cost of diversions	€/year	No Validation Target
Predictability and punctuality	Predictability	PRD1 Variance of Difference in actual & Flight Plan or RBT durations	Minutes^2	Strategic delay cost (avoided-; additional +)	€/year	No Validation Target
	Punctuality	**PUN1** % Departures < +/- 3 mins vs. schedule due to ATM causes	% (and # movements)	Tactical delay cost (avoided-; additional +)	€/year	No Validation Target

Performance Framework KPA[1]	Focus Area	KPI/PI from the Performance Framework	Unit	Metric for the CBA	Unit	Total benefits from IOC to 2043
Flexibility	ATM System & Airport ability to respond to changes in planned flights and mission	**FLX1** Average delay for scheduled civil/military flights with change request and non-scheduled / late flight plan request	Minutes	Tactical delay cost (avoided-; additional +)	€/year	No Validation Target
Environment	Time Efficiency	**FEFF3** Reduction in average flight duration	% and minutes	Strategic delay: airborne: direct cost to an airline <u>excl. Fuel</u> (avoided-; additional +)	€	€548m
	Fuel Efficiency	**FEFF1** Average fuel burn per flight	Kg fuel per movement	Fuel Costs	€	€933m
	Fuel Efficiency	**FEFF2** CO2 Emissions	Kg CO2 per movement	CO2 Costs	€	€66m
	Noise	**NOI2** Surface of these contours (Km2)	km^2 (per decibel band)	Cost of noise	€	€53m
	Noise	**NOI4** Number of people inside noise contours	People affected			
Civil-Military Cooperation & Coordination	Civil-Military Cooperation & Coordination	**CMC2.1a** Fuel saving (for GAT operations)	Kg fuel per movement	Fuel Costs	€/year	
		CMC2.1b Distance saving (for GAT operations)	NM per movement	Time Costs	€/year	

Table 14: Results of the benefits monetisation per KPA

5 Cost assessment

This section contains the cost assessment information for the stakeholders that need to deploy required enablers for PJ.02-W2-14.3. The optional enablers are not included in the cost assessment. The values included here were initially defined in Wave 1, by PJ.02-02, using a bottom-up approach to estimate the stakeholders' implementation and operating costs. The scope of each enabler was analysed, discussed, reviewed, and challenged within the CBA team as well as with other operational and technical experts. The values have subsequently been reviewed in Wave 2 leading to some updates.

As mentioned in section 3.2, the institutional enablers related to ISGS, REG-0530 and STD-113, are now linked to the system and human enablers, rather that appearing independently as they did when the PJ.02-02 CBA was produced. For the following cost assessment, it is assumed that:

- STD-113 "Update of EASA/ICAO regulatory frameworks for new visual ground aids (ISGS)" is a pre-requisite to the deployment of ISGS and the costs of updating the frameworks are not included.
- REG-0530 "Regulatory provisions for Increased Second Glide Slope operations (ISGS)" is an enabler that is addressed for each deployment with the relevant ANSP covering the costs of the activity to get advice from the regulatory authorities on the acceptability of the safety case supporting the ISGS related ATM rule modification.

5.1 ANSP costs

The ANSP stakeholder covers several different service provision aspects, for PJ.02-W2-14.3 this includes ATS provision at Aerodromes (Tower) and in Approach (terminal airspace, TMA). Within DS23 draft, some of the enablers are identified as applicable for Military ANSPs, however, due to the candidate airports included in the CBA the Military stakeholders are not included in the cost assessment for this solution[18].

5.1.1 ANSP cost approach

Costs were estimated based on expert judgement and are in line with other PJ.02 solutions considering an increased glide slope.

For ISGS operations a separation delivery tool was considered unnecessary since it is assumed that ISGS is operated only during off-peak periods, especially at night, and is addressing only noise issues and not airport capacity. Therefore, a procedural ISGS is considered for the purpose of this CBA.

What is needed is the information for the approach controller to know which aircraft are capable of flying the ISGS and to record which glide slope a flight has been assigned. The aerodrome (Tower) controller then needs to be provided with the information.

The cost impact of providing and capturing this information can differ depending on the system being used, for example, if the controllers are still using paper strips or have electronic strips.

5.1.2 ANSP cost assumptions

[18] Some enablers are also required or optional for other solutions in which the Military stakeholders may have a role.

Costs for this solution are mainly borne by the ANSPs to provide the relevant tools and functionalities in the approach and aerodrome systems. This assumes that costs for the controller systems used at the airports and their relevant maintenance are incurred by the ANSPs[19].

5.1.3 Number of deployment locations (units)

ISGS (without a separation delivery tool) is assumed to be implemented at all Very Large and Large airports for use during off peak periods, especially at night.

Table 15 shows the number of ANSP deployment locations included in the CBA Solution Scenario.

Airport (Aerodrome)				Approach Centre handling Terminal Airspace				En-route			
VL	L	M	S	VH	H	M	L	VH	H	M	L
32		0	0	25		0	0	Not applicable			

Table 15: Number of deployment locations – ANSPs

These values assume that the Very High and High complexity Approach Centres handling Terminal Airspace (either Terminal Airspace Only or En-route and Terminal Airspace) are those that handle the arrivals for the Very Large and Large airports.

5.1.4 Cost per unit

Table 16 shows the cost per enabler as well as the total cost per location. It is noted that some of the approach units may handle arrival traffic for several airports and so there may be fewer investments needed, however as a conservative approach, one investment per airport is maintained.

Enabler	Enabler Title	Implementation Costs (M€)	Operating costs (M€/year)
AERODROME-ATC-102 (R)	Aerodrome ATC system to support final approach operations (distinguish approach procedures)	0.20	-
APP ATC 170 (R)	Approach ATC system upgraded to support approach procedure assignment	0.20	-
HUM-32 (R)	ATC training for ISGS approach	1.00	-
REG-0530 (R)	Regulatory provisions for Increased Second Glide Slope (ISGS)	0.05	-

Table 16: ANSP Costs per Enabler

Note that the HUM-32 training costs are considered to include the initial training and were estimated using the PJ19.04 Training Cost Tool [20]. This is an overall cost for the CBA Solution Scenario and not a cost per deployment location.

The optional enablers listed in Table 17 are not monetised in the CBA as they are not required for the deployment of the procedural ISGS solution.

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[19] In reality the situation will differ across airports as some airports may own and maintain the systems.

Enabler ref.	Enabler definition	Applicable stakeholders
AERODROME-ATC-71 (O)	Aerodrome ATC System to support ISGS operations (separation delivery)	Air Navigation Service Provider - Civil ATS Aerodrome Service Provider - Military ATS Aerodrome Service Provider
APP ATC 114 (O)	Approach ATC System to support ISGS operations (separation delivery)	Air Navigation Service Provider - Civil ATS Approach Service Provider - Military ATS Approach Service Provider

Table 17: Optional ANSP Enablers for PJ.02-W2-14.3 – not included in the CBA

Table 18 shows the cost for an ANSP deploying the solution at an airport.

Cost category	Airport			
	VL	L	M	S
Pre-Implementation Costs	0.25 M€ per Aerodrome		No deployment considered at these locations	
Implementation costs	0.20 M€ per Approach Centre 1.00 M€ initial training costs			
Operating costs	No costs identified			

Table 18: Cost per Unit

5.2 Airport operator costs

The Airport operator enabler is identified within the DS23 draft as being applicable to both civil and military airports. Due to the candidate airports included in the CBA the Military airport operators are not applicable for this solution.

5.2.1 Airport operator cost approach

The cost data were provided during Wave 1 and revised during Wave 2 within the Solution team.

5.2.2 Airport operator cost assumptions

Airports will incur costs related to installing a PAPI for the increased second glide slope.

5.2.3 Number of deployment locations (units)

Table 19 shows the number of airports included in the CBA Solution Scenario where it is assumed that one additional PAPI will be deployed at each airport. However, if ISGS is deployed on more than one runway end then each one will need an additional PAPI.

The CBA considers that 32 airports from the Very Large and Large categories will deploy ISGS.

Airport			
VL	L	M	S
32		0	0

Table 19: Number of deployment locations - Airports

5.2.4 Cost per unit

Table 20 shows the cost per enabler as well as the total cost per location.

Enabler	Enabler Title	Development Costs (M€)	Operating costs (M€/year)
AIRPORT-53 (R)	PAPI for ISGS approach procedures	0.04	0.01
Total for AO-0320		**0.04**	**0.01**

Table 20: Airport Costs per Enabler

Table 21 shows cost for an Airport operator deploying the solution at a candidate airport.

Cost category	Airport			
	VL	L	M	S
Pre-Implementation Costs	0.04 M€ per airport		No deployment considered at these locations	
Implementation costs				
Operating costs	0.01 M€ per airport per year			

Table 21: Cost per Unit - Airport

5.3 Airspace User costs

Airspace Users have three enablers allocated for ISGS. However, none are included in the CBA for the following reasons.

- HUM-22 (R): Flight Crew new role for handling ISGS approach

  Pilot training needs for ISGS will vary depending on the location and the local characteristics of the procedure and traffic. Local operators may decide to implement a specific training or briefing for their pilots depending on the fleet of aircraft that they operate and their ability to fly ISGS. This local training and its associated cost will therefore vary according to the airports and the airlines and is considered to be very limited in terms of number of pilots flying on some aircraft types at specific locations. This cost item has not been included in the CBA.

The following two airborne enablers are not included in the CBA because they are optional. This implies that they will only be needed for certain aircraft and as described in the dataset “decisions on providing such systems are left to aircraft manufacturers who must decide on the significance of such assistance versus their products’ capacities (for instance deceleration capacity), operating methods (SOP application), etc.”.

- A/C-86 (O): On-board assistance to aircraft energy management

  This is an on-board system that provides energy management cues to the flight crew supporting them in managing appropriately the overall aircraft energy to succeed in reaching energy rendez-vous. The reference used is the stabilization gate, usually at 1000 ft above airport elevation.

- A/C-87 (O): On-board assistance to flare

  This is an on-board system that provides flare assistance information to the flight crew supporting them in landing appropriately.

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For both these airborne enablers it is mentioned that steeper operations (use of an increased glide slope) are a major driver for providing these kinds of assistance. It is highly recommended when the angle is above 3.5° and, in addition, these assistance systems may also support standard approaches.

There are no investments required at the Flight Operation Centres (FOC) (ground).

5.4 Cost Summary

This section provides a summary of how the data in the previous sections is used to feed the CBA model. The tables show the values that are used to produce the CBA results in section 7.

Investment Costs

	Cost per-unit		Deployment Locations		Cost
ANSP (Aerodrome)	0.25 M€	x	32	=	8.0 M€
ANSP (Approach)	0.20 M€	x	25	=	5.0 M€
ANSP Initial ISGS training	1.00 M€	x	1	=	1.0 M€
Airport Operator	0.04 M€ per airport	x	32	=	1.3 M€
				Total Investment Costs	**15.3 M€**

Table 22: Investment Cost Summary

Annual Operating Cost changes

	Annual costs		Deployment Locations		Cost
Airport Operator	0.01 M€ per airport	x	32	=	0.3 M€
				Annual Operating Cost Change	**0.3 M€**

Table 23: Operating Cost Summary

6 CBA Model

The model used to calculate the CBA results will be the Single Solution CBA model (s7.4.1) developed by PJ.19. This CBA Model has been developed in Excel and calculates the costs and benefits of the implementation of the ISGS Solution as described in the CBA Solution Scenario.

The CBA model uses the values from section 4:

- Scenario 1 uses the low benefit values
- Scenario 2 uses the high benefit values
- Scenario 3 uses the average benefit values and is used to produce the results in section 7.

The same cost data is used in the 3 scenarios.

s7.4.1-for-PJ02-W2-14.3_v0.2.xlsm

6.1 Data sources

Cost Inputs

Cost items reflect a combination of inputs from relevant partners in Wave 1 projects PJ.02-01 and PJ.02-02. Airport costs relating to the PAPI have been reviewed by experts in PJ.02-W2-14.3. No airborne costs are included.

Benefit Inputs

The main source for the benefit calculation inputs is a combination of Performance Assessment Results from the PJ.02-02 Wave 1 Performance Assessment Report (PAR) [17], as included in the PJ.02-W2-14.3 PAR [22] and separate calculations based on the noise calculation methods used in Wave 1. More information on the calculation of these benefits is available in the Benefit section.

Other Inputs Parameters

The data sources for the non-Solution specific CBA Model parameters are referenced in the various input sheets of the CBA Model with details provided in the sheet 'Source of Reference'. These are all part of the PJ.19.04 Common Assumptions [11].

7 CBA Results

The following section provides the results of the PJ.02-W2-14.3 V3 CBA that has assessed the deployment of ISGS (procedural) at 32 candidate airports that can realise the associated noise reduction benefits during off-peak periods and especially at night.

The CBA has been built on the following information:

- The Investments costs (pre-implementation and implementation costs) and Operating Costs have been identified for the main stakeholders impacted: ANSPs and Airport Operators.
- The impact of ISGS on the Capital Expenditures (CAPEX) (investments) has been analysed and only the costs on top of what could be expected in the CBA Reference Scenario have been estimated in the cost assessment and integrated in the CBA Model.
- Benefits (noise reduction as well as fuel and time efficiency) have been estimated and monetised in the CBA Model for Airspace Users (Scheduled Airlines and Business Aviation operating at the 32 candidate Very Large and Large airports during off-peak periods) and society, which refers to the communities living around the airports. See section 4 for more details.
- The noise reduction benefits from ISGS are considered to be attractive for all airports with high surrounding population density. However, this analysis has limited the scope and only assessed noise benefits for the 32 Very Large and Large candidate airports.

The PJ.02-W2-14.3 CBA results[1] shown here are visible in the CBA model (see section 6) by selecting Scenario 3.

The **Net Present Value (NPV)** is **509 M€**, this is discounted at 8% over the period 2022 to 2043. Table 25 shows the undiscounted values, which show that **without discounting the overall net benefits are 1580 M€.**

The discounted values are detailed in section 7.1.1 while the undiscounted values are detailed in section 7.1.2.

7.1.1 Discounted Values

This section provides the discounted CBA results. The values shown in table 14 below are discounted to account for the time value of money[2]. Undiscounted values are shown in the next section.

The Net Present Value (NPV) for PJ.02-W2-14.3 is **509 M€**. This is calculated with an 8% discount rate over the period 2022 to 2043.

The payback year is 2027, this is shown in Figure 6 where the discounted cumulative net benefits line crosses back over the x-axis, however, due to the high cumulative benefits compared to the low costs the crossing is not very clear in the figure and has been taken from the CBA model values.

Discounted 8% (M€)	Net Present Value	Capex	Opex	Benefits
ANSP	-8	-8	0	0

[1] Any differences in totals are due to rounding errors

[2] The time value of money reflects the idea that 1€ received today has more value than 1€ received in 2040 because it could be invested and earn interest over that period.

Discounted 8% (M€)	Net Present Value	Capex	Opex	Benefits
Airport operators	-2	-1	-2	0
Business Aviation	41	0	0	41
Scheduled Aviation	461	0	0	461
Societal Benefits	18	0	0	18
Overall	**509**	**-9**	**-2**	**520**

Table 24: PJ.02-W2-14.3 Discounted CBA results in M€ (per stakeholder and overall)

Based on the current assumptions and inputs, the expected benefits offset the overall costs.

The sensitivity analysis in section 8 will explore these results in more detail to see the impact on the NPV of changing some of the assumptions.

Figure 6 shows these discounted values on a year-by-year basis. The net benefits are the benefit value per year minus the cost value for that year; these are then shown cumulatively as a line in the figure.

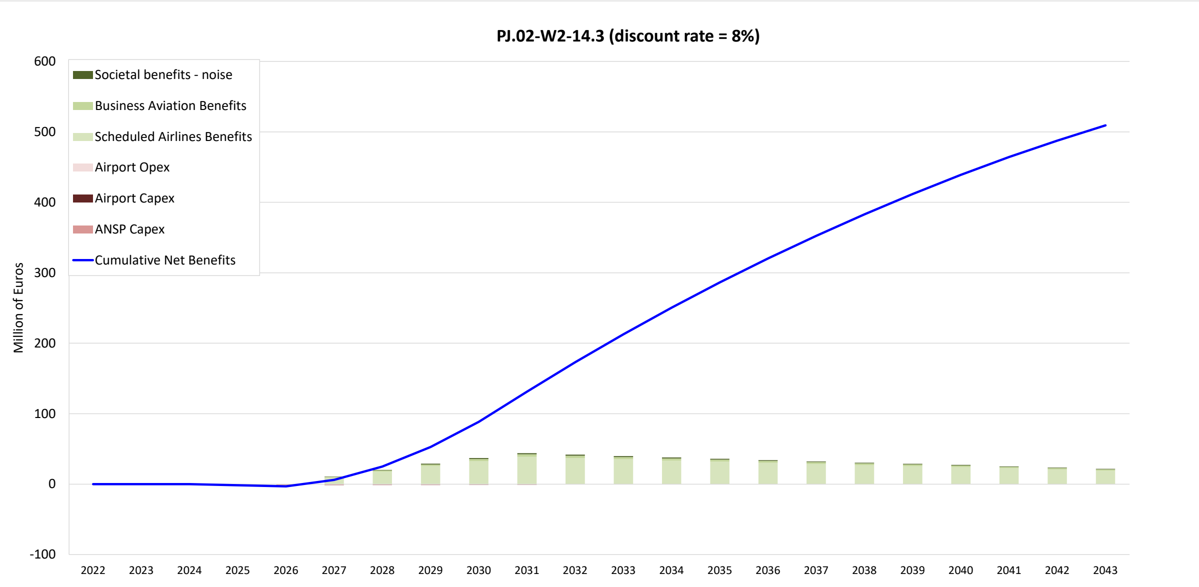

Figure 6: PJ.02-W2-14.3 Annual Investment Levels and Benefits (discounted)

Figure 7 shows the cost and benefit data without the cumulative net benefits line so that the scale of the costs and benefits per stakeholder are visible.

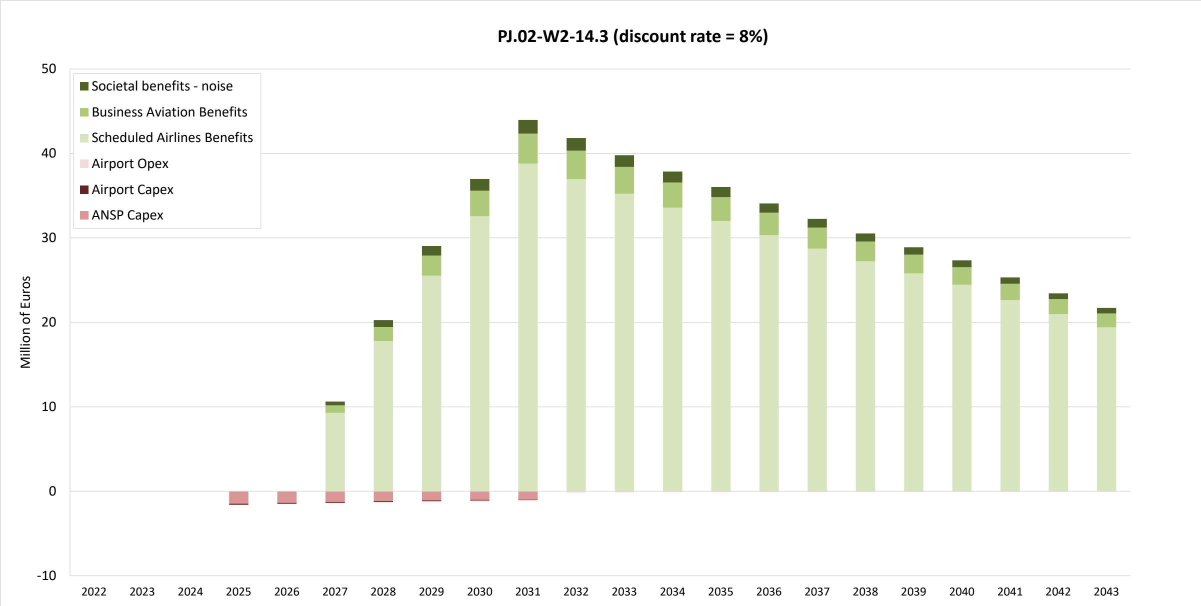

Figure 7: PJ.02-W2-14.3 Annual Investment Levels and Benefits expanded (discounted)

7.1.2 Undiscounted Values

The values shown in this section do not consider the time value of money, so one unit of currency spent or received in 2043 is considered to have the same value as one unit of currency spent or received today.

The table below contains the undiscounted values, which show that without discounting, i.e. doing the CBA calculation with a discount rate of 0%, the overall net benefits are **1580 M€**.

Undiscounted	Net Benefits	CAPEX	OPEX	Benefits
ANSP	-14	-14	0	0
Airport operators	-6	-1	-5	0
Business Aviation	125	0	0	125
Scheduled Aviation	1422	0	0	1422
Societal Benefits	53	0	0	53
Overall	**1580**	**-15**	**-5**	**1600**

Table 25: PJ.02-W2-14.3 Undiscounted CBA results (per stakeholder and overall)

Figure 8 shows the undiscounted costs and benefits over each year.

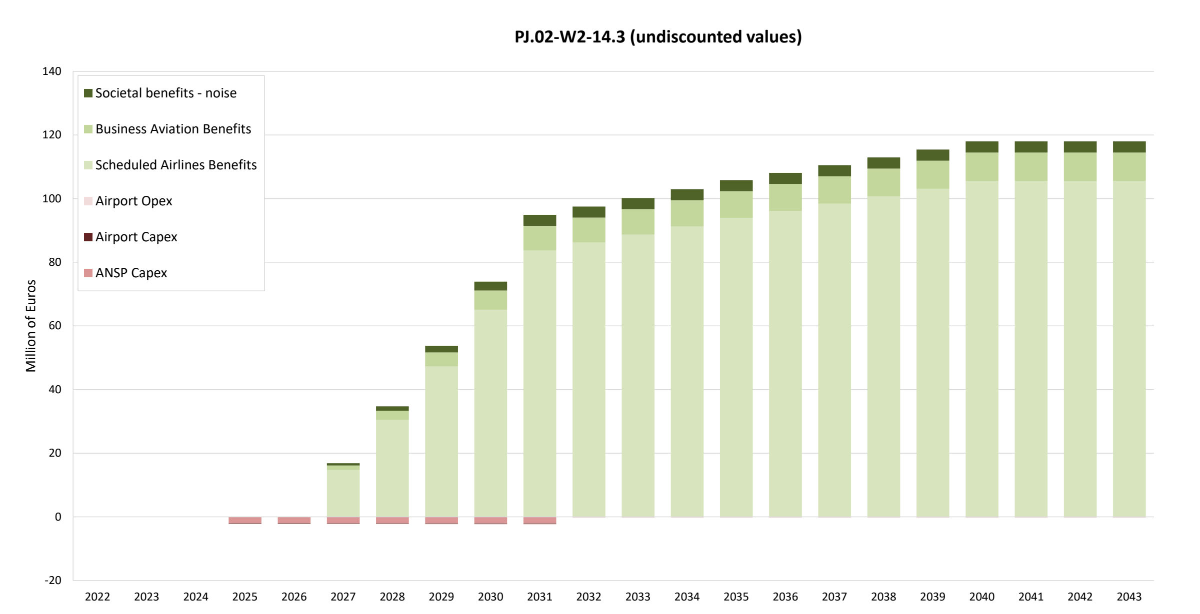

Figure 8: PJ.02-W2-14.3 Annual Investment Levels and Benefits (undiscounted)

The undiscounted values are useful, especially for the costs, as they provide an idea of the overall investments that will be required. For example, based on these results, the stakeholders will need to invest **15 M€** (CAPEX) to deploy this Solution over the deployment period. The **9 M€** discounted CAPEX value, Table 24, simply reflects the present value of those investments in 2022.

8 Sensitivity analysis

This section[3] provides data on how sensitive the CBA results are to changes in the inputs values. When making investments it is useful to know which values can have the most impact on the results to help focus further work on refining data and assumptions.

8.1 Discount Rate

The discount rate is used to reflect the time value of money[4] so reducing the discount rate reduces the difference between the value of money today and its value in the future. There is often much discussion on which discount rate to use so it is useful to look at a range of values. In this case, doubling the discount rate still provides a positive Net Present Value.

Figure 9 shows that using a lower discount rate increases the NPV.

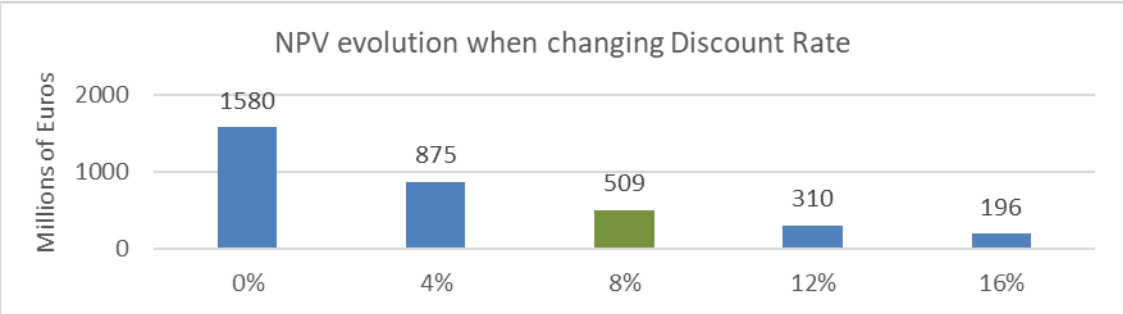

Figure 9: Sensitivity Analysis – Discount Rate

8.2 Sensitivity Comparison

Figure 10 shows the tornado diagram produced when the different cost and benefit inputs were each varied by -10% to +10%. The input values which produce the larger changes in the NPV are candidates for further investigation as they have the most potential to negatively impact the NPV.

The figure shows that the inputs **Fuel Efficiency** and **Time Efficiency** have the largest impact on the NPV, while the costs Ground Capex (ANSP and Airport) and Ground Opex (Airport) have lowest impact on the CBA results.

For Fuel Efficiency, the tornado diagram shows that a 10% reduction in fuel burn benefits would result in just over a 6% reduction in the Net Present Value. The CBA is considered to be very sensitive to an input value if the impact on the NPV is higher than the change in the input value, e.g. a 10% change in the input value resulted in a 15% change in the NPV.

[3] Risk Analysis has not been performed for this CBA as the Excel CBA model is not designed to apply Monte Carlo simulation techniques which are needed to calculate the NPV results for thousands of scenarios where different combinations of the input values (taken from probability distributions) are used in each.

[4] The time value of money reflects the idea that 1€ received today has more value than 1€ received in 2040 because it could be invested an earn interest over that period.

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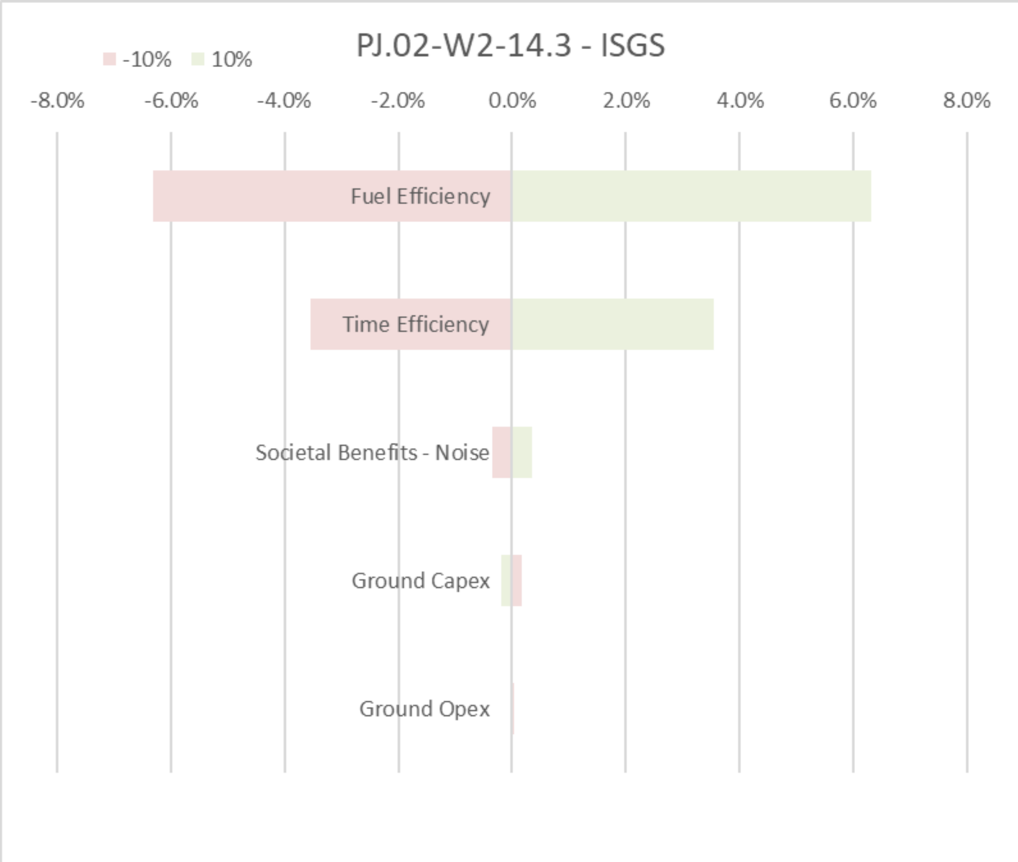

Figure 10: Tornado diagram

8.3 Sensitivity Scenario

This section provides the Net Present Value when the cost inputs are doubled at the same time as the benefit inputs are set to their low values, see section 4. This can be considered as a pessimistic view.

The CBA input values are shown below.

8.3.1 Costs double

Investment Costs

	Cost per-unit		Deployment Locations		Cost
ANSP (Aerodrome)	0.50 M€	x	32	=	16.0 M€
ANSP (Approach)	0.40 M€	x	25	=	10.0 M€
ANSP Initial ISGS training	2.00 M€	x	1	=	2.0 M€
Airport Operator	0.08 M€ per airport	x	32	=	2.6 M€
				Total Investment Costs	**30.6 M€**

Table 26: Investment Cost Summary

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Annual Operating Cost changes

	Annual costs		Deployment Locations		Cost
Airport Operator	0.02 M€ per airport	x	32	=	0.6 M€
				Annual Operating Cost Change	**0.6 M€**

Table 27: Operating Cost Summary

8.3.2 Benefits set to low values

The benefits are set to the low values from Table 8 in section 4. This means:

- Noise benefits (societal benefits) – no reduction in noise contours so no monetised noise benefits
- Fuel efficiency becomes $-7.99 \text{ kg per arrival} \cdot 15\% = -1.20 \text{ kg per flight}$
- Time Efficiency becomes $-0.22 \text{ minutes per arrival} \cdot 15\% = -0.03 \text{ minutes per flight}$

8.3.3 Pessimistic Scenario CBA Results

Table 28 shows that even in the pessimistic situation where the costs doubled and the benefits are set to their low values, the NPV was still positive, although much lower, at 133 M€.

Discounted 8%	Net Present Value	Capex	Opex	Benefits
ANSP	-17	-17	0	0
Airport operators	-5	-2	-3	0
Business Aviation	15	0	0	15
Scheduled Aviation	140	0	0	140
Societal Benefits	0	0	0	0
Overall	**133**	**-18**	**-3**	**155**

Table 28: PJ.02-W2-14.3 Pessimistic Scenario - Discounted CBA results (per stakeholder and overall)

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9 Recommendations and next steps

In summary, the PJ.02-W2-14.3 V3 CBA results are positive with a Net Present Value (NPV) of **509 M€** reflecting that the benefits from deploying this Solution at 32 candidate airports are expected to exceed the costs of deploying and operating it.

Confidence in the fuel and time efficiency benefits is medium as they are based on Fast Time Simulation results. Confidence in the noise results is low to medium as they generalise the benefits calculated from the noise simulations produced in the Wave 1 Solution PJ.02-02 'Enhanced Arrival Procedures'.

The NPV has been calculated with an 8% discount rate over the period 2022 to 2043, with PJ.02-W2-14.3 being deployed between 2025 and 2030 and with benefits starting to be realised from late 2026. The payback year is 2027, which reflects when the cumulative net benefits will exceed the costs.

These values are underpinned by the assumptions that the required "updates to EASA/ICAO regulatory frameworks for new visual ground aids (ISGS)" and "Regulatory provisions for Increased Second Glide Slope operations (ISGS)" occur in the planned timeframes.

The sensitivity analysis shows that even if the costs doubled and the benefits are set to their low values, the deployment, as described in the CBA Solution Scenario, would still have a positive NPV of 133 M€.

The validation activities have shown that the Solution works and will bring benefits when deployed at airports with operational needs to reduce the impact of noise on the local inhabitants during off-peak periods, especially at night.

Airport specificities will impact the scale of the benefits. These include, but are not limited to, traffic mix, operating mode (mixed/segregated) population density under the final approach and the number of runways where ISGS will be deployed. The main recommendation is therefore, that airports considering the deployment of this Solution to address their operational needs, should review the content of this CBA and develop their own CBA based on their specific infrastructure, operations, layout, etc. to assess the scale of their potential benefits. They should also review related solutions, such as PJ.02-W2-14.2 Second Runway Aiming Point and PJ.02-W2-14.5 Increased Glide Slope to Second Runway Aiming Point, which can also offer capacity benefits during peak hours, to ensure they deploy the most appropriate solution for their needs.

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10 References and Applicable Documents

10.1 Applicable Documents

[1] SESAR 2020 Project Handbook, edition 02.02.00, 08 June 2020

[2] SESAR Cost-Benefit Analysis Model[24] (Single Solution Wave 2)

[3] EUROCONTROL, Standard Inputs for EUROCONTROL Economic Analyses, Edition 9, December 2020

[4] SESAR 16.06.06-D26_03, Methods to Assess Costs and Monetise Benefits for CBAs, Ed. 00.02.02

[5] EUROCONTROL, Method to assess cost of European ATM improvements and technologies, v1.0, 28 July 2014

[6] SESAR 16.06.06-D26_08, ATM CBA Quality checklist, Edition 02.00.01

[7] SESAR 16.06.06-D26_04, Guidelines for Producing Benefit and Impact Mechanisms, Ed. 03.00.01

[8] European ATM Master Plan Portal 2019, https://www.atmmasterplan.eu/

[9] SESAR 16.06.06-D51 SESAR 1 Business Case 2016, Edition 00.01.01, 13 July 2016

10.2 Reference Documents

[10] SESAR 2020 W1, PJ20 Classification of APTs (Airport OE_October 2019 Version (1_0).xlsx)

[11] SESAR 2020 W2, PJ19, D4.0.30 S2020 Common Assumptions (2019), Edition 00.00.02

[12] SESAR 2020 W2, D4.7, PJ19.04: Performance Framework (2019), Edition 01.00.01, 30 November 2019

[13] SESAR 2020 W2, D4.0.1, PJ19-W2: Validation Targets – SESAR 2020 Wave 2 & Wave 3, Edition 00.01.00, 04 May 2021

[14] SESAR 1, P06.08.08 D07 Enhanced Arrival Procedures enabled by GBAS – OSED Consolidation, Edition 00.01.01

[15] SESAR 1, P06.08.05 D04 – Operational Service and Environment Definition (OSED) Displaced Thresholds, 00.02.00

[16] SESAR 2020 W1, D2.1.048, PJ.02-02 VALR (V3), Edition 00.01.00, 04 March 2020

[17] SESAR 2020 W1, D2.1.013, OSED-SPR-Interop Part V Performance Assessment Report, Edition 00.00.04, 04 March 2020

[18] SESAR 2020 W1, D2.1.05, PJ.02-02 CBA (V3), Edition 00.01.00, 25 March 2020

[19] CE Delft (on behalf of European Commission)- Handbook on the External Costs of Transport – Version 2019

[20] SESAR1 Training Cost assessment framework and database, Edition 2, 2019

[21] SESAR 2020, PJ.02-W2-14.3, D4.3.002, SPR-INTEROP/OSED - Part I final, Edition 00.01.00, 20 September 2022

[22] SESAR 2020 PJ.02-W2-14.3, D4.3.002, SPR-INTEROP/OSED V3 - Part V - Final, Performance Assessment Report Deliverable, Edition 00.01.00, 05 August 2022

[24] This reference is no more accessible from Programme library but it is now available in ATM Performance Assessment Community of Practice.

Appendix A Description of the Enhanced Arrival Procedures

Description of ISGS (AO-0320)

ISGS concept consists in mixing aircraft flying the final segment following an ILS conventional slope (usually 3°) with aircraft following another higher final segment, with a limitation at 4.49°, and landing on the same threshold.

Having two arrival slopes active at the same time, it can be envisaged to have one or two interception altitudes, according to each local case. The figures below show the two cases.

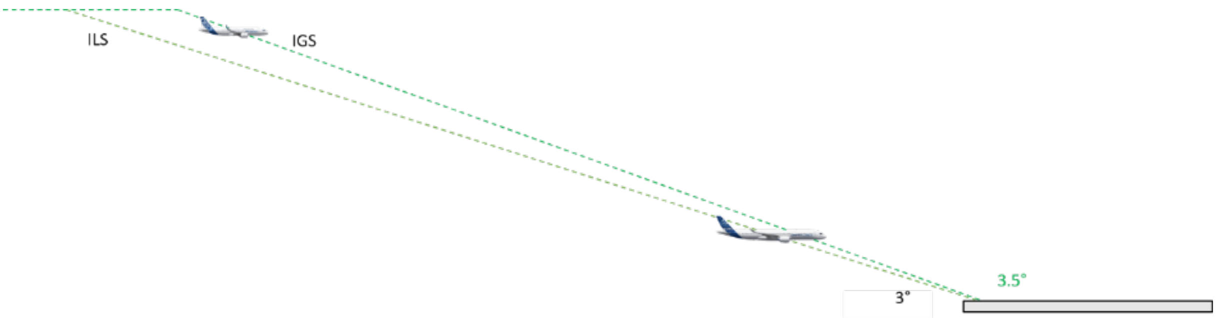

Figure 11: ISGS procedure with one interception altitude

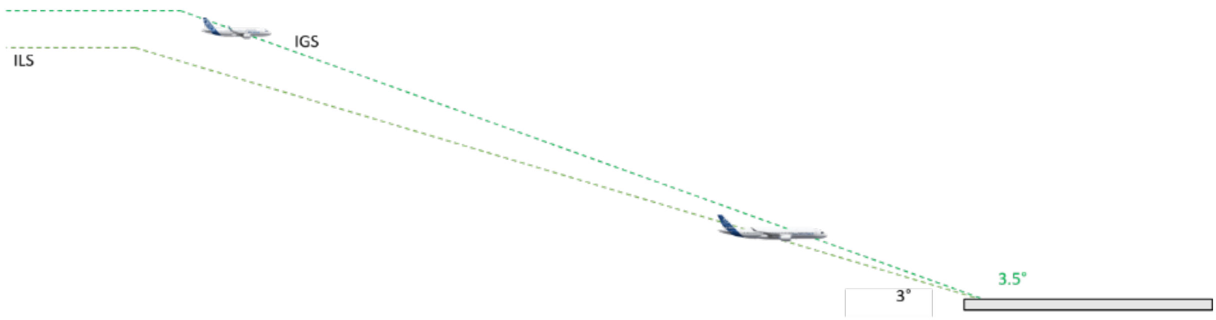

Figure 12: ISGS procedure with two interception altitudes

Appendix B Discount rate

This note explains the choice of 8% for the discount rate in the SESAR CBAs.

The discount rate is used to reflect the Time Value of Money (i.e. money received today has more value than money that will be received in 10 years because money received today can be invested to get some income.)

The discount rate used to calculate the Net Present Value (NPV) can be interpreted as the interest on invested money (from a project or a savings account) or as the interest charged on borrowing money (to fund an investment).

The 8% discount rate used in the SESAR CBA model to calculate the NPV reflects the higher end of the range of Cost of Capital values faced by the partners involved in PJ.20 sWP2.6 (Business Cases) to acquire the funds necessary to invest. This value is used by some partners in their local CBAs.

If a Solution has a positive NPV at 8% then it will be more positive at lower discount rates. However, a positive NPV with a lower rate, e.g. 4%, may be negative at an 8% discount rate. Therefore 8% is a conservative value, which can also be considered to include a risk premium to cover the uncertainties associated with such broad CBAs. The undiscounted values (i.e. a discount rate of 0%) are also provided to allow a comparison.

In addition, the SESAR CBAs do not consider inflation (i.e. the discount rate is the real rate and not the nominal rate). This is because it would be necessary to make many assumptions about how inflation rates evolve over the CBA period and how they would differ in the different states and how they would apply to the costs and benefits in each state.

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Appendix C Mapping ATM Master Plan Performance Ambition KPAs and SESAR 2020 Performance Framework KPAs

Mapping between ATM Master Plan Performance Ambition KPAs and SESAR 2020 Performance Framework KPAs, Focus Areas and KPIs

ATM Master Plan SESAR Performance Ambition KPA	ATM Master Plan SESAR Performance Ambition KPI	Performance Framework KPA	Focus Area	#KPI / (#PI) / <Design goal>	KPI definition
Cost efficiency	PA1 - 30-40% reduction in ANS costs per flight	Cost efficiency	ANS Cost efficiency	CEF2	Flights per ATCO hour on duty
				CEF3	Technology Cost per flight
Capacity	PA7 - System able to handle 80-100% more traffic	Capacity	Airspace capacity	CAP1	TMA throughput, in challenging airspace, per unit time
				CAP2	En-route throughput, in challenging airspace, per unit time
	PA6 - 5-10% additional flights at congested airports		Airport capacity	CAP3	Peak Runway Throughput (Mixed Mode)
			Capacity resilience	<RES1>	% Loss of airport capacity avoided
				<RES2>	% Loss of airspace capacity avoided
	PA4 - 10-30% reduction in departure delays	Predictability and punctuality	Departure punctuality	PUN1	% of Flights departing (Actual Off-Block Time) within +/- 3 minutes of Scheduled Off-Block Time after accounting for ATM and weather related delay causes
Operational Efficiency	PA5 - Arrival predictability: 2 minute time window for 70% of flights actually arriving at gate		Variance of actual and reference business trajectories	PRD1	Variance of differences between actual and flight plan or Reference Business Trajectory (RBT) durations

ATM Master Plan SESAR Performance Ambition KPA	ATM Master Plan SESAR Performance Ambition KPI	Performance Framework KPA	Focus Area	#KPI / (#PI) / <Design goal>	KPI definition
	PA2 - 3-6% reduction in flight time	Environment	Fuel efficiency	(FEFF3)	Reduction in average flight duration
	PA3 - 5-10% reduction in fuel burn			FEFF1	Average fuel burn per flight
Environment	PA8 - 5-10% reduction in CO2 emissions			(FEFF2)	CO2 Emissions
Safety	PA9 - Safety improvement by a factor 3-4	Safety	Accidents/incidents with ATM contribution	<SAF1> see section 3.4	Total number of fatal accidents and incidents
Security	PA10 - No increase in ATM related security incidents resulting in traffic disruptions	Security	Self- Protection of the ATM System / Collaborative Support	(SEC1)	Personnel (safety) risk after mitigation
				(SEC2)	Capacity risk after mitigation
				(SEC3)	Economic risk after mitigation
				(SEC4)	Military mission effectiveness risk after mitigation

Table 29: Mapping between ATM Master Plan Performance Ambition KPAs and SESAR 2020 Performance Framework KPAs, Focus Areas and KPIs

EUROCONTROL