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SESAR SOLUTION 25.1 : COST BENEFIT ANALYSIS (CBA) - FINAL FOR V3

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PJ.02-W2 AART

SAFETY SUPPORT TOOLS FOR AVOIDING RUNWAY EXCURSIONS

This CBA V3 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) for Solution PJ.02-W2-25. "Enhanced runway condition awareness for runway excursion prevention", which aims for V3 target maturity level (S2020 wave 2).

The CBA forms part of the PJ.02-W2-25.1 V3 Data Pack and it's developed to:

- Identify and agree on the main elements and assumptions that will support the development of a CBA Model;
- Identify impacted stakeholders' groups and propose options in terms of possible deployment scenario options;
- Provide an initial estimation of the potential costs and benefits of the solution.

This document along with the attached CBA Model spreadsheet (Excel file embedded in Section 6) provides the Cost Benefit Analysis (CBA).

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1 Executive Summary

This document provides the Cost Benefit Analysis (CBA) related to a SESAR Solution PJ.02-W2-25.1 that has been validated during validation activities at a V3 level and forms part of the data pack supporting the V3 maturity gate session. Its objective is to provide information on the costs and benefits of deploying Solution PJ.02-W2-25.1 in an ECAC-level CBA Scenario which would support the decision of proceeding with the Solution to V3 phase.

Solution PJ.02-W2-25.1 “Enhanced runway condition awareness for runway excursion prevention“ addresses a safety issue, which is the risk of runway excursions during take-off and landing. Runway-Taxiway excursions are the most frequent type of accident (25% of all accidents over the 2015-2019 period according to 2019 IATA Safety Report[12]).

A runway excursion is defined as “an event in which an aircraft veers off or overruns the runway surface during either take-off or landing”. The risk of a runway excursion is increased by wet and contaminated runways, in combination with gusts or strong cross or tailwinds.

The most straightforward way to prevent such events is to give to Flight Crews clear and objective information for them to make the right decisions in the preparation and execution of take-off, approach, and landing phases. While the main focus of services provided by solution PJ.02-W2-25.1 is to prevent overruns, caused by the wrong estimation of runway surface condition, it may also contribute to the prevention of other types of excursions by increasing the awareness of all involved actors.

The solution is compatible with the GRF which uses the Runway Condition Assessment Matrix (RCAM) and resulting Runway Condition Code (RWYCC) as a mean to uniformly communicate the runway condition to all stakeholders. Solution PJ.02-W2-25.1 is built of two cooperating systems that together aim to provide continuous awareness of the Current RWYCC:

- RCAMS is a ground-based system operated by the Airport Operator. It performs a continuous assessment of current runway surface condition based on various inputs. Under Airport Operator control, it disseminates this information to other stakeholders.
- OBACS is an airborne system generating reports of runway surface condition as sensed by the braking aircraft. The reports are in line with GRF.

The benefits of this Solution are primarily in terms of Safety but also in terms of Resilience to adverse weather conditions, through a better management of runway inspections, potentially less flights diversions due to bad runway conditions and optimised decontamination operations.

The Solution has been validated at V3 maturity level through validation exercises, and a series of workshops gathering experts and end users. The results of validation exercises have been aggregated in the Performance Assessment Report and thereafter monetised in the CBA to provide monetary values of the benefits which Solution is expected to produce. In parallel, a cost assessment has been performed. Both costs and benefits have then been confronted at Solution level in one NPV per a design option. By definition, the CBA focuses on deployment of the Solution and is not limited to the scope of the validation activities.

2 Introduction

2.1 Purpose of the document

This document provides the Cost Benefit Analysis (CBA) related to a SESAR Solution PJ.02-W2-25.1 which has been validated to V3 level. It presents a high-level view on the costs and benefits of deploying Solution PJ.02-W2-25.1 at relevant locations across ECAC.

2.2 Scope

The CBA integrates costs and benefits brought by both the ground aspects and the airborne aspects of the Solution.

This V3 CBA covers one Operational Improvement (OI) Steps included in the Solution PJ.02-W2-25.1, as listed in section 3.2:

- AO-0216: "Enhanced Runway Condition Awareness".

The Solution and Reference Scenarios consider a 21 years period of time for the analysis of all potential costs and benefits, from 2022 to 2043.

The geographical scope of the PJ.02-W2-25.1 CBA covers the European Civil Aviation Conference (ECAC) countries.

The solution is designed to be implementable in all airport operating environments regardless of their complexity and layout.

2.3 Intended readership

This V3 CBA is written to provide useful information to the following audience:

- SESAR JOINT UNDERTAKING (SJU) as SESAR 2020 Programme coordinator.
- Project PJ.02-W2 AART (other Work Areas and Project Content Integration Team) to ensure consistency,
- Project PJ.04-W2 TAM (Total Airport Management), as PJ.02-W2-25.1 developments can be interesting for this project
- PJ19 W2 CI (Content Integration) responsible for managing the content integration process to ensure the needed coherency (in terms of operational concept, architecture) between the different SESAR 2020 projects. Project PJ.19-04, who provide CBA guidance and are also involved in assessing Solution CBAs against the Maturity Assessment Criteria.
- Project PJ.20 W2 AMPLE (Master Planning) responsible for ATM Master Plan maintenance.

- International Organizations (Standard setting Bodies, International Airport Associations, ICAO, etc.) can be interested in the standardization of functionalities and services specified in this document, and therefore plan to define specifications which could become industry standards.

2.4 Structure of the document

The structure of this CBA is as follows:

- Section 2 (the present section) provides general information on the document.
- Section 3 describes the scope and objectives of the CBA.
- Sections 4 and 5 detail, respectively, the benefits and the costs.
- Sections 6, 7 and 8 detail, respectively, the CBA model, the CBA results and sensitivity analysis.
- Section 9 provides recommendations and next steps for the deployment.

2.5 Background

The subject has already been studied by EUROCONTROL and the FAA, and is supported by the following initiatives:

- European Action Plan for the Prevention of Runway Excursions (EAPPRE) - Edition 1.0 - EUROCONTROL - January 2013 [17]
- A Study of Runway Excursions from an European Perspective, EUROCONTROL – March 2010 [18]
- Take Off and Landing Performance Assessment (TALPA) Initiative by the FAA [19]
- Numerous Safety Enhancements (SEs) have been assessed by the Commercial Aviation Safety Team (CAST) to mitigate the risks of runway excursions. It includes Safety Enhancement SE222 Airplane-Based Runway Friction Measurement and Reporting. [20]

Moreover, the baseline from which this document has been written consists of:

- SESAR Wave 1 PJ.03b-06 delivered FINAL CBA: SESAR Solution PJ.03b-06 CBA for V2 [D5.2.110]

2.6 Glossary of terms

Term	Definition	Source of the definition
Net Present Value	Net Present Value (NPV) is the sum of all discounted cash inflows and outflows during the time horizon period.	*Investopedia*
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.	*SESAR 1*
Business Case	A Business Case 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 1*
Time Horizon	Time horizon refers to a definite time period during which all cost and benefits related to a given project occur.	*SESAR 1 - ATM CBA for Beginners*
Stakeholder	Stakeholders are organizations and entities who will have to pay for or will be impacted by the project directly or indirectly.	*SESAR 1 - ATM CBA for Beginners*
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 1 - ATM CBA for Beginners*
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 1 - ATM CBA for Beginners*
Benefit mechanisms	Benefit mechanisms are a cause effect description of the improvement proposed by the project. They show how benefits are delivered.	*SESAR 1 - ATM CBA for Beginners*
Benefit	Benefit is a positive impact of monetary value to stakeholders.	*SESAR 1 - ATM CBA for Beginners*

Table 1: Glossary of terms

2.7 List of Acronyms

Acronym	Definition
ANSP	Air Navigation Service Provider
AO	Airport
ATM	Air Traffic Management
ATCO	Air Traffic Control Officer
AU	Airspace User
BIM	Benefit and Impact Mechanism
CBA	Cost Benefit Analysis
ECAC	European Civil Aviation Conference
EU	European Union
FOC	Final Operating Capability
GRF	Global Reporting Format
IOC	Initial Operating Capability
HC	High complexity (airport)
LC	Low complexity (airport)
KPA	Key Performance Area
KPI	Key Performance Indicator
N/A	Not Applicable
NPV	Net Present Value
OBACS	On-board Braking Action Computation System
OE	Operating Environment
OI	Operational Improvement
OSED	Operational Service and Environment Definition
PAR	Performance Assessment Report
PI	Performance Indicator
PIRM	Programme Information Reference Model
PJ	Project
RCAMS	Runway Condition Assessment Matrix System
RWY	Runway
SESAR	Single European Sky ATM Research Programme
SJU	SESAR Joint Undertaking (Agency of the European Commission)
VALP	Validation Plan

VALR	Validation Report

Table 2: List of acronyms

3 Objectives and scope of the CBA

3.1 Problem addressed by the solution

Runway excursions remain one of the top challenges to Aviation, with serious impacts in terms of Safety and cost.

A runway excursion is defined as an event in which an aircraft veers off or overruns the runway surface during either take-off or landing (ICAO - ADREP taxonomy). Runway-Taxiway excursions are the most frequent type of accident (26% of all accidents (70 accidents over 266) during the 2016-2020 period according to 2020 IATA Safety Report [13]).

The runway/taxiway excursion trend rate has stagnated over the past five years. The runway excursion accidents has typically a low likelihood of fatality due to overrun safety areas and clear areas surrounding most runways.

Contaminated runways – poor braking actions are considered as a significant threat for runway excursion (contribution percentage of 37%) according to IATA Safety report. A threat is an event or error that occurs outside the influence of the flight crew, but which requires flight crew attention and management to properly maintain safety margins.

Most of the accidents from this year featured adverse weather reports of rain or snow and gusting winds. Aside from the effects of rain or snow on visibility, runway contamination continues to represent a major risk for runway excursions.

3.2 SESAR Solution description

The Solution PJ02-W2-25.1 focuses on mitigating the risk of runway excursions by providing the flight crew with more accurate and harmonised information about the runway condition to plan and execute take-off and landing.

Runway friction is important to both aircraft deceleration and lateral control; as such, timely, accurate and practical reporting for pilot assessment and decision-making is crucial.

Thus, the primary opportunity to prevent runway excursions is to give to flight crew objective and consolidated information elements to make the right decisions when preparing and executing take-off, approach, and landing manoeuvres.

The performance assessment results have confirmed that the solution concept is feasible and have validated it to V3 maturity level. However, due to the safety-focused nature of the Solution, it was not possible to directly measure monetizable benefits during the validation exercises.

PJ.02-W2-25.1 Solution can be deployed as a standalone solution, independently from any other S2020 solutions as there are no interdependencies with other S2020 Solutions considered in the analysis.

The expected benefits are the costs that were avoided because the Solution provided relevant information, which avoided the occurrence of the hazardous situation – runway excursion. The benefits are received by Airspace Users and Airport Operators and are the avoided costs that would have been incurred if a hazardous situation had occurred such as costs of blocked taxiway or closed runway and aircraft's incident/accident costs. The stakeholders who need to invest are Airport Operators and Airspace Users.

Runway Condition Awareness and Monitoring System (RCAMS) supports airport duty officers in facilitating the continuous runway condition awareness. Built-in runway sensors and a dedicated runway condition model are the core elements of this system. RCAMS is delivering a dedicated interface for duty officers equipped with both appropriate alerts and assistance in rapid Runway Condition Report (RCR) dissemination to critical stakeholders (e.g. Control Tower). RCAMS is fully compatible with the Global Reporting Format (GRF) introduced by ICAO.

The ground-based system can be supported by an On-board Braking Action Computation System (OBACS) which estimates the runway condition during the landing roll. The resulting measurements are pushed automatically to RCAMS interface allowing for subsequent duty officer alerting if needed. OBACS output can also be used independently by the flight crew for PIREP (Pilot Report) assistance.

This solution is targeting all airport operating environments and is expected to reduce the probability of runway excursion occurrence

PJ.02-W2-25.1 Solution OIs and Enablers:

SESAR Solution ID	OI Steps ref. (coming from the Integrated Roadmap)	OI Steps definition (coming from the Integrated Roadmap)	OI step coverage	Source reference
PJ02-W2-25.1	AO-0216	Enhanced Runway Condition Awareness	FULL	**No dependency**

Table 3: SESAR Solution PJ02-W2-25.1 Scope and related OI steps

OI Steps ref.	Enabler[1] ref.	Enabler definition	Enabler coverage	Applicable stakeholder	Source reference
AO-0216 — Enhanced Runway Condition Awareness	AIRPORT-57	Runway condition awareness management system based on manual assessment, weather information and runway sensors + PIREP + machine-learning based RWY condition model and predictions	Required	Airport Operators	Enabler only associated with this Solution No dependency
	AIRPORT-59	RCAMS system function to integrate aircraft observed runway braking action into runway condition information	Optional	Airport Operators	Enabler is synchronised with A/C-64
	A/C-64	Data transmission means supporting downlinked observed runway surface condition (aircraft side)	Optional	Airspace Users	Enabler is synchronised with AIRPORT-59
	A/C-84a & b	Braking action computation function in on-	Optional	Airspace Users	

[1] This includes System, Procedural, Human, Standardisation and Regulation Enablers

	board braking action computation system (OBACS)			
SVC-061	Runway condition report service	Optional	Airport Operators	
SVC-071	Runway Braking Action Service	Optional	Airspace Users	

Table 4: OI steps and related Enablers

3.3 Objectives of the CBA

The objective of the V3 CBA is to provide information on the costs and benefits of deploying Solution PJ.02-W2-25.1 in an ECAC-level CBA Scenario and explore different architectures or different deployment scenarios in each operating environment to identify the most efficient ones. The CBA results are calculated using high-level cost values and an initial approach to quantify the safety benefits. This assessment will help build the 'big picture' of whether the Solution is worth deploying. While the views of individual stakeholders involved in the deployment are considered, this CBA task does not provide CBA results for specific local deployments. However, the output already includes a first order of magnitude of benefits and net present value (NPV) of the different options being compared.

Please note that as the safety monetisation approach is new in SESAR 2020 the calculations used here are not prescribed by PJ.19-04. Nevertheless, same safety monetisation approach has been used in EASA NPA 2018-12. This NPA proposes to require the installation of a runway overrun awareness and alerting system on new large aeroplane designs (CS-25), and on certain new large aeroplanes operated in commercial air transportation (CAT), and manufactured after a predetermined date (Part-26/CS-26).

Stakeholders identification

The following table lists the stakeholders considered in the CBA along with an overview of whether they will have costs (i.e. are required to invest) to deploy the Solution and whether they will receive any benefits. It also mentions if the stakeholder was involved in the CBA production and whether they have CBA results in Section 7.

Sources used to identify the stakeholders were the:

- Benefit and Impact Mechanisms (from the OSED Appendix)
- List of stakeholders assigned to each Enabler in the EATMA Draft Dataset 19

Stakeholder	The type of stakeholder and/or applicable sub-OE	Type of Impact	Involvement in the analysis	Quantitative results available in the current CBA version
Airport Operators	Deploying airports	Invest, operate, enjoy benefits	Involved in CBA and in the validation	Costs and benefits available
Airspace Users (Airlines)	Commercial & business airlines operating at deploying airports	Invest, operate, enjoy benefits	Not involved	*Costs and benefits available*
Airspace Users (Pilots)	Airspace Users (pilots from Commercial & business airlines) operating at deploying airports	Enjoy benefits	Not involved	*No quantifiable results available*
Aircraft Manufacturer	Commercial & business aircraft manufacturers	Develop	Provided inputs, reviewed results	No quantifiable results available

Table 5: SESAR Solution PJ.02-W2-25.1 CBA Stakeholders and impacts

3.5 CBA Scenarios and Assumptions

3.5.1 Reference Scenario

The reference scenario considers current situation where only GRF manual procedures applies.

The GRF comprises an evaluation of a runway by human observation (normally done by airport operations staff) and, using a runway condition matrix, the consequent assignment of a Runway Condition Code (RWYCC). This code is complemented by a description of the surface contaminant based upon its type, depth and coverage for each third of the runway.

The outcome of the evaluation and associated RWYCC are then used to complete a standard report, the Runway Condition Report (RCR), which is forwarded to air traffic services and the aeronautical information services for dissemination to pilots

The reference scenario also considers the deployment of ROAAS on new aircraft deliveries from 2026 as per plan established in EASA NPA 2018-12. Forecast of accidents and accidents avoided over 20-years period thanks to ROAAS deployment were estimated.

3.5.2 Solution Scenario

The Solution Scenarios consider the future situation with the deployment of the Solution. It is proposed to only focus on two configurations and several scenarios of deployment to establish recommendations as done in NPA2018-12 for ROAAS.

The selected enablers of AO-0216 are:

- AIRPORT-57 Runway condition awareness management system based on manual assessment, weather information and runway sensors + PIREP machine-learning based RWY condition model and predictions
- AIRPORT-59 RCAMS system function to integrate aircraft observed runway braking action into runway condition information
- A/C-84a & b Braking action computation function in on-board braking action computation system (OBACS)
- A/C-64 Data transmission means supporting downlinked observed runway surface condition (aircraft side)
- SVC-061 Runway condition report service
- SVC-071 Runway Braking Action service

The two configurations considered:

Configuration	Enablers	Details
Reference	None	reference configuration where only ICAO GRF applies
Configuration 1	Configuration Reference completed by AIRPORT-57 through SVC-061	Runway condition awareness management system based on manual assessment of contamination, weather information and runway sensors
Configuration 2	Configuration 1 completed by A/C-84a & b inputs sent by A/C-64 and collected by AIRPORT-59 though SVC-071	Configuration 1 + OBACS

Table 6 Configurations

The different deployment scenarios considered:

- **Most likely scenario:** forecast is based on first deployment figures of the technologies. Good adoption is already observed on the first year. From a regulatory standpoint, there is no mandate scheduled up to now. So, the further introduction of the technology will depend on the will of airport operators and airspace users.

- **Scenario 1 - mandate for new A/C deliveries from 2032:** mandates the installation of OBACS on new type designs and all newly delivered aeroplanes to be operated in commercial air transport by European operators from 2032. Consequently, roughly 75 % of the fleet would be equipped with the technology by 2043.

- **Scenario 2 - mandate for airports from 2032:** mandates the deployment of the technology at airport level from 2032. It would more than double the airports equipped compared with the most likely scenario.

- **Scenario 3 - mandate for new A/C deliveries and airports from 2032:** this scenarios is the combination of scenario 1 and 2. Both Airports and new A/C deliveries have to be equipped with the technologies.

3.5.3 Assumptions

3.5.3.1 Operating environment

The solution is designed to be implementable in all airport operating environments regardless of their complexity and layout.

Assumptions are based on 2016 figures including Very Large down to Small airports in ECAC. Increase of the number of airports was not considered. So all airports may be affected and shall be included in the CBA analysis.

The following table summarises the applicable operating environments.

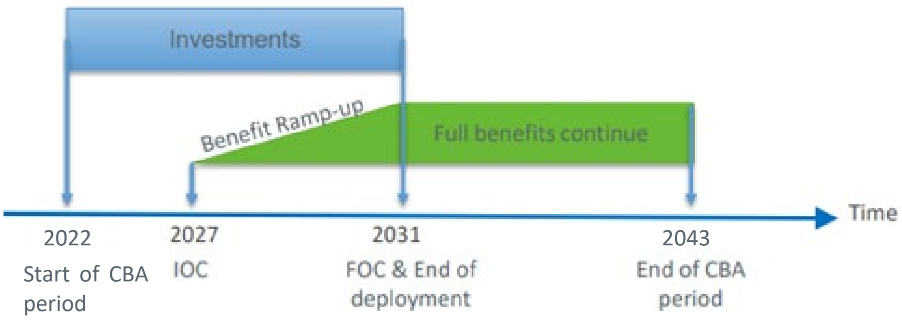
OE	Applicable sub-OE	Special characteristics
Airports	Very Large / Large / Medium / Small	

Table 7 Applicable Operating Environments

3.5.3.2 Time-horizon

The Solution and Reference Scenarios consider a 21 years period of time for the analysis of all potential costs and benefits, from 2022 to 2043. The time horizon has been aligned with the Common assumptions for CBAs as maintained by PJ.19.

Net Present Values should have been calculated back to 2019 (the end of Wave 1) but upon SJU request, they start in 2022.



Deployment timeframe is based on Solution OI steps / Enablers:

a. Deployment Start date(s) – reflect the start of investments for the first deployment location

b. Deployment End date(s) – reflect the end of the investments for the final deployment location

c. Initial and Final Operating Capability (IOC/FOC dates) – reflect the ramp-up of benefits across ECAC as more locations deploy the Solution

OI step	Deployment (V5) Start date	Deployment (V5) End date	Initial Operating Capability	Final Operating Capability
AO-0216	01/01/2022	31/12/2031	01/01/2027	31/12/2031
Solution			01/01/2027	31/12/2031

Table 8 Deployment timeframe

Human performance: no influence expected on the introduction of a Solution.

3.5.3.3 Traffic evolution

The table below shows the forecast for the accommodated demand, the fuel price and the CO2 value. The figures for the demand are derived from figure 20, page 33 of the Challenges of Growth Annex 1 [10], published by EUROCONTROL STATFOR (interpolated for 2041 to 2043).

Regulation & Growth scenario				
Year	**Accomodated demand (flights)**	**Unaccomodated demand (flights)**	**CO2 value (€ /tonne)**	**Fuel price (kerosene) (€/tonne)**
2022	11,718,541	1,622	15	799
2023	11,955,206	8,566	15	819
2024	12,196,650	45,342	16	840
2025	12,442,971	243,052	16	859
2026	12,711,844	269,224	17	874
2027	12,986,527	298,256	17	888
2028	13,267,146	330,466	18	903
2029	13,553,828	366,215	18	919
2030	13,846,705	405,901	19	934
2031	14,102,465	477,477	20	948
2032	14,362,949	562,060	20	962
2033	14,628,245	662,153	21	976
2034	14,898,441	780,792	21	990
2035	15,173,627	921,682	22	1,004
2036	15,373,591	992,871	23	1,018
2037	15,576,189	1,069,803	23	1,031
2038	15,781,458	1,152,978	24	1,045
2039	15,989,431	1,242,945	25	1,059
2040	16,200,145	1,340,305	26	1,074

2041	16,413,636	1,445,291	27	1,089
2042	16,629,940	1,558,501	28	1,104
2043	16,849,095	1,680,579	29	1,119

Table 9 STATFOR long-term traffic forecast

3.5.3.4 Discount rate

A discount rate of 8% was used for all stakeholder's segments in the NPV calculation in line with D4.0.30 PJ19 S2020 Common Assumptions.

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 in WP2.6 (and SESAR 1) to acquire the funds necessary to invest. This value is used by some partners in their local CBAs.

3.5.3.5 Runway excursion forecast

EASA NPA 2018-12 [16] provides the future expected landing overrun fatalities and injuries of European operators in a regulatory no change scenario and then safety benefits assessed with ROAAS deployment.

Such forecasts were based on:

- the number of serious accidents occurred from 1991 to 2017.
- the assumption of a 3.9 % average annual increase in traffic as the number of runway excursions that occur is proportionate to the number of aircraft movements.

Several ROAAS deployment options were assessed giving the statistical safety benefits of ROAAS over the 20-year analysis period. The option finally retained is to mandate through CS-26 the installation of ROAAS on new type designs and all newly delivered aeroplanes to be operated in commercial air transport by European operators from 2022. Consequently, roughly 75 % of the fleet would be equipped with the technology by 2037.

The reference to assess safety benefits of PJ02-25 solution is thus considering CS-26 deployment as per plan.

NPA2018-12 [16] provides data up to 2037. Data were extrapolated up to 2042 to support CBA exercise.

Based on NPA2018-12 [16], the forecast of remaining number of future accidents and fatalities due to runway excursion at landing considering CS-26 implementation can be easily derived including correction of the average increase from 3.9% to 1.9% (consistency with EUROCONTROL STATFOR assumptions).

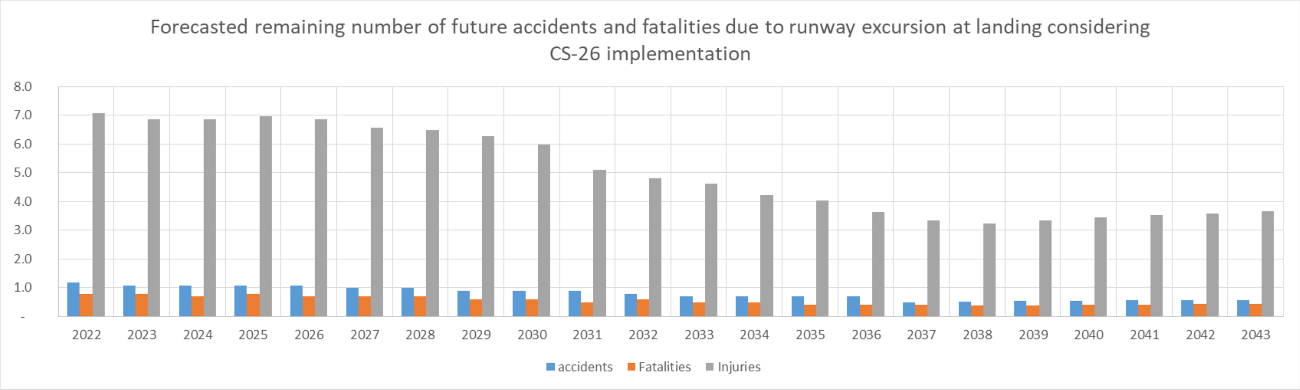


Figure 1: Future accidents and fatalities forecast due to runway excursion at landing

The total future runway excursion accident is estimated at 17.4 over 2022 to 2043. So less than 1 runway excursion per year in average.

4 Benefits

This section provides an early rough estimation of the monetised benefits deriving from the potential implementation of the solution under analysis.

4.1 Expected benefits

The benefits of this Solution are primarily in terms of Safety but also in terms of Resilience to adverse weather conditions, through a better management of runway inspections, potentially less flights diversions due to bad runway conditions and optimised decontamination operations.

A first overview of the main expected benefits in terms of Key Performance Areas (KPAs) and Key Performance Indicators (KPIs) may be found in the Benefit Mechanism defined within the PJ.02-W2-25.1 V3 Validation Plan [22].

4.2 Validated benefits

Some of the expected benefits have been measured during the validation activity and are going to be monetised here, where possible, following a two-stage process as presented in the picture below. First, the performance results from the validation exercises reported in the VALR were aggregated per each KPA and KPIs in the PAR. In a second stage, the relevant KPIs performance figures from the PAR were translated in compliance with PJ19 guidelines [2], into monetary values in this CBA.

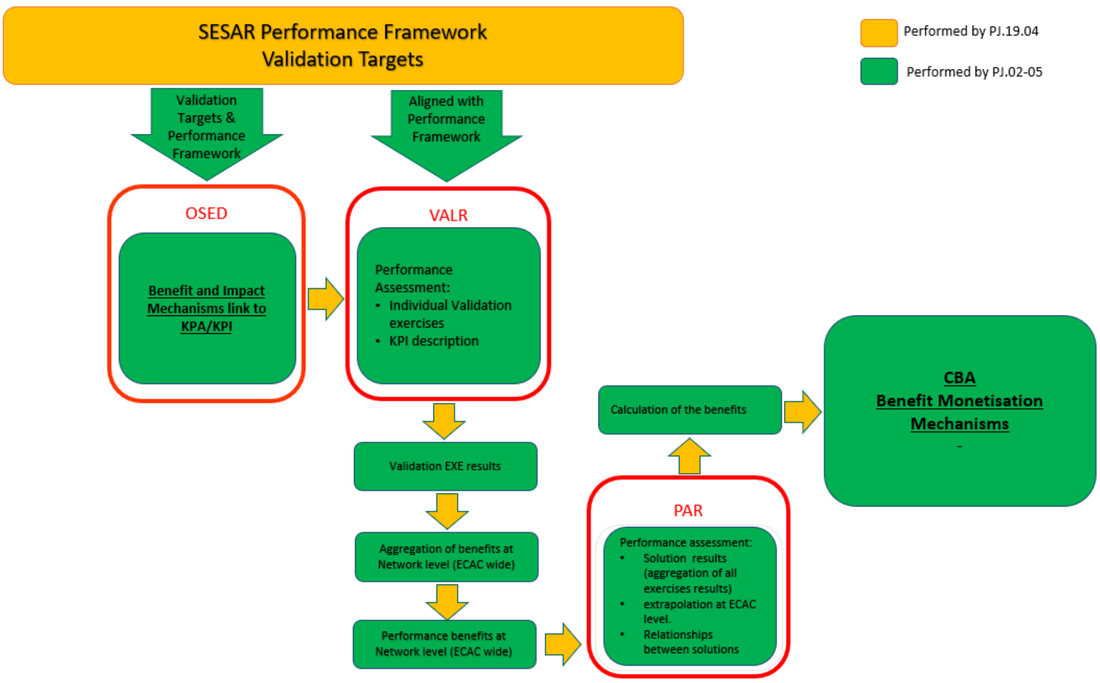


Figure 2: CBA logic calculation

The CBA Benefit Monetisation mechanism, the “CBA Model” used for translating validations results into monetary benefits is the CBA spreadsheet and embedded in the following Section 6.

PJ19 S2020 CBA model does not cover such safety benefits and a dedicated CBA model has been developed.

There was one Validation Exercise of the PJ02-W2-25.1 Solution in V3 with performance results available for SAF, HP and RES and thus quantitative results. On top, workshops/survey have been led to gather qualitative results. Each Runway Excursion that occurred in ECAC during 2017-2020 period and classified as serous incident or accident where analysed to assess if the solution would have permitted to prevent it. 2017 and 2018 were monitored and recorded. A total of 130 runway excursions were recorded worldwide. 27 of these runway excursions concerned airports in the ECAC area. These runway excursions were analysed by the project team to assess whether the Solution would have provided a mitigation (see the Performance Assessment Report [21], section 4.3.3 for details).

The table below summarises the comparisons between the Reference Validation Targets document and the validated benefits from the performance assessment results.

KPI	Validation Targets – Network Level (ECAC Wide)	Performance Benefits Expectations at Network Level (ECAC Wide or Local depending on the KPI)	Rationale
SAF1: Safety - Total number of fatal accidents and incidents with ATM Contribution per year	0%	Contribution through mandatory PI “RWY-excursion accident”: Solution PJ02-W2-25.1 is expected to reduce the Runway Excursion rate in the ECAC area by 22%.	N/A
CAP3: Airport Capacity – Peak Runway Throughput (Mixed mode).	0.17%	No benefit is expected from the Solution.	CAP3 is not addressed by the Solution based on OSED BIM analysis. However, the Capacity Resilience is a Focus Area under the CAP KPA

Table 10 Gap analysis Summary

4.2.1 Safety

4.2.1.1 AO-0216 expected improvement

Based on the PAR results, the Solution would have provided a mitigation for 22% of the runway excursions in the ECAC area in 2017-2020.

The Solution would have provided a mitigation for 6 runway excursions (22%).

The mitigation rate for each configuration is then expected at:

- 15% for configuration 1 when deployed at airport

- 15% (configuration 1) +7.5% (OBACS) = 22% for configuration 2 when deployed at airport and considering aircraft equipped with OBACS landing before.

PIs	Unit	Calculation	Absolute expected performance benefit in SESAR2020	% expected performance benefit in SESAR2020
SAF4.1 Runway Excursions	% Change in count of events or Frequency of occurrence per flight or movement	Measured, calculated, or supported by qualitative evidence as relevant	About 1.8 RE avoided from 2019 to 2040 in ECAC if fully deployed (over an estimation of 19.5 RE)	15% - 22% of RE avoided in ECAC
SAF4.5 Approach to a weather affected runway	% Change in count of events or Frequency of occurrence per flight or movement	Measured, calculated, or supported by qualitative evidence as relevant	Considered in SAF4.1	Considered in SAF4.1

Table 11: SAF performance expected benefit from AO-0216

Enablers Config. Id.	RCC-0 (Ref. case)	Configuration 1	Configuration 2
Mitigation rate	0%	15%	22%

Table 12: AO-0216 mitigation rate allocated to each design option – After GRF and ROOAS implementation

4.2.2 Resilience

The Solution improves the resilience to adverse weather conditions for the following reasons:

With AO-0216, there will be better awareness of runway conditions, particularly in adverse weather conditions. As this information is shared among stakeholders (Airport Operator, ATC & Airspace Users), there will be a better use of the runway in adverse weather conditions because:

- As everyone shares a better knowledge of the runway conditions, runway excursions should be less frequent. As explained above, this is expected to decrease the number of temporary losses of runway capacity.
- As the runway is constantly monitored by various data sources, the need for long and frequent runway inspections will decrease. This is expected to decrease the number of temporary losses of runway capacity. Prediction on runway surface contamination will optimize decontamination operations (better anticipation will permit coordination and decision making among all involved stakeholders)

- As the runway is constantly monitored by various data sources, flight diversions due to bad runway conditions should be less frequent, avoiding losses of runway capacity due to bad weather.

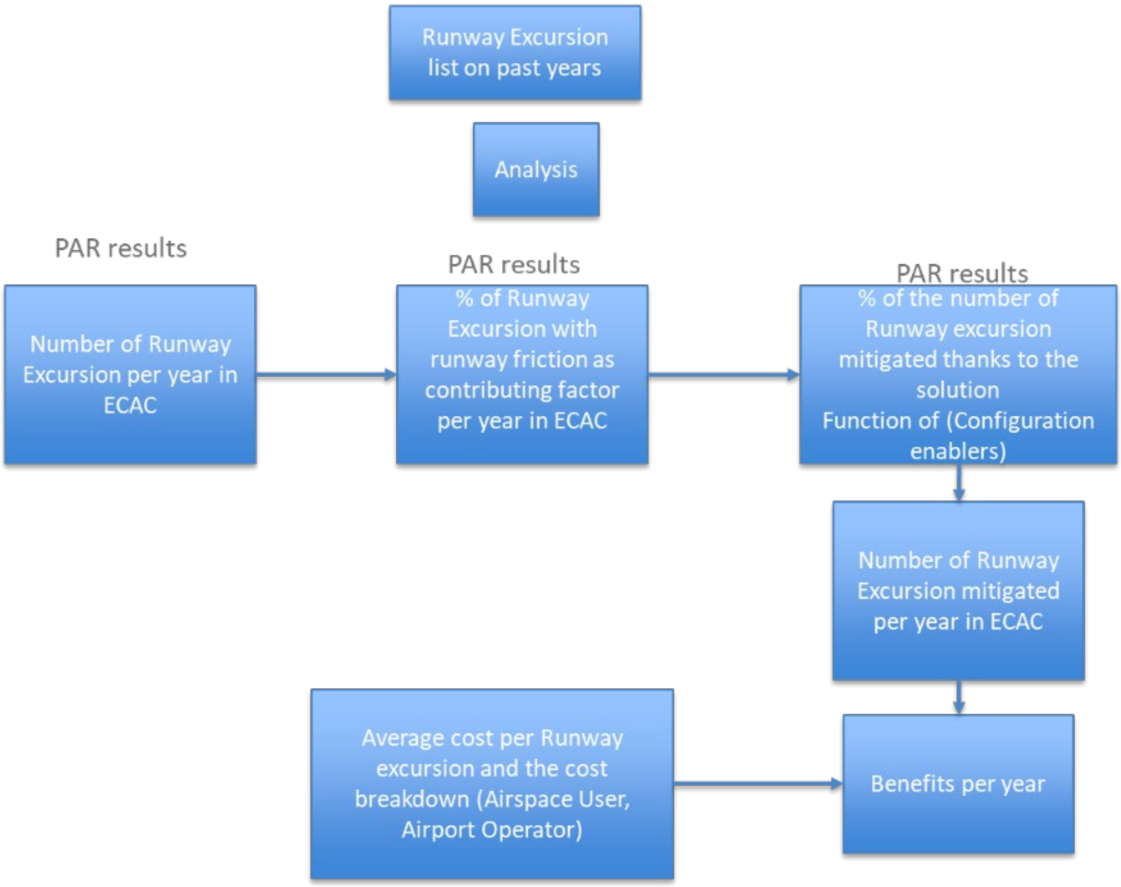
The Performance Assessment Result confirms that the impact can be substantial in case of runway excursions, with a total (but temporary) loss of runway capacity for 15-16 hours, and probable flight diversions. This is based on the analysis of the runway excursions that occurred in the ECAC area in 2017-2018, so the confidence level is relatively high. Nevertheless, this assessment result cannot be extrapolated to get a statistical value with a high confidence level because it is based on very few occurrences. There is a need to continue to monitor and analyse the runway excursions at the next maturity level.

PIs	Unit	Calculation	Absolute expected performance benefit in SESAR2020	% expected performance benefit in SESAR2020
RES4 Minutes of delays	Minutes	Impact on AUs measured through delays resulting from capacity degradation. RES1 and RES2 KPIs drive this PI, though the PI may need to be measured on a condition-by-condition basis (e.g. fog, wind, system outage).	Unknown	Extrapolation is not relevant
RES5 Number of cancellations	Nb flights	Impact on AUs measured through Cancellations resulting from capacity degradation. RES1 and RES2 KPIs drive this PI, though the PI may need to be measured on a condition-by-condition basis (e.g. fog, wind, system outage).	Unknown but flight diversions are expected for such duration of runway closures	Extrapolation is not relevant

Table 13: RES performance expected benefit

4.3 Monetisation of benefits

The benefits are assessed for each configuration. To develop the monetisation mechanisms, it is necessary to assess how many times runway excursion accident/incident is found in each type of hazardous situation in each scenario to see the change that the Solution brings. The frequency of hazardous events is generally low, however, in some cases it occurs that impact can be significant for the impacted stakeholders.



Based on NPA2018-12, the forecast of remaining number of future accidents and fatalities due to runway excursion at landing considering CS-26 implementation can be easily derived. The total Future runway excursion accident is estimated at **17.4** over 2022 to 2043. So **less than 1 Runway excursion per year**.

Reduce runway excursion allow to save money to the airspace users (airline) and airport operator.

<u>Average cost per runway excursion and cost breakdown</u>

The cost per stakeholder are:

Aircraft Operator

- Aircraft damage costs,
- Delay and Diversion costs,
- Passengers compensation.

Public data available and reference data to be used is in NPA2018-12. The NPA2018-12 details the cost of runway excursion. The average value of the aircraft damage caused by a runway excursion is estimated to amount to EUR 11 million per accident.

The costs for the airport delays, cancellations and diversions that follow a runway excursion accident have been also estimated in NPA2018-12 [16] to be EUR 2.6 million per accident.

The total cost of runway excursion accident for airspace user is estimated at **13.7 Million Euros**.

Aerodrome operator

- Opportunity costs,
- Repair costs to runway, its environment and equipment.

There is insufficient public data to estimate it. But, based on the Future Sky Safety Study [15], 60% of total runway excursion cost apply to airspace users and 4% to airport operators. So, this cost can be considered as 15times lower than aircraft operator cost.

Consequently, the total cost per runway excursion accident for airport operator is estimated at **900.000 Euros**.

Human

- Injury and casualty costs.

This cost is not considered in this CBA as out of airport operator and aircraft operator cost.

Indirect Safety Cost:

- Investigation costs, search and rescue, recovery, legal, third party costs, loss of investment income, loss of reputation, increase of insurance premium.

This Indirect Safety cost has to be paid by one or more of the runway occurrence associated parties (including the government and or their insurance companies). The distribution is unknown (no public study available). So, this cost has not been considered.

The monetary values for the economic benefits are considered to be under-estimated, since they neither include the above 'indirect safety costs', nor the costs of incidents and serious incidents.

The following table summarizes the results of benefit monetization for Solution PJ02-W2-25.1 for 2 years: 2022 – the first year of CBA, 2043 – the last year of CBA for most likely scenario (no mandate for RCAMS or OBACS).

Perf. Framework KPA	KPI/PI from the Perf. Framework	Unit	Metric for the CBA	Scenario	2022	2043
Safety	SAF4.1 Runway Excursions	% Change in count of events	1 Runway excursion cost 14.6 million €	Config.1	312,003 €	9,916,407 €
				Config2	395,216 €	14,734,364 €

Table 14: Results of the benefits monetisation per KPA

CBA V2 has built an initial safety monetisation mechanisms. Further effort in V3 has permitted to find more robust data sources (consistent with EASA Notice of Proposed Amendment 2018-12 and adjust the calculations).This section describes the monetised benefits deriving from the implementation of the solution(s) under analysis, based on the CBA Scenarios illustrated in the previous section.

5 Cost assessment

This section describes and analyses all the costs stemming from implementing the Solution PJ02-W2-25.1, based on the CBA Scenarios illustrated in section 2. The analysis considers PJ02-W2-25.1 as a stand-alone solution, i.e. deployed independently from any other S2020 Solution. Only the differential (or delta) value implied by the Solution Scenario over the Reference one is included in the analysis. Also, R&D and Pre-Industrialisation costs are already incurred in the SESAR Development Phase and therefore not included in the cost assessment.

The cost assessment is based on the list of enablers attached to PJ02-W2-25.1 OIs, as described in Section 3.2. SESAR Solution description. The costs included in the CBA reflect the investments that stakeholders will need to make to deploy the Solution and bring it into operation. The key cost elements considered are the Enablers (system, human, procedural …) assigned to the OI Steps.

The currency and all costs of the PJ02-W2-25.1 CBA are provided in Euro (€).

5.1 Airport operators costs

- **Not recurring cost:**
  - Safety support tool software installation, local server
  - Validation and certification
  - Initial Airport Operators training
  - Built-in sensors installation and calibration
  - Integration costs
- **Recurring cost:**
  - Maintenance and regular updating of software
  - Built-in sensors maintenance
  - Data transmission cost for on-board braking action

5.1.1 Airport operators cost approach

The costs have been obtained by expert judgement during the dedicated sessions with Solution partners

5.1.2 Airport operators cost assumptions

Assumptions applied to the cost assessment:

- Cost of built-in sensor installation will mainly depend on the number of runways.
- Low/High sensitivity scenario: -/+ 25%

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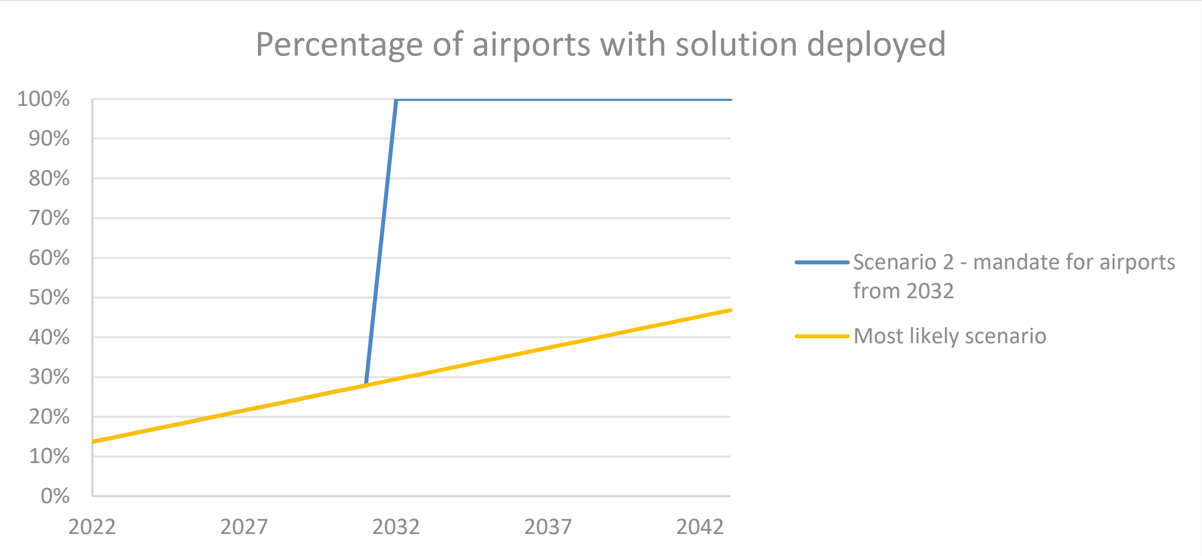
5.1.3 Number of investment instances (units)

A number of 190 airport has been estimated in ECAC.

Number of airports equipped	2022	2032	2043
Most likely scenario and scenario 1	23	53	86
Scenarii 2 and 3	23	190	190

Table 15: Number of investment instances – Aos

23 airports are already equipped in 2022 in ECAC with Configuration 2.



5.1.4 Cost per unit

Costs categories which have been considered during estimations of the PJ02-W2-25.1 costs:

- Implementation costs
    - One-off Costs (Initial training, project management, administrative costs, installation and commissioning, validation and certification, installation cost of in-built sensors)
- Capital costs (Equipment and system, integration costs)
    - Operating costs
    - Maintenance and repair

Final cost of the Solution PJ02-W2-25.1 per unit, expressed in Min and Max value, based on OI step and airport category and number RWY, are summarized in the following table.

Cost category	Configuration 1	Configuration 2
	Per Airport In average	Per Airport In average
Pre-Implementation Costs	N/A	N/A
Implementation costs	277,772 €	280,872 €
Operating costs	16,698 €	38,198 €

Table 16: Cost per Unit – Airport

Configuration 2 includes OBACS which has low implementation costs (mainly data integration in the RCAMS system) but high operating costs (service fees to broadcast data to RCAMS tool).

5.2 Airspace User costs

5.2.1 Airspace User cost approach

Assumptions applied to the cost assessment:

- The number of aircraft is based on the SESAR Cost Benefit Analysis for Master Plan Update, vol. 4.0, 2015,
- Costs are dependent of the aircraft category (business aviation or scheduled airline).

5.2.2 Airspace User cost assumptions

Assumptions applied to the cost assessment:

- Low/High sensitivity scenario: -/+ 25%

5.2.3 Number of investment instances (units)

At ECAC level, 551 scheduled airline aircraft are already equipped with OBACS in 2021. OBACS shows a fast and good adoption on scheduled airlines in both linefit and retrofit, 2 years after the entry into service on some Aircraft versions.

In the most likely scenario, OBACS technology remains limited to A320/A330 and Falcon 10X from 2025. Forecast is based on this assumption and current figures of technology adoption.

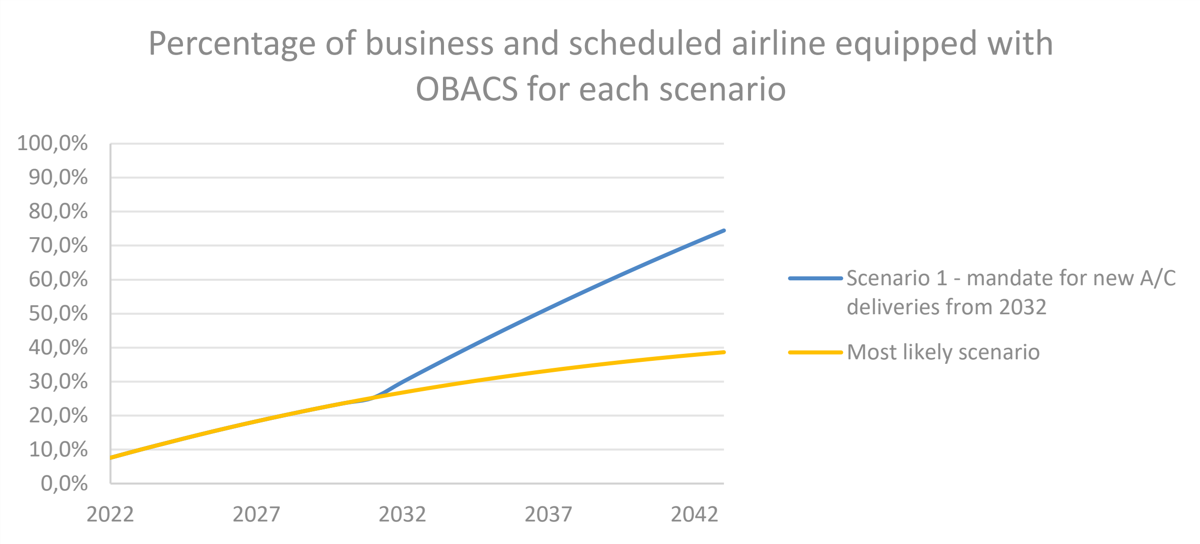


Figure 3: Percentage of aircraft equipped with OBACS for each scenario

	2022	2025	2043
Number of A/C equipped (Business Aviation) – most likely scenario	0	5	95
Number of A/C equipped (Scheduled Airline) – most likely scenario	750	1500	6000

Table 17: Number of investment instances - AUs

5.2.4 Cost per unit

	Configuration 1	Configuration 2	
	Per AC	Per AC (Business Aviation)	Per AC (scheduled airline)
Pre-Implementation Costs	N/A	N/A	N/A
Implementation costs	0 €	112 500 €	555 €
Operating costs	0 €	140 €	75 €

Table 18: Cost per unit – AUs

5.3 Other relevant stakeholders

N/A

6 CBA Model

Please find embedded the Excel file including the CBA Model below.

Solution scenario	Item	Most likely scenario	Scenario 1 - mandate for new A/C deliveries from 2032	Scenario 2 - mandate for airports from 2032	Scenario 3 - mandate for new A/C deliveries and airports from 2032
Configuration 1	Total costs – AU	- €	- €	- €	- €
	Total costs – AO	43,909,668 €	43,909,668 €	96,943,715 €	96,943,715 €
	Benefits - AU	9,305,121 €	9,916,407 €	18,920,960 €	18,920,960 €
	Benefits – AO	611,285 €	611,285 €	1,242,983 €	1,242,983 €
	NPV AU	4,413,962 €	4,413,962 €	7,598,664 €	7,598,664 €
	NPV AO	- 22,838,955 €	- 22,838,955 €	- 45,257,315 €	- 45,257,315 €
	Net Present Value Total	**- 18,424,992 €**	**- 18,424,992 €**	**- 37,658,651 €**	**- 37,658,651 €**
	Payback period[1]	No	No	No	No
	fatalities prevented	**0.47**	**0.47**	**0.97**	**0.97**
	Total Cost per fatalities prevented	**39,172,641**	**39,172,641**	**38,947,098**	**38,947,098**
Configuration 2	Total costs – AU	19,415,625 €	217,273,575 €	19,415,625 €	217,273,575 €
	Total costs – AO	69,954,768 €	69,954,768 €	96,943,715 €	154,400,215 €
	Benefits - AU	13,826,081 €	13,826,081 €	28,249,840 €	28,249,840 €
	Benefits – AO	908,283 €	908,283 €	1,855,829 €	1,855,829 €
	NPV AU	- 1,859,588 €	- 63,351,468 €	2,917,466 €	- 58,574,415 €
	NPV AO	- 33,673,127 €	- 33,673,127 €	- 45,015,974 €	- 66,139,632 €
	Net Present Value Total	**- 35,532,715 €**	**- 97,024,595 €**	**- 42,098,509 €**	**- 124,714,047 €**
	Payback period	No	No	No	No
	fatalities prevented	**0.70**	**0.70**	**1.44**	**1.44**
	Total Cost per fatalities prevented	**50,835,492 €**	**138,809,911 €**	**29,157,702 €**	**86,377,764 €**

[1] From Deployment Start Date

6.1 Data sources

The model uses the following data sources:

- EATMA Dataset 19
- Common assumptions
- STATFOR EUROCONTROL Seven-Year Forecast, Feb 2019
- STATFOR European aviation in 2040: Challenges of growth (2nd of October 2018 edition); Annex1: Flight Forecast to 2040
- Standard Inputs for EUROCONTROL Cost-Benefit Analyses vol. 8.0
- Standard Inputs for EUROCONTROL Cost-Benefit Analyses vol. 7.0
- SESAR Cost Benefit Analysis for Master Plan Update, vol. 4.0, 2015
- The number of Airports: Actual Data Airport OE and Forecast Data Airport OE - Airport OE Dataset, February 2019
- The number of Runways in ECAC region: Airport OE Dataset, February 2019
- Accidents cost, number of runway excursion: NPA 2018-12 Reduction of runway excursions RMT.0570
- Cost distribution per type of operator: Future sky safety study
- Avg. number of annual IFR movements per airport: US-europe-comparison-operational-performance-2017

7 CBA Results

The table below summarises the results of the Cost Benefit Analysis of the Solution (Undiscounted Costs and Benefits per Stakeholders):

Solution scenario	Item	Most likely scenario	Scenario 1 - mandate for new A/C deliveries from 2032	Scenario 2 - mandate for airports from 2032	Scenario 3 - mandate for new A/C deliveries and airports from 2032
Configuration 1	Total costs – AU	- €	- €	- €	- €
	Total costs – AO	43,909,668 €	43,909,668 €	96,943,715 €	96,943,715 €
	Benefits - AU	9,305,121 €	9,916,407 €	18,920,960 €	18,920,960 €
	Benefits – AO	611,285 €	611,285 €	1,242,983 €	1,242,983 €
	NPV AU	4,413,962 €	4,413,962 €	7,598,664 €	7,598,664 €
	NPV AO	-22,838,955 €	-22,838,955 €	-45,257,315 €	-45,257,315 €
	Net Present Value Total	**-18,424,992 €**	**-18,424,992 €**	**-37,658,651 €**	**-37,658,651 €**
	Payback period	No	No	No	No
	fatalities prevented	**0.47**	**0.47**	**0.97**	**0.97**
	Total Cost per fatalities prevented	**39,172,641 €**	**39,172,641 €**	**38,947,098 €**	**38,947,098 €**
Configuration 2	Total costs – AU	19,415,625 €	217,273,575 €	19,415,625 €	217,273,575 €
	Total costs – AO	69,954,768 €	69,954,768 €	96,943,715 €	154,400,215 €
	Benefits - AU	13,826,081 €	13,826,081 €	28,249,840 €	28,249,840 €
	Benefits – AO	908,283 €	908,283 €	1,855,829 €	1,855,829 €
	NPV AU	- 1,859,588 €	-63,351,468 €	2,917,466 €	-58,574,415 €
	NPV AO	-33,673,127 €	-33,673,127 €	-45,015,974 €	-66,139,632 €
	Net Present Value Total	**-35,532,715 €**	**-97,024,595 €**	**-42,098,509 €**	**-124,714,047 €**
	Payback period	No	No	No	No
	fatalities prevented	**0.70**	**0.70**	**1.44**	**1.44**
	Total Cost per fatalities prevented	**50,835,492 €**	**138,809,911 €**	**29,157,702 €**	**86,377,764 €**

Table 19: CBA Results (in EUR)

For comparison with ROAAS, ROAAS equipment installation would result in a cost of EUR 11 million per fatality prevented (as evaluation in NPA2018-12 [16])

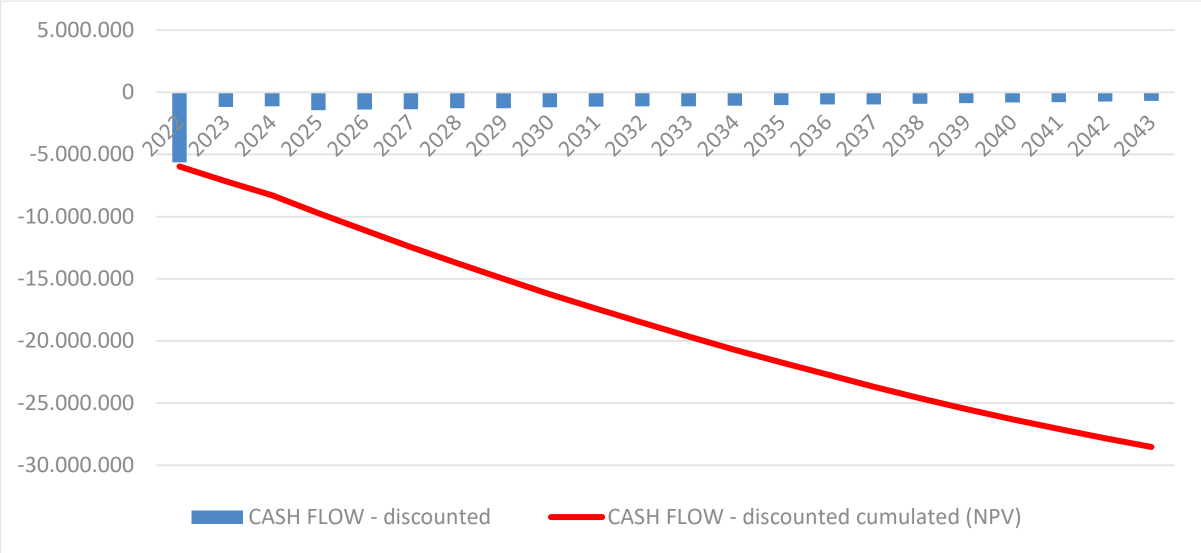


Figure 4: Configuration 2 – Most likely scenario - cash flows (in EUR)

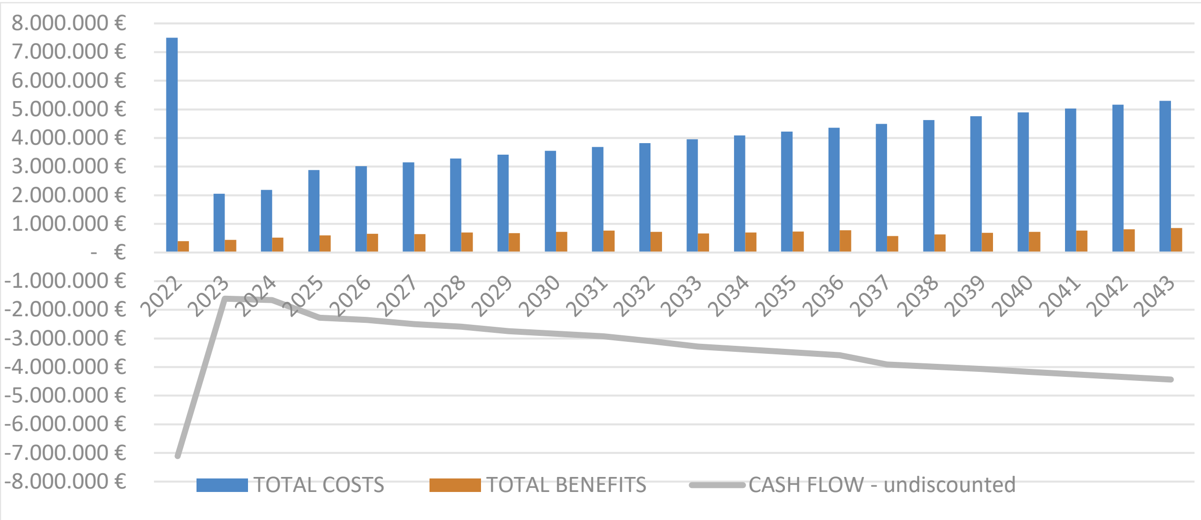


Figure 5: Configuration 2 – Most likely scenario - total costs and benefits (in EUR)

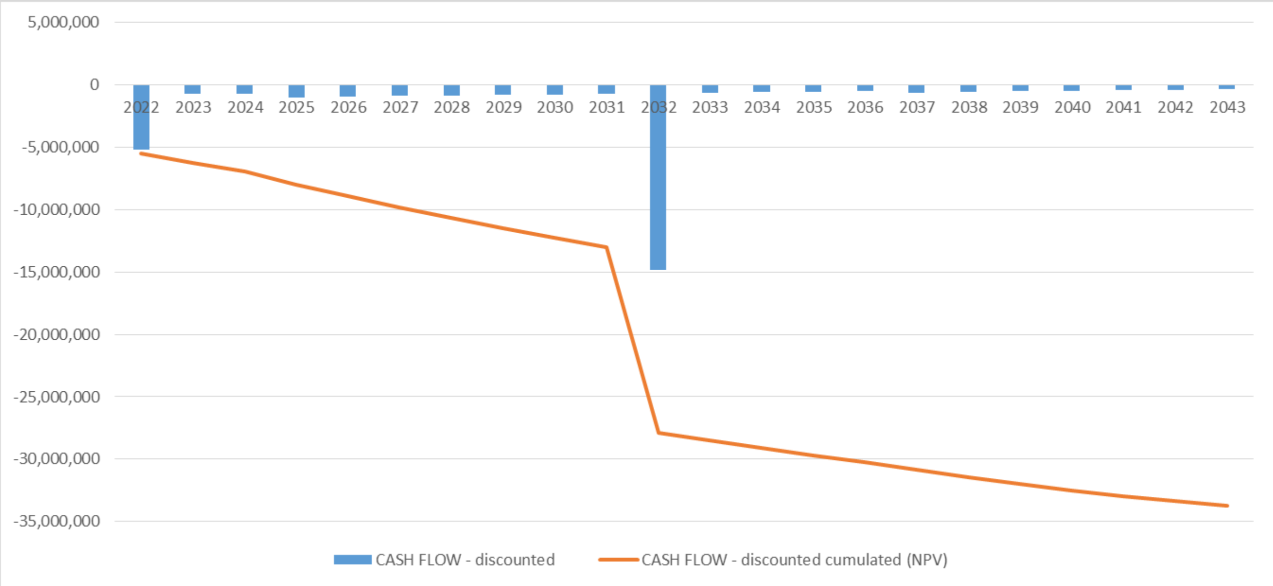


Figure 6: Configuration 2 – Scenario2 - cash flows (in EUR)

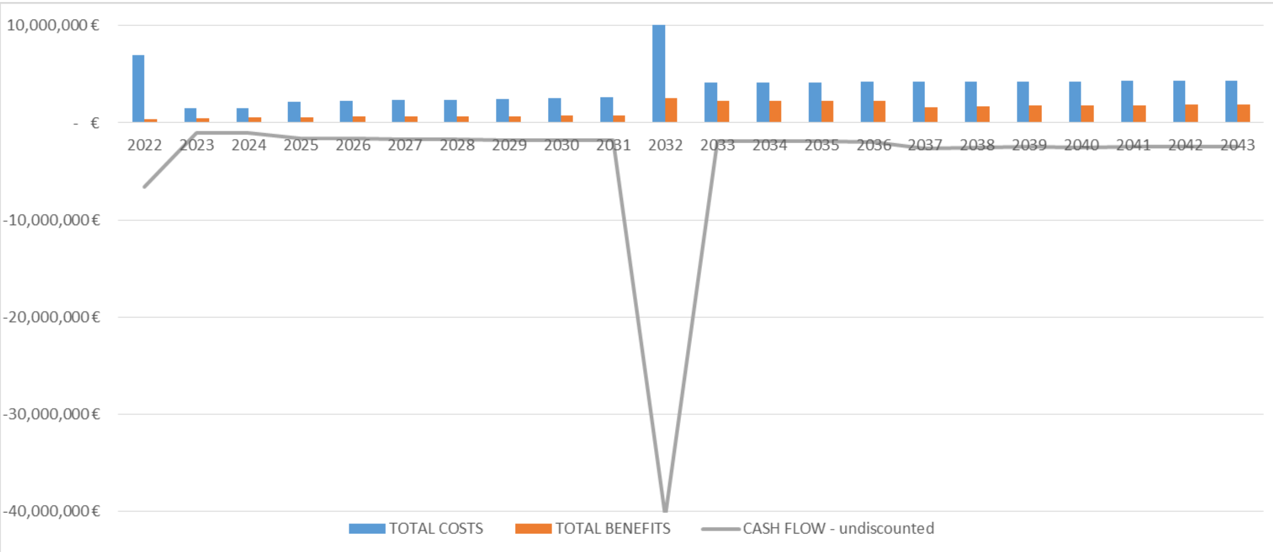


Figure 7: Configuration 2 – Scenario2 - total costs and benefits (in EUR)

8 Sensitivity and risk analysis

In order to measure the impact of risk which might affect the final result of the CBA a sensitivity analysis has been carried out. The tornado diagram below presents the change of the NPV in high/low scenarios of the most influential parameters for two specific design options: Configuration 1 (most likely scenario) then Configuration 2 (most likely scenario).

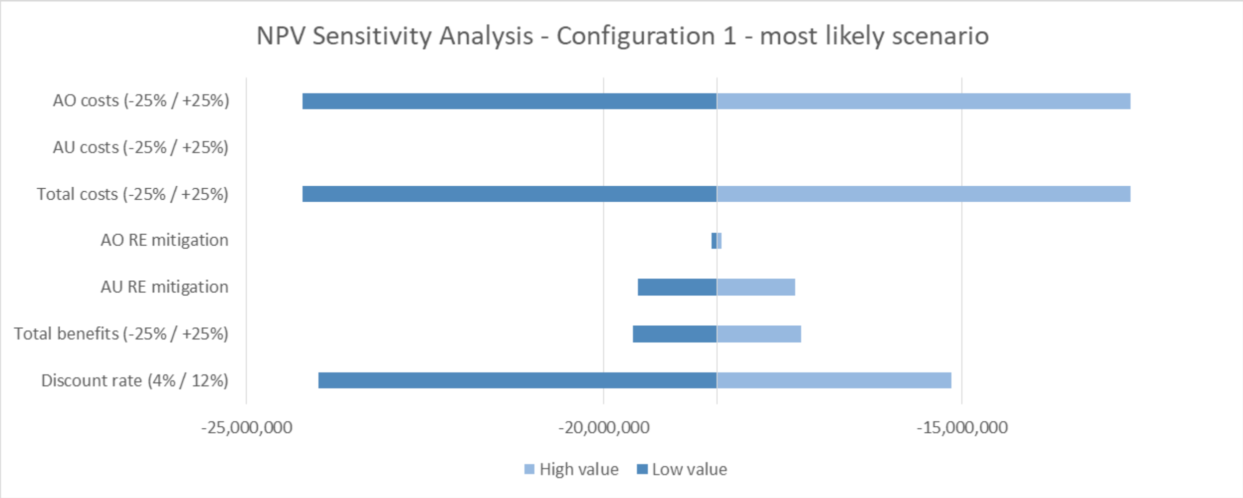


Figure 8: Configuration 1 – most likely scenario - sensitivity analysis (in EUR)

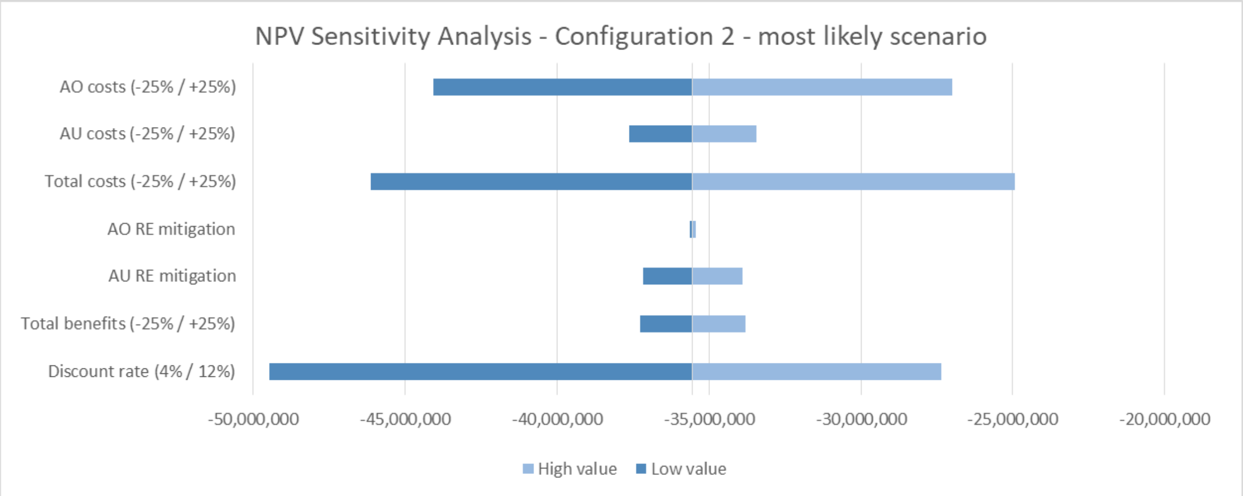


Figure 9: Configuration 2 – most likely scenario - sensitivity analysis (in EUR

In both configuration :

- AO costs are influencing most the total costs variations, AU costs are neglectible,
- On the contrary, AU RE mitigation will influence total benefits variations and AO RE mitigation is neglectible,

- Total Costs being far higher than benefits, NPV is negative so discount rate influence is strong on NPV.

Thus AO Costs shall be closely monitored and optimized in order to increase NPV.

9 Recommendations and next steps

The most likely scenario shows already good adoption and deployment of OBACS-equipped aircraft, ensuring a sufficient coverage and frequency of the measurements. A mandate for the installation of OBACS on new type designs and all newly delivered aeroplanes to be operated in commercial air transport by European operators from 2032 does not show added-value. Nevertheless, some airport may be not sufficiently covered by OBACS-equipped aircraft. As recommendation, it can be studied a way to encourage OBACS implementation locally.

A mandate for the deployment of the configuration 2 at airport level from 2032 would more than double the airports equipped compared with the most likely scenario and would bring the best result in terms of Total Cost per fatalities prevented. As the solution will bring safety benefit for operations on airports concerned by winter contaminant, strong rain conditions or slippery when wet runway, most of the airports in ECAC should benefit of the solution. In this CBA, the benefits of the solution leans only on runway excursion cost reduction. As recommendation, it could be further studied benefits of the solution in terms of resilience and optimization of runway de-icing treatment. With these additional results, a study of the mandate for airport of the configuration 2 is recommended.

10 References and Applicable Documents

10.1 Applicable Documents

[1] SESAR 2020 Project Handbook v2.0 for W2;

[2] Guidelines for Producing Benefit and Impact Mechanisms;

[3] Methods to Assess Costs and Monetise Benefits .

[4] SESAR 2020 Cost-Benefit Analysis Model[2]

[5] Cost Benefit Analyses – Standard Input

[6] Cost Benefit Analyses – Method to assess costs

[7] ATM CBA Quality checklist

[8] Methods to Assess Costs and Benefits for CBAs

10.2 Reference Documents

[9] Common assumptions

[10] EUROPEAN AVIATION IN 2040 CHALLENGES OF GROWTH Annex1 Flight Forecast to 2040 https://www.eurocontrol.int/sites/default/files/2019-07/challenges-of-growth-2018-annex1_0.pdf

[11] Performance Framework

[12] 2019 IATA Safety Report

[13] 2020 IATA Safety Report

[14]Safe-Runway GmbH; https://www.safe-runway.com/news

[15] Future Sky Safety Study, https://www.futuresky.eu/projects/safety

[16]European Aviation Safety Agency, Notice of Proposed Amendment 2018-12, Reduction of runway excursions, RMT.0570; https://www.easa.europa.eu/sites/default/files/dfu/NPA%202018-12.pdf

[17] European Action Plan for the Prevention of Runway Excursions (EAPPRE) - Edition 1.0 - EUROCONTROL - January 2013 [50]

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

[18] A Study of Runway Excursions from an European Perspective, EUROCONTROL – March 2010

[19]Take Off and Landing Performance Assessment (TALPA) Initiative by the FAA

[20] Runway Excursion Joint Safety Analysis and Implementation Team - Final Report Analysis and Recommendations - February 2015

https://www.cast-safety.org/pdf/JSAIT_RE_FinalReport_Feb2015.pdf

[21] SESAR PJ02-W2-25.A SPR/INTEROP-OSED V3 - Part V - Performance Assessment Report, PU/CO/CL, v00.02.00, 30 June 2022

[22] PJ.02-W2-25.1 V3 Validation Plan

11 Appendix

Mapping between ATM Master Plan Performance Ambition KPAs and SESAR Performance Framework KPAs, Focus Areas and KPIs, source reference *[11]*

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

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
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
	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>	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 20: Mapping between ATM Master Plan Performance Ambition KPAs and SESAR Performance Framework KPAs, Focus Areas and KPIs

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