INDUSTRIAL RESEARCH

SESAR Solution PJ.02-W2-21.1: Cost Benefit Analysis (CBA) for V3

Deliverable ID:	D6.1.010
Dissemination Level:	PU
Project Acronym:	AART
Grant:	874477
Call:	H2020-IBA-SESAR-2019-1
Topic:	Airport Airside and Runway Throughput
Consortium coordinator:	Eurocontrol
Edition date:	24 May 2023
Edition:	00.01.03
Template Edition:	02.00.06

Authoring & Approval

Authors of the document

Beneficiary	Date
ALG-INDRA	27/02/2023

Reviewers internal to the project

Beneficiary	Date
DFS	01/03/2023

Reviewers external to the project

Beneficiary	Date

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

Beneficiary	Date
DFS	02/03/2023
ENAIRE	02/03/2023
Indra	02/03/2023
LEONARDO	02/03/2023

Rejected By - Representatives of beneficiaries involved in the project

Beneficiary	Date

Document History

Edition	Date	Status	Beneficiary	Justification
00.00.01	28/02/2023	Draft	ALG-INDRA	1st Draft for review
00.00.02	02/03/2023	Draft	ALG-INDRA, DFS	Updates after review comments
00.00.03	02/03/2023	Draft	DFS, ENAIRE, Indra, LEONARDO	Version for approval
00.01.00	02/03/2023	Final	DFS	Version for submission
00.01.01	14/04/2023		ALG-INDRA	Update after SJU review
00.01.02	04/05/2023		DFS	Update according to MG comments.
00.01.03	24/05/2023	Final	DFS	Version for submission

EUROPEAN PARTNERSHIP

Co-funded by the European Union

AART

AIRPORT AIRSIDE AND RUNWAY THROUGHPUT

This Deliverable is part of a project that has received funding from the SESAR3 Joint Undertaking under grant agreement No 874477 under the European Union's Horizon 2020 research and innovation programme.

Abstract

This document provides the final version of Cost Benefit Analysis (CBA) at V3 level for Solution PJ.02-W2-21.1 in SESAR 2020 Wave 2. This final version of the document is based on the refinement of the research findings of the Intermediate CBA for Solution PJ.02-W2-21.1, delivered at the end of 2020. Moreover, this CBA takes into account the last operational and technical developments included in the OSED, addressing the Operational Improvement step (OI) AO-0104-B.

EUROPEAN PARTNERSHIP

Co-funded by the European Union

Table of Contents

List of Tables

List of Figures

1 Executive Summary

This document reports the **final version** of the **Cost Benefit Analysis (CBA)** for the following solution expected to reach **V3 maturity in 2023**:

PJ.02-W2-21.1 – Extended airport safety nets for controllers A-SMGCS airports.

This CBA is based on the update of the initial CBA version delivered in December 2020. The Performance improvements detailed in the PAR of the solution have been taken into account for the development of this document. Specifically, the information reported in chapter 4.3.2 of the Performance Assessment Report (PAR), which has been used to calculate and monetize resilience benefits based on the methodology developed in the initial version of this CBA.

The Solution PJ.21-W2-21.1 aims at enhancing Safety for airport operations as Support Tools for controllers at A-SMGCS Airports to detect potential and actual conflicting situations, incursions and non-conformance to procedures or ATC clearances, involving mobiles (and stationary traffic) on runways, taxiways and in the apron/stand/gate area as well as unauthorised/unidentified traffic. Controllers are provided in all cases with the appropriate predictive indications and alerts. The developments of this solution in Wave 2 start from the activities performed and related outcomes obtained in the Wave 1 solution PJ.03b-01, continuing respectively the work done on the Operational Improvement (OI) step AO-0104-B.

According to the final OSED document [15], this solution is intended to be implemented at Very Large, Large and Medium airports , the geographical scope of this CBA. The benefits of this solution are limited to airports equipped with A-SMGCS. Deployment activities are planned to start in Q2 of 2025 and last six years, ending in Q2 2031. Thanks to a sequenced deployment of the solution at different locations, the first set of airports deploying the solution are expected to start generating benefits in 2027.

As defined in the Benefits Impact Mechanisms (BIMs) reported in Appendix B, this solution mainly generates benefits in the Safety, Resilience and Human Performance KPAs. It is important to note that the Safety KPA is a transversal area impacting indirectly on other ones: the happening of a safety occurrence will have impacts on the airport resilience through the temporary reduction of its capacity (considered in the BIMs), enabling the estimation of part of the benefits in terms of avoided costs of delays, cancellations and diversions. Additionally, also physical damages to colliding vehicles in case of safety major or substantial damage accidents are quantified. Potential injuries to human life are not quantified, according to PJ.19-04 guidelines on safety benefits monetisation [3].

Starting from an assessment of the number of safety occurrences that may be reduced by the solution (0.79 annual safety occurrences in taxiway and 1.34 in runway), benefits are quantified following the approach initially used in the V3 CBA intermediate version of this solution. In details, safety and resilience benefits are quantified for Airspace Users, Air Navigation Service Providers and Airport Operators as:

- Avoided costs of delays, cancellations, and diversions due to a safety occurrence in taxiway and runway, including also the cost of any go-around operation performed in case of missed landing due to a serious incident in runway,
- Avoided loss of ANS and airport charges due to cancellations at the happening of a safety accident,

EUROPEAN PARTNERSHIP

Co-funded by the European Union

- Cost of repairs of physical damages suffered by colliding aircraft and ground vehicles.

This approach compares the solution scenario (where the hazardous situation is avoided by the solution) with the reference scenario (where the solution is not implemented and the hazardous situation occurs), being the delta the benefit (and costs) the solution could bring.

The cost assessment methodology leverages on a combination between a Top-Down and a Bottom-Up approach. In the former case, the applicable results of V3 CBA intermediate version elaborated in 2020 are taken as reference, being further on refined and expanded. In the latter case, cost estimations provided by solution partners are considered as main inputs to enable the Bottom-Up approach. Inputs from both ANSPs and industry partners have been collected during the CBA activities and are used for the definition of a potential range of values.

Costs included in the CBA reflect the investments that ANSPs will need to make to deploy the solution and bring it into operation, as part of the proposed solution scenario. At the moment, a unitary implementation cost of 2.5 M€ is estimated, being a 91% in the concept of implementation and a 9% covering transition activities. Variation of operating expenditures has been also analysed, leading to the conclusion that no changes are expected since the solution will not increase nor decrease them.

Having a look at CBA results, investments start in 2025 with an undiscounted value of -9.12 M€, increasing up to -93.45 M€ in 2031 (undiscounted, cumulated). On the other hand, benefits generation starts in 2027 with an undiscounted value of 0.29 M€ and increasing with a ramp-up distribution to a maximum annual generation of benefits of 1.43 M€.

At current conditions, investments are not expected to be recovered in the time horizon of the CBA (i.e., payback year not reached), although the cumulated NPV is characterised by a positive trend starting from the FOC year (i.e., 2031), increasing from a -55.69 M€ to -50.29 M€ by 2043 (discounted values with an 8% discount rate).

Although the economic appraisal does not seem to strongly support the implementation of the solution, other qualitative factors should be added to the profitability assessment. In fact, the PJ.02-W2-21.1 is safety oriented, this is by itself a good reason to implement the solution and could justify funding/incentives to mandate its deployment.

Level of confidence on results is considered low/medium, considering the results obtained from validation activities and the cost estimations received from Solution partners.

2 Introduction

2.1 Purpose of the document

This document provides the Cost Benefit Analysis (CBA) for Solution 21.1 for the V3 level, part of the SESAR Project PJ.02-W2-21 – Digital evolution of integrated surface management.

According to SESAR 2020 Project Handbook [1], CBA in V3 should include all the evidence gathered in terms of impacts, benefits, and costs of the solution. CBA task should provide the overall NPV of the solutions and their distribution per stakeholder group, a sensitivity analysis identifying the most critical variables to the value of the project, a risk analysis, the CBA model, a report, and a set of recommendations.

This CBA has been developed to identify and agree on:

- The deployment scenario approach for the solution,
- The assumptions related to the solutions and reference scenario,
- The stakeholders impacted by each solution, i.e., those who will support the deployment and operating costs and those who will benefit from the solutions,
- The cost elements to be assessed for each stakeholders' group considering the operating environments where the solutions are expected to provide benefits, as defined in the deployment scenario approach and in the final version of the SESAR Solutions PJ.02-W2-21.1 SPR-INTEROP/OSED for V3 [15],
- The mechanisms to quantify the benefits, based on the BIMs (Benefit and Impact Mechanisms) developed in the OSED task and presented in Appendix A of the SESAR Solutions PJ.02-W2-21.1 SPR-INTEROP/OSED for V3 document.

This V3 CBA provides a consolidated evaluation of the overall costs at the solution level and per affected stakeholder. Costs have been quantified and monetised in the CBA for ANSPs. This has been done based on the gathering of inputs from solutions partners and their correspondent extrapolation to estimate the impact on the rest of the EU stakeholders.

Safety benefits have been quantified during the validation activities, providing the percentage of observed reduction in safety occurrences during the run planned for the validation exercise. In line with PJ.19-04 guideline [3], a set of hazardous situations has been considered and an estimation of their monetary impact has been calculated. This value represents the cost that would have been incurred had the hazardous situation occurred, i.e., without the solution. Therefore, solution benefits are the costs avoided thanks to the provision of relevant alerts by the solution systems, which enable the avoidance of the hazardous event. More details are provided in section 4.

2.2 Scope

In accordance with the OSED, the scope of this document consists of the assessment of the cost incurred and benefits generated by the OI Step and enablers of the Solutions PJ.02-W2-21.1, which are:

SESAR Solution ID	SESAR Solution Title	OI Steps ID	OI Steps Title	Enabler ID	Enabler Title	OI Step/Enabler Coverage
PJ.02-W2-21.1	Enhanced Airport Safety Nets for Controllers at A-SMGCS Airports	**AO-0104-B**	Enhanced Airport Safety Nets for Controllers at A-SMGCS Airports	**AERODROME-ATC-06b**	A-SMGCS incorporating the function that detects Conflicting ATC Clearances (CATC) on the entire airport surface	OI step/Enable: Fully Enabler: Required
				AERODROME-ATC-07b	A-SMGCS incorporating the function that provides an advanced set of Conformance Monitoring Alerts for Controllers (CMAC) on the movement area	OI step/Enable: Fully Enabler: Required
				AERODROME-ATC-115	A-SMGCS incorporating the function that provides RMCA/CMAC vs ATC Clearance alerts	OI step/Enable: Fully Enabler: Required
				AERODROME-ATC-116	A-SMGCS incorporating the function that provides Runway-Busy notifications	OI step/Enable: Fully Enabler: Required

Table 1: SESAR Solution PJ.02-W2-21.1 Scope and related OI steps /enablers

2.3 Intended readership

The intended readership for this document includes:

- PJ.02-W2-21.1 Solution Members,
- All other PJ.02-W2 Project Members,
- SESAR Programme Management,
- PJ.19, as Content Integration Project,
- PJ.20, as Master Plan Maintenance project,
- SESAR Joint Undertaking,
- ANS providers regarding deployment activities.

2.4 Structure of the document

This report is structured as follows:

- **Section 1** provides the executive summary,
- **Section 2** provides the overall scope, time horizon, intended audience, structure of the document, background, glossary of terms and acronyms,
- **Section 3** presents the objectives and scope of this CBA, describing the PJ.02-W2-21.1 solutions and the problem addressed by them, identifies the main stakeholders impacted and describes the different scenarios compared in the CBA,
- **Section 4** provides a view of the overall contribution to Key Performance Indicators and a description of the expected benefits per stakeholder,
- **Section 5** describes the cost approach and the main assumptions taken when assessing the cost elements of the solutions and presents the results of the cost assessment per stakeholder group,
- **Section 6** provides a description of the CBA model and the main sources of data used to build the CBA Model,
- **Section 7** reports the overall CBA results, considering on one side the single perspective of each relevant stakeholder and on the other side the overall results obtained from the sum of the previous perspectives,
- **Section 8** includes sensitivity and risk analysis, identifying the main variables and parameters whose variation has a relevant impact on the assessment,
- **Section 9** includes recommendations and next steps extracted from the results of the analysis,
- **Section 10** includes the references and applicable documents,
- **Appendix A** provides the mapping between ATM Master Plan Performance Ambition KPAs and SESAR 2020 Performance Framework KPAs, Focus Areas and KPIs,
- **Appendix B** provides the Benefit Impact Mechanisms (BIMs), as reported in the OSED document,

- **Appendix C** provides the list of applicable deployment locations, a part of which has been considered for the definition of the geographical scope of the CBA.

2.5 Background

Previous activities relevant to SESAR Solution PJ.02-W2-21.1:

Internal to SESAR 1

- OFA04.02.01 Final OSED
- OFA04.02.01 Final SPR
- OFA04.02.01 SAR

Internal to SESAR 2020

- Solutions PJ02-W2-21.1 Intermediate version CBA V3 [16]
- Solutions PJ02-W2-21.1 SPR-INTEROP/OSED [15]

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* (https://www.investopedia.com/)
Key Risk Area	A key risk area is defined by its potential accident outcome and by the immediate precursors of that accident outcome. In other words, each area collects the number of occurrences that lead or could have led to a specific type of accident (e.g. Runway collision)	*European Plan for Aviation Safety (EPAS) Volume III – EASA*
Cost Benefit Analysis (CBA)	A cost-benefit analysis is a systematic process that businesses use to analyse which decisions to make and which to forgo. The cost-benefit analyst sums the potential rewards expected from a situation or action and then subtracts the total costs associated with taking that action.	*Investopedia* (https://www.investopedia.com/)
Sensitivity Analysis	Sensitivity analysis is a financial model that determines how target variables are affected based on changes in other variables known as input variables. It is a way to predict the outcome of a decision given a certain range of variables.	*Investopedia* (https://www.investopedia.com/)

Term	Definition	Source of the definition
Risk Analysis	The term risk analysis refers to the assessment process that identifies the potential for any adverse events that may negatively affect organizations and the environment. Conducting a risk analysis can help organizations determine whether they should undertake a project or approve a financial application, and what actions they may need to take to protect their interests.	*Investopedia* (https://www.investopedia.com/)

Table 2: Glossary of terms

2.7 List of Acronyms

Acronym	Definition
ANS	Air Navigation Services
ANSP	Air Navigation Service Provider
AO	Airport Operator
APT	Airport
A-SMGCS	Advanced Surface Movement Guidance and Control System
ASR	Annual Safety Report
ATC	Air Traffic Control
ATCO	Air Traffic COntroller
ATM	Air Traffic Management
ATS	Air Traffic Services
AU	Airspace User
BIM	Benefit Impact Mechanism
CAPEX	CAPital EXpenditure
CATC	Conflicting ATC Clearances
CBA	Cost Benefit Analysis
Civ	Civil
CMAC	Conformance Monitoring Alerts for Controllers
EFS	Electronic Flight Strips
EN	ENabler
FOC	Final Operational Capability

EUROPEAN PARTNERSHIP
Co-funded by the European Union

Acronym	Definition
FOC	Flight Operation Centre
INTEROP	Interoperability
IOC	Initial Operational Capability
KPA	Key Performance Area
KPI	Key Performance Indicator
Mil	Military
MTOW	Maximum Take-Off Weight
NPV	Net Present Value
OE	Operating Environment
OI	Operational Improvement
OPEX	OPerating EXpenditure
OSED	Operational Service and Environment Definition
PAR	Performance Assessment Report
R/T	Radio Telephony
RMCA	Runway Monitoring and Conflict Alerting
RWY	Runway
SESAR	Single European Sky ATM Research Programme
SJU	SESAR Joint Undertaking
SPR	Safety and Performances Requirements
TWY	Taxiway
VALR	Validation Report

Table 3: List of acronyms

3 Objectives and scope of the CBA

3.1 Problem addressed by the solution

The main objective of the solution in the scope of this CBA is to support the air traffic controllers through the safety support tools at A-SMGCS Airports to detect potential and actual conflicting situations, incursions, and non-conformance to procedures at ATC clearances.

This document is developed to:

- Identify and agree on the main elements and assumptions that have been used in the development of the CBA Model,
- Identify impacted stakeholder groups and propose the number of airports to be considered in the deployment scenario approach, taking into account the Operational Improvements (OIs) and Enablers (ENs) implementation requirements,
- Provide a mechanism for the evaluation of the potential costs of the Solutions for Air Navigation Service Providers (ANSPs),
- Update the previous version of the CBA report including content modifications aligned with the final version of the OSED,
- Update the previous results according to the new geographical scope, including 13 Very Large, 12 Large and 3 Medium airports.

3.2 SESAR Solution description

3.2.1 Solution PJ.02-W2-21.1

The Solution builds on the Airport Safety Nets defined and validated (V3) in SESAR1. The Conflicting ATC Clearances (CATC) and Conformance Monitoring Alerts for Controllers (CMAC) alerting functions are updated to improve their operational usability and extended to cover the entire airport surface. The updated and new alerts are provided in addition to the SESAR1 CMAC/CATC alerts, which are deployed on top of the Runway Monitoring and Conflict Alerting (RMCA), together with the Routing & Planning service (SESAR Solution #22). The aim is to improve overall safety by providing more barriers to the corresponding Reason’s model, each of the new improvements being independent of the others from a safety benefit point of view, provided that the alerts are composed for their individual operational environment and fine-tuned to the specific local procedures and conditions.

SESAR Solution ID	OI Steps ref. (coming from the Integrated Roadmap)	OI Steps definition (coming from the Integrated Roadmap)	OI step coverage	Source reference
PJ.02-W2-21.1	**AO-0104-B**	Extended airport safety nets for controllers at A-SMGCS airports	Fully	EATMA DS23

Table 4: SESAR Solution PJ.02-W2-21.1 Scope and related OI steps

OI Steps ref.	Enabler ref.	Enabler definition	Enabler coverage	Applicable stakeholder	Source reference
AO-0104-B	**AERODROME-ATC-06b**	A-SMGCS incorporating the function that detects Conflicting ATC Clearances (CATC) on the entire airport surface	Fully	ANSP	EATMA DS23
	AERODROME-ATC-07b	A-SMGCS incorporating the function that provides an advanced set of Conformance Monitoring Alerts for Controllers (CMAC) on the movement area	Fully	ANSP	EATMA DS23
	AERODROME-ATC-115	A-SMGCS incorporating the function that provides RMCA/CMAC vs ATC Clearance alerts	Fully	ANSP	EATMA DS23
	AERODROME-ATC-116	A-SMGCS incorporating the function that provides Runway-Busy notifications	Fully	ANSP	EATMA DS23

Table 5: SESAR Solution PJ.02-W2-21.1 OI steps and related Enablers

3.3 Objectives of the CBA

The objective of the V3 CBA is to provide a consolidated assessment of the costs and benefits generated thanks to the deployment of Solution PJ.02-W2-21.1 in a specific set of Very Large, Large and Medium airports, as will be further discussed in the deployment scenario description. This CBA will compare the benefits expected for the deployed solution with the costs incurred by stakeholders over the CBA time horizon.

According to the Benefit Impact Mechanisms described in the OSED, Appendix A.2, this solution is expected to generate benefits in the SESAR Performance Framework (PF) KPAs of Resilience, Human Performance and Safety.

This V3 CBA will help in building an assessment of whether the PJ.02-W2-21.1 solution is worth deploying from an economic perspective for the involved stakeholders, although a more general perspective should be also considered taking into account other qualitative reflections linked to the impacted KPAs.

The CBA development is structured as three consecutive phases illustrated in Figure 1:

1. Scenario definition: the reference scenario upon which the solution will be deployed (i.e. solution scenario) is defined, assessing also the prerequisites of the solution to be fulfilled at least before the start of benefits generation,

2. Benefit and cost items identification: benefits and cost figures characterising the delta between the reference and solution scenario are identified, enabling the following and final phase,

3. Benefits and costs quantification: these are quantified by applying ad-hoc methodologies and assumptions that will be clearly stated along with the CBA analysis reported in this document.

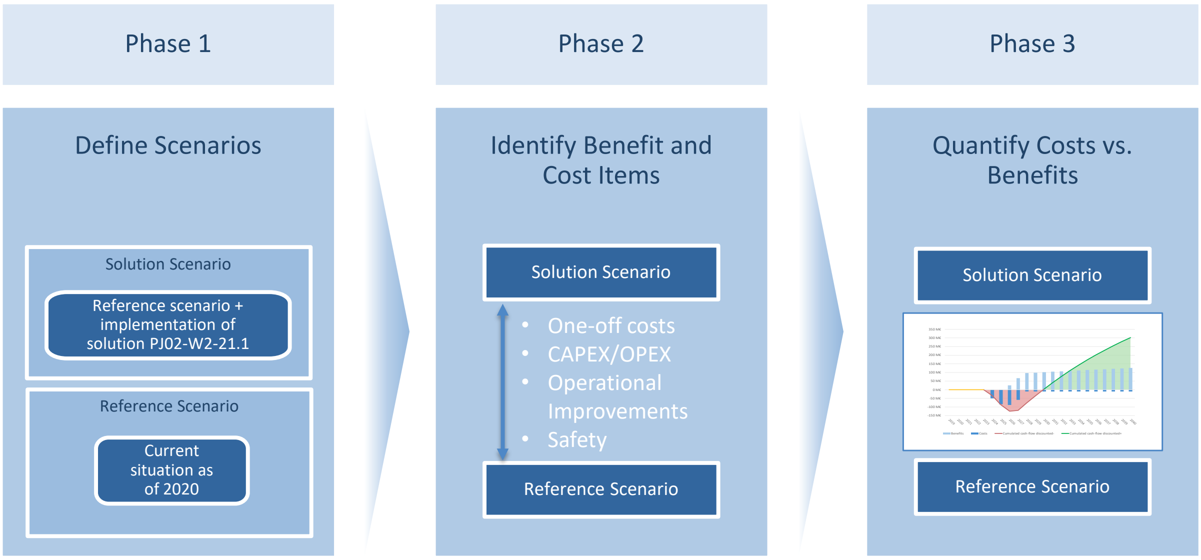


Figure 1: PJ.02-W2-21.1 CBA development phases

3.4 Stakeholders[1] identification

Table 6 lists the stakeholders considered in the solution in the scope of the CBA. They provide also an overview of the costs they will afford to deploy the solution (if any) and the benefits generated by its implementation (if any, including indirect benefits on stakeholders not investing in solution deployment). It also reports if the stakeholder was involved in the CBA production and whether the related costs and benefits have been finally included in the CBA calculations.

[1] 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.

3.4.1 Solution PJ.02-W2-21.1

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
ANSP	ANSP providing ATS Aerodrome services at the deploying airports (Very Large, Large and Medium Airports)	Costs: investments to be done in the ANSP systems to include the functionalities needed to provide the alerts to the controller working positions Benefits: Controllers will have improved situational awareness, will avoid last minute actions and avoid the workload associated with the occurrence of a hazardous events. Additionally, avoided safety incidents/accidents will avoid the loss of ANS charges.	To provide cost estimates for ground system upgrades. These cost estimates are requested to be provided not only by ANSPs but also by Industry Partners. The provision of cost estimates is not related to the involvement in validation.	ANSP costs included in this CBA version. Avoided loss of ANS charges in case of cancellations is quantified. ANSP benefits of increased situational awareness are not monetised (as not expected to change in ATCO Hours in Ops – CEF2 KPI)
Airport Operators	Very Large, Large and Medium airports	Costs: No costs - the surveillance infrastructure at the airports is considered as a prerequisite Benefits: Airport operators will have fewer hazardous situations and will therefore avoid the workload and costs associated with the resulting impacts (runway closure, reduced capacity, …)	Not involved	Avoided loss of airport charges and avoided costs of repairs of colliding ground vehicles considered as benefits in the CBA
Network Manager	Network	Costs: No costs Benefits: NM will avoid the effort associated with managing the consequences of a hazardous event (cancellations,	Not involved	No costs or monetised benefits in this CBA version

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
		diversions, delays) – not monetised		
Airspace Users: - Scheduled Airlines (Mainline / Regional) - Business Aviation - Rotorcraft - General Aviation IFR / VFR	CBA focuses on Scheduled Airlines (Mainline / Regional) Specific fleet depends on the airports that deploy	Costs: No costs Benefits: Avoided hazardous events will avoid cancellations, diversions and delay, including also costs related to aircraft damages	Not involved	CBA includes monetised benefits for Scheduled Airlines (Mainline and Regional) in terms of delays, cancellations, diversions and aircraft damages
Airspace Users – Ground (FOC)	Flight Operation Centres for the fleet operating at deploying airports	Costs: No costs Benefits: Avoided workload associated with managing cancellations, diversions, delay. Avoided costs associated with managing damage to an aircraft (rescheduling, admin, lease replacement aircraft – if needed, …)	Not involved	No costs or monetised benefits in this CBA version
Military – Airborne	Military fleet operating at an airport that deploys	Costs: No costs Benefits: Military aircraft using airports that deploy the solution would get the same benefits as civil AU, although overall impact expected to be very low considering traffic volumes comparison, so not included separately in the CBA.	Not involved	No separate military costs or monetised benefits in this CBA version
Military – Ground	Military ATS Aerodrome Service Provider depending on	Costs: No costs as it is assumed that either (a) deployment will be made by civil ANSPs operating at the deploying airports or (b) the military costs will be	Not involved	No separate military costs or monetised benefits in this CBA version. According to the Airport OE

Co-funded by the European Union

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
	deploying airports Military Airport Operator	the same as for the civil (if applicable) Benefits: As for civil ANSP and Airport Operators		repository, airports in scope are Civil or Civil/Military, but not only Military.
Other impacted stakeholders (ground handling, weather forecast service provider, NSA….)	Ground handlers Catering Fuel providers …	Costs: No costs Benefits: Stakeholders that have vehicles operating at the airport which may be involved in a hazardous event or whose operations could be impacted/delayed due to a hazardous event	Not involved	Avoided costs related to a safety accident between an aircraft and a ground vehicle are monetised in this CBA as part of Airport Operator.

Table 6: SESAR Solution PJ.02-W2-21.1 CBA Stakeholders and impacts

3.5 CBA Scenarios and Assumptions

This CBA aims at providing sufficient results about the economic and financial viability of deploying this SESAR solution at the European level, calculated as the difference between the solution scenario proposed and a reference scenario, where the solution would not be deployed. The reference scenario is built considering what has already been introduced by SESAR 1 and relevant to the solution considered.

The CBA uses therefore a delta approach, i.e. solution scenario identifies all the additional elements that will have to be put in place on top of what is assumed to be already deployed or part of the reference scenario.

3.5.1 Reference Scenario

The reference scenario considers the future situation without the deployment of the solution in the scope of this CBA. This solution requires a set of prerequisites which will be listed and described in paragraph 3.5.3.1 whose costs and benefits are not accounted for in this CBA. This scenario will not be quantified but only used to assess the delta that the solution will bring.

3.5.2 Solution Scenario

The solution scenario estimates the potential benefits and costs derived from the implementation of the solution upon the reference scenario, considering such impacts as a delta. The main new functionalities introduced by the solution have been already summarised in chapter 3.2 and more information could be found in the OSED document. The enablers considered in the solution are summarised in the next paragraphs and related tables, whereas additional characteristics of the scenario are collected in the next paragraph and related tables, in terms of deployment prerequisites, geographical scope, time-horizon and traffic evolution.

The solution scenario concerns the deployment of SESAR solution PJ.02-W2-21.1 described in paragraph 3.2.1 and based on the OI step AO-0104-B, which is composed of the enablers reported in Table 7.

PJ.02-W2-21.1 Solution	
Enabler	**Description**
AERODROME-ATC-06b	A-SMGCS incorporating the function that detects Conflicting ATC Clearances (CATC) on the entire airport surface
AERODROME-ATC-07b	A-SMGCS incorporating the function that provides an advanced set of Conformance Monitoring Alerts for Controllers (CMAC) on the movement area
AERODROME-ATC-115	A-SMGCS incorporating the function that provides RMCA/CMAC vs ATC Clearance alerts
AERODROME-ATC-116	A-SMGCS incorporating the function that provides Runway-Busy notifications

Table 7: PJ.02-W2-21.1 Solution Enablers list

3.5.3 Assumptions

This paragraph describes the main assumptions taken in terms of deployment prerequisites, geographical scope, time horizon of the solution and traffic evolution, which are relevant for the definition of the scope of this CBA. Additional assumptions are presented also in the following chapters, embedded into the explanation of the methodologies applied for the costs and benefits quantification.

3.5.3.1 Deployment prerequisites

The prerequisites assumed to be in place at the airports in the scope of this solution (by the IOC date at the latest) are:

- ATC systems are already equipped with A-SMGCS, including the CATC and CMAC alerting functions defined in the scope of the SESAR 1 Solution #02 (AO-0104-A), as defined in the MP L3 implementation objective AOP12,
- ATS systems are already equipped with Electronic Flight Strips (EFS),
- ATS systems are already equipped with A-SMGCS, including the Airport Safety Support Service defined in the scope of the SESAR 1 solution #02 (AO-0104-A), as defined in the MP L3 implementation objective AOP12.1

3.5.3.2 Geographical Scope

The solution scenario considers the deployment of the OI step at the relevant airport operating environments as shown in Table 8, which is based on the airport classification reported in Table 9.

Appendix C provides a complete list of which may be the deployment locations, providing also additional information about airports' volume of traffic. The airport list presented is produced to give a high-level overview of which airports may take advantage in the future of the solution functionalities and does not constitute any commitment regarding deployment.

Solution	Number of potential airports			Notes
	Very Large	Large	Medium	
21.1	13	12	3	*Considering the mandatory prerequisites defined in the previous paragraph for the implementation of the solution, the geographical scope of the CBA has been reduced only to the airport that are currently included in the MP L3 implementation objective AOP12.1*

Table 8: PJ.02-W2-21.1 potential implementation locations

	Operating Environment Categories (OEs)			
Overall Category	"Network"			
Primary Categories (OEs)	"En-route"	"Terminal"	"Airport"	
Secondary Categories (Sub-OEs)			Annual airport's movements (range)	Sub-OEs
			>250 000	Very large
			[250 000; 150 000]	Large
			(150 000; 40 000]	Medium
			(40 000; 15 000]	Small
			< 15 000	Other
			No available data	Not classified

Table 9: Airport Classification scheme according to OEs

	Airport OE	Nº of airports	Location list
Solution 21.1	Very Large	13	Frankfurt, Amsterdam, Paris, London Heathrow, Muenchen, Madrid Barajas, Barcelona El Prat, Roma Fiumicino, London Gatwick, Zurich, Kobenhavn, Oslo, Wien-Schwechat.
	Large	12	Stockholm, Dublin, Paris-Orly, Brussels, Palma de Mallorca, Duesseldorf, Manchester, London Stansted, Milano, Chopina W Warszawie, Berlin-Tegel, Praha.
	Medium	3	Nice-Cote D'azur, Budapest Liszt Ferenc International, Luxembourg

Table 10: CBA geographical scope of solution PJ.02-W2-21.1

It must be reminded that the solution scenario considers a simplified situation involving the deployment of the solution in the number of airports in each applicable operating environment. It does not consider specific requirements and constraints of any specific airport.

3.5.3.3 Time-Horizon of the CBA

The deployment timeframe of the CBA is based on the combination of the expected implementation timeframes of the solution OI steps / Enablers previously introduced and summarised in Table 11:

- Deployment Start date(s) – reflect the start of investments for the first deployment location (assumed 2 years before the start of benefit generation),
- Deployment End date(s) – reflect the end of the investments for the final deployment location (equivalent to the FOC date),
- Initial and Final Operating Capability (IOC/FOC dates) – reflect the ramp-up of benefits across the ECAC area, as more locations deploy the solution.

OI step	Deployment Start date	Deployment End date	Initial Operating Capability (IOC)	Final Operating Capability (FOC)
AO-0104-B	18/04/2025	18/04/2027	18/04/2027	18/04/2031

Table 11: SESAR Solution PJ.02-W2-21.1 Deployment timeframe

Figure 2 summarises the key dates implemented in the CBA model. For simplicity and thanks to the almost correspondent key milestones of the solution, a unique investments and benefits generation timeframe is considered for the definition of the overall CBA time horizon. Figure 2 summarises the key dates implemented in the CBA model.

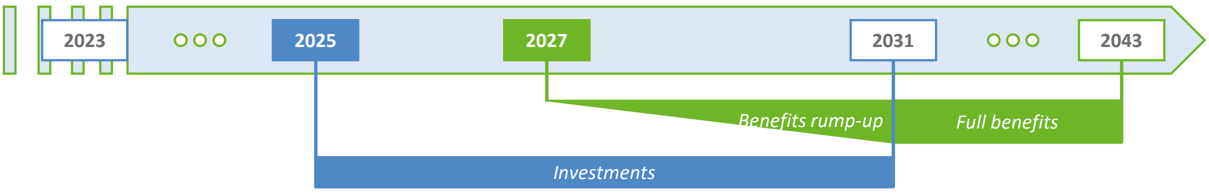


Figure 2: Overall CBA implementation and benefit timeframes

3.5.3.4 Traffic Evolution

The traffic evolution values were taken from the “STATFOR Long-term forecast 2019-2040 Challenges of Growth” already embedded in the CBA model 7.3.8 [4] for SESAR solutions. The traffic forecast is assumed to growth approximately 53% from 11.7 M flights in 2022 to 16.2 M flights in 2043.

EUROPEAN PARTNERSHIP
Co-funded by the European Union

4 Benefits

This section provides an overview of the monetised benefits generated in the case of implementation of the solution under analysis. Such benefits are monetised according to the SESAR Performance Framework [3].

The benefits analysis starts with the review of the Benefit Impact Mechanisms (BIMs) defined in the OSED and reported in Appendix B. Once identified the impacted KPAs and KPIs, the performance results obtained during the validation exercises and qualitative performance estimations reported in the VALR [24], PAR [23], and SAR [25] are analysed. These values are translated into monetary values in the CBA according to the two benefits groups methodologies previously introduced. Figure 3 summarises the methodology presented.

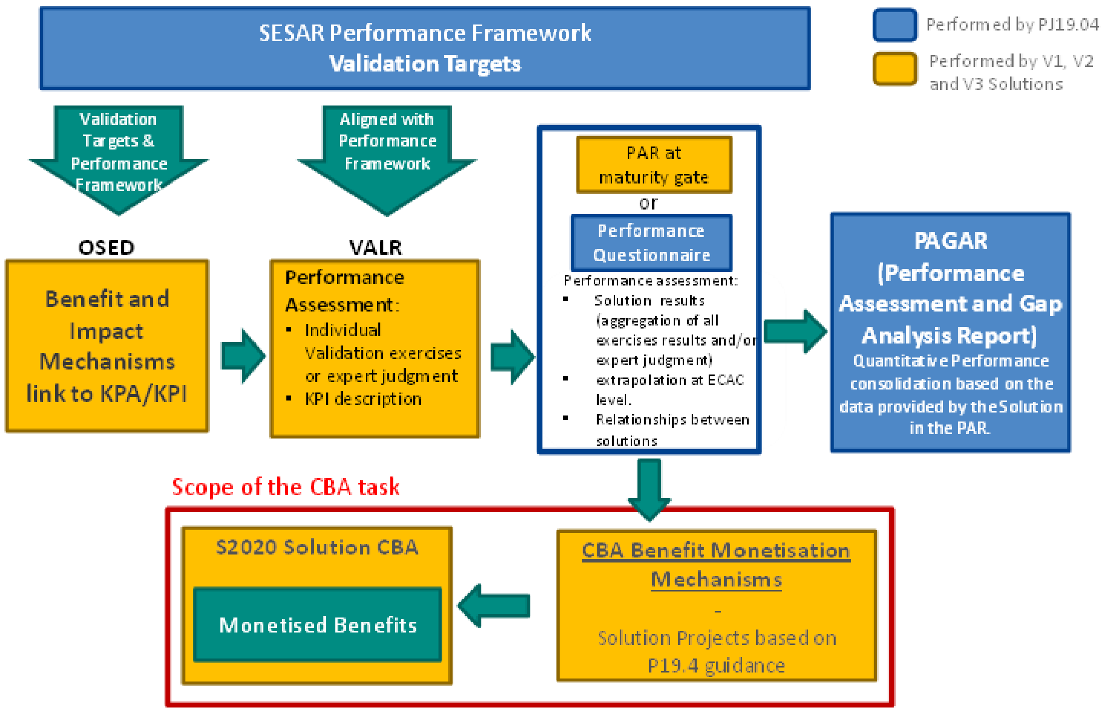


Figure 3: CBA Logic Model

4.1 Overall benefits assessment

This chapter presents the methodology and computations performed in the benefits assessment. A more detailed benefits distribution per stakeholder group has been implemented in the CBA model to extract results that will be shown in section 7.

4.1.1 Benefits Monetisation related to the Performance Framework

Since the solution has impacts only on Safety, Resilience and Human Performance KPAs, Table 12 does not provide useful insights about the benefits assessed during the VALR [24] and PAR [23] activities. It is maintained as part of the template structure.

Performance Framework KPA[1]	Focus Area	KPI/PI from the Performance Framework	Unit	Metric for the CBA	Unit	2024	2026	2030
Cost Efficiency	ANS Cost efficiency	**CEF2** Flights per ATCO-Hour on duty (thanks to increase automation)	%	ATCO employment Cost change	M€/year (undiscounted)	Not addressed by the solution and not included in the CBA.		
				Support Staff Employment Cost Change	M€/year (undiscounted)			
				Non-staff Operating Costs Change	M€/year (undiscounted)			
		CEF3 Technology cost per flight	EUR / flight	G2G ANS cost changes related to technology and equipment	€/year			
	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			
		AUC4 Indirect operating costs for an airspace user	EUR / flight	Impact on operating costs that don't relate to a specific flight. Examples: parking charges, crew and	€/year			

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

Performance Framework KPA[1]	Focus Area	KPI/PI from the Performance Framework	Unit	Metric for the CBA	Unit	2024	2026	2030
				cabin salary, handling prices at Base Stations				
		AUC5 Overhead costs for an airspace user	EUR / flight	Impact on overhead costs. Examples: dispatchers, training, IT infrastructure, sales.	€/year			
Capacity	Airspace capacity	**CAP1** TMA throughput, in challenging airspace, per unit time	% and # movements	Tactical delay cost (avoided-; additional +)	€/year	Not addressed by the solution and not included in the CBA.		
			% and # movements	Strategic delay cost (avoided-; additional +)	€/year			
		CAP2 En-route throughput, in challenging airspace, per unit time	% and # movements	Tactical delay cost (avoided-; additional +)	€/year			
			% and # movements	Strategic delay cost (avoided-; additional +)	€/year			
	Airport capacity	**CAP3** Peak Runway Throughput (Mixed mode)	% and # movements	Value of additional flights	€/year			
Resilience	Resilience	**RES4a** Minutes of delays	Minutes	Tactical delay cost (avoided-; additional +)	€/year	Quantified in chapter 4.2.		
		RES4b Cancellations	% and # movements	Cost of cancellations	€/year			
		Diversions	% and # movements	Cost of diversions	€/year			

Performance Framework KPA[1]	Focus Area	KPI/PI from the Performance Framework	Unit	Metric for the CBA	Unit	2024	2026	2030
Predictability and punctuality	Predictability	**PRD1** Variance of Difference in actual & Flight Plan or RBT durations	Minutes^2	Strategic delay cost (avoided-; additional +)	€/year	Not addressed by the solution and not included in the CBA.		
	Punctuality	**PUN1** % Departures < +/- 3 mins vs. schedule due to ATM causes	% (and # movements)	Tactical delay cost (avoided-; additional +)	€/year	Not addressed by the solution and not included in the CBA.		
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	Not addressed by the solution and not included in the CBA.		
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 +)	€/year	Not addressed by the solution and not included in the CBA.		
	Fuel Efficiency	**FEFF1** Average fuel burn per flight	Kg fuel per movement	Fuel Costs	€/year			

Performance Framework KPA[1]	Focus Area	KPI/PI from the Performance Framework	Unit	Metric for the CBA	Unit	2024	2026	2030
	Fuel Efficiency	**FEFF2** CO2 Emissions	Kg CO2 per movement	CO2 Costs	€/year			
Civil-Military Cooperation & Coordination	Civil-Military Cooperation & Coordination	**CMC2.1a** Fuel saving (for GAT operations)	Kg fuel per movement	Fuel Costs	€/year	Not addressed by the solution and not included in the CBA.		
		CMC2.1b Distance saving (for GAT operations)	NM per movement	Time Costs	€/year			

Table 12: Results of the benefits monetisation per KPA

4.2 Safety benefits per stakeholder group

Benefit Impact Mechanisms (BIMs) defined in the OSED [15] and listed in Appendix B, clearly state how the solution PJ.02-W2-21.1 has impacts mainly on Safety, Resilience and Human Performance KPAs, which have been quantified. It should be also considered that the Safety KPA is a transversal area impacting indirectly on other ones. In this specific case, it can be observed as the happening of a safety occurrence will have an impact on the Airport Resilience (considered in the BIMs), enabling the estimation of part of the benefits in terms of avoided costs of delays, cancellations and diversions.

Starting from an assessment of the number of safety occurrences that may be reduced by the solution, benefits are quantified following the approach initially used in the V2 CBA of Solution PJ.03b-01 based on the methodology proposed by the PJ.19-04 to monetise safety benefits within solution CBAs. The approach compares the solution scenario (where the hazardous situation is avoided) with the reference scenario (where the hazardous situation occurs), being the benefit delta the solution could bring.

The main source of safety related information used for the quantification of the number of safety occurrences in scope of the solution is the Annual Safety Review (ASR) 2020 [18] prepared by EASA, combined with the information provided by the ICAO iSTAR tool [12], when further information is needed. Such information is considered as valid, as reporting safety occurrences happened in 2019: year with the highest traffic levels before the advent of COVID-19 pandemic. Additional assumptions, which will be explained when required along the analysis, had to be taken in order to complete the benefits quantification.

The main safety benefit estimated in the scope of this CBA are presented in Figure 4, and further on described in next chapters.

Figure 4: Safety benefits and impacted stakeholders

4.2.1 Airspace Users (AUs)

Two types of benefits are considered for the AUs and derived from the avoidance of hazardous events in taxiway and runway: avoided costs in terms of cancellations, diversions and delays, and avoided costs of repairs of physical damages that are caused to the aircraft involved in the safety accident. Due to the limited availability of safety information and in particular of specific safety reports for runway and taxiway events, numerous assumptions had to be taken based on the analysis of the available information.

The assessment of safety benefits starts with the identification of the number and distribution of serious incidents and accidents in 2019 in the "ATM and ANS" and "Aerodrome and Ground handling" domains, which could be avoided in taxiway and runway thanks to the implementation of the solution. Figure 5 shows the methodology considered, starting with the total number of serious incidents and accidents in 2019, as extracted from the EASA ASR 2020, and further on described.

In order to obtain the maximum number of safety occurrences that may be avoided thanks to the implementation of the solution, the total number of annual occurrences should be reduced considering the geographical scope (i.e. distribution per airport type – described in paragraph 3.5.3.2) and the percentage of occurrences that effectively happens while using a runway or taxiway, or in the really initial phase of climbing after take-off.

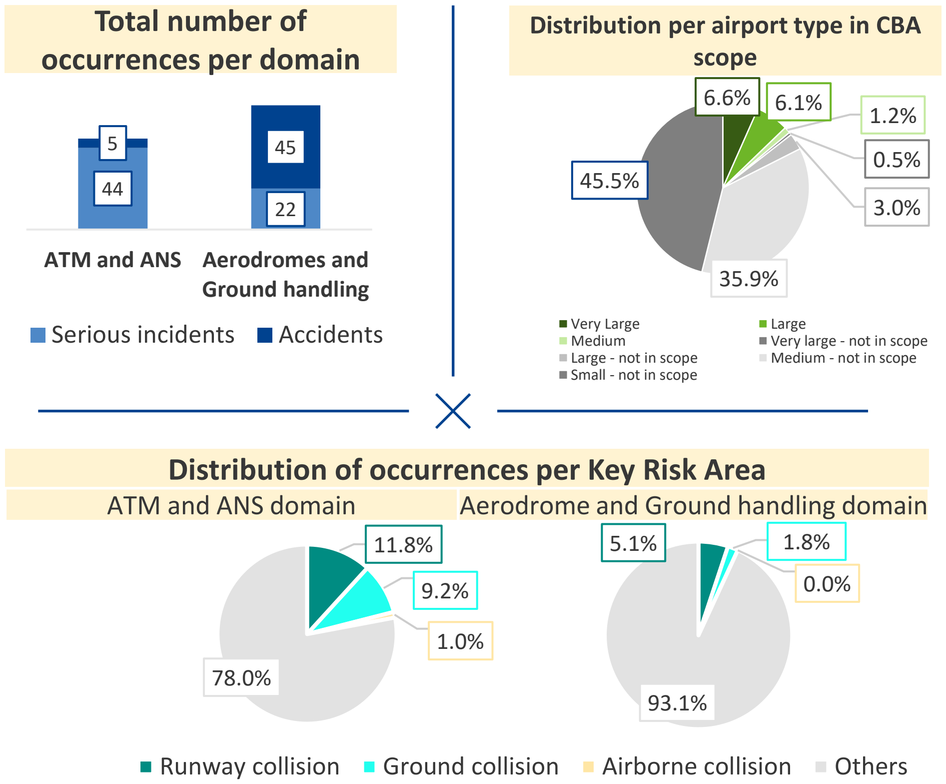


Figure 5: Quantification of safety accidents and serious incidents in 2019 in scope of the solution [18]

As the effective distribution per type of the occurrences is not clearly provided in the ASR, it had to be calculated taking into account the comparisons per key risk areas[3] provided by the report. Figure 6 shows the graph extracted from the EASA ASR for the "ATM and ANS" domain and the methodology

[3] A key risk area is defined by its potential accident outcome and by the immediate precursors of that accident outcome. In other words, each area collects the number of occurrences that lead or could have led to a specific type of accident (e.g. Runway collision)

applied for the extraction of the weighted distribution presented in Figure 5 (i.e. distribution of occurrences per key risk area).

The calculation of this weighted distribution leverages on a 3-step approach:

1. Key Risk Areas of relevance for the solution are identified: these are Runway and Airborne collision for occurrences in runways, and Ground collisions for occurrences in taxiways,

2. The X-axis component of the different areas reported in the graph are compared and their proportionality extracted,

3. Such longitudinal proportionality is converted into a weighted distribution, obtaining the percentages that are finally used in the calculation of the number of occurrences in scope of the solution.

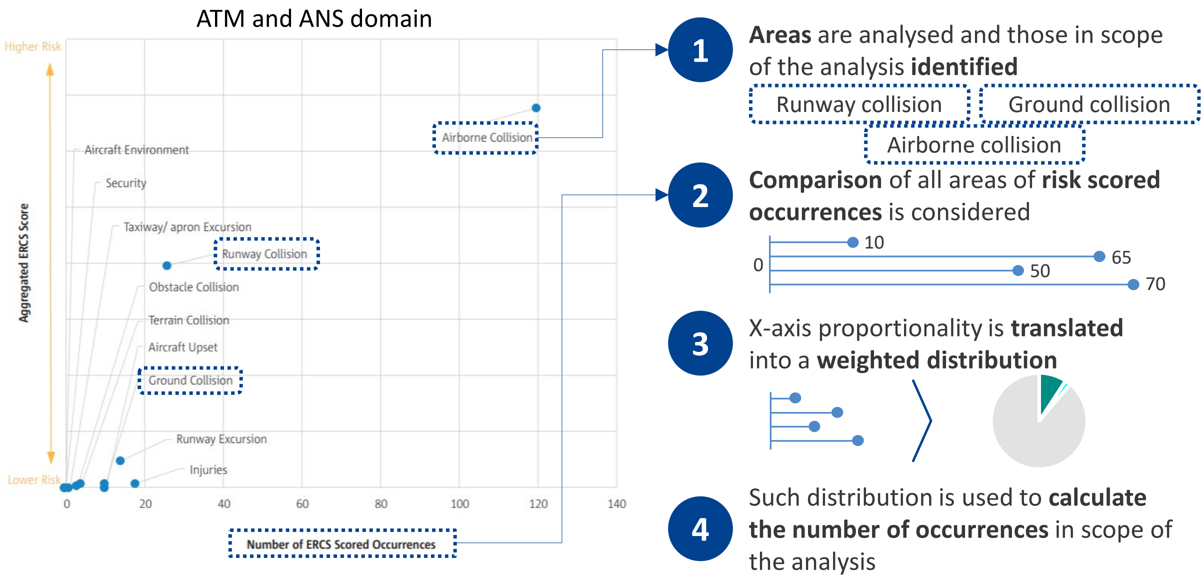
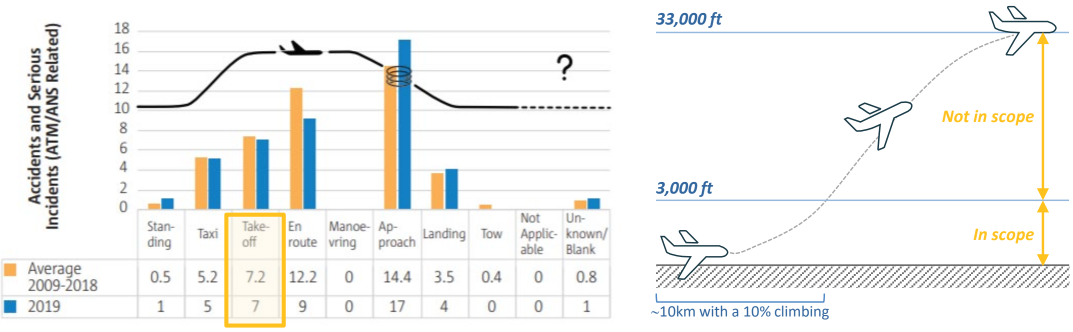


Figure 6: Methodology for the extraction of the distribution of occurrences per Key Risk Areas in ATM and ANS domain [18]

It should be clarified that the "Airborne collision" area is specific for the take-off vs. take-off alert described in the OSED [15], which has a limited coverage area that should be integrated in the assessment of the relevant number of occurrences. Therefore, the number of resulting safety occurrences for this area is reduced to a 18.9%, considering as relevant only those occurring during the climbing phase after take-off (i.e. occurrences identified as take-off in Figure 7; 7 out of 37). Then, only the initial phase of climbing is considered, assumed to be limited by a maximum altitude of 3,000 ft. w.r.t. an en-route flight altitude of 33,000 ft. (i.e. 9.1% of take-off occurrences presented in Figure 7). This last assumption is needed in order to limit the potential scope of the alert, focusing only on converging SIDs potentially leading to an airborne collision near the airport.



	Stan-ding	Taxi	Take-off	En route	Manoe-vring	Ap-proach	Landing	Tow	Not Applic-able	Un-known/ Blank
Average 2009-2018	0.5	5.2	7.2	12.2	0	14.4	3.5	0.4	0	0.8
2019	1	5	7	9	0	17	4	0	0	1

Figure 7: Distribution of occurrence per phase of flight [18]

A similar methodology has been applied for the "Aerodrome and Ground handling domain", as shown in Figure 8. It should be noted that in this case the taxiway occurrences are not presented separately in the graph, but they are included in the "Ground damage" key risk area (including damages caused while loading or unloading the aircraft). As additional assumption, a 3% of the occurrences of this new area have been considered in substitution of the missing "Ground collision" one. Moreover, "Airborne collision" area has not been considered as not relevant for the scope of the solution in this domain, thus runway occurrences are estimated only through the "Runway collision" area.

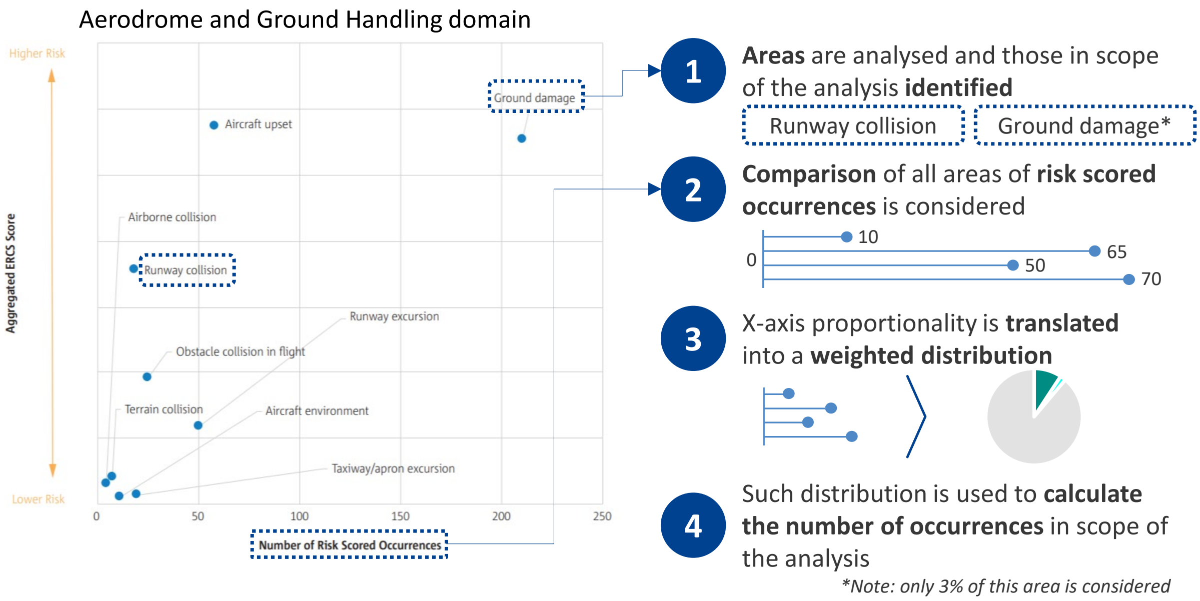


Figure 8: Methodology for the extraction of the distribution of occurrences per Key Risk Areas in Aerodrome and Ground Handling domain [18]

Then, the distribution per type of airport has been calculated considering the geographical distribution of occurrences in EU airports collected in the ICAO iSTAR tool [20]. Initial distribution has been decreased considering the effective geographical scope of the CBA, not considering thus the portion of airports not implementing the MP L3 objective AOP12 (prerequisite of the solution as stated in paragraph 3.5.3.1). Figure 9 summarises the calculations done.

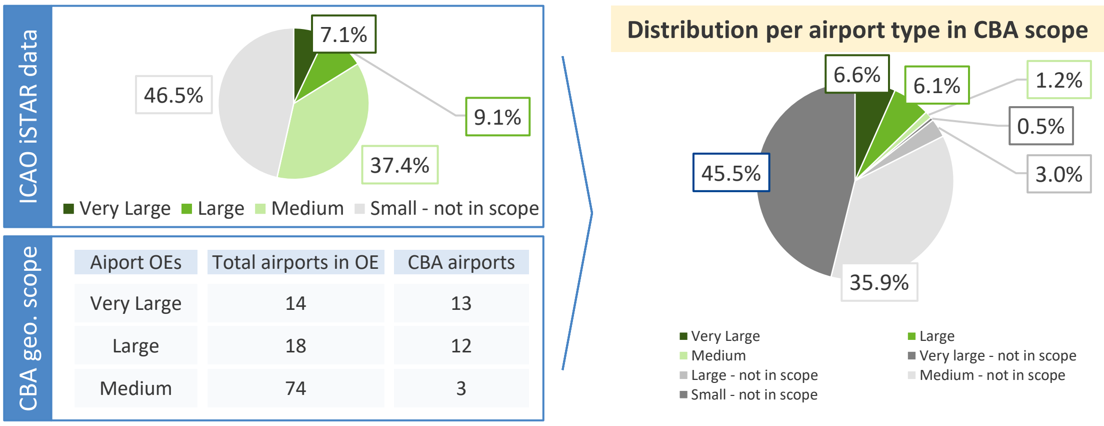


Figure 9: Distribution per airport type calculation [18]

Taken into account the data from Figure 5, the maximum number of avoidable safety occurrences are:

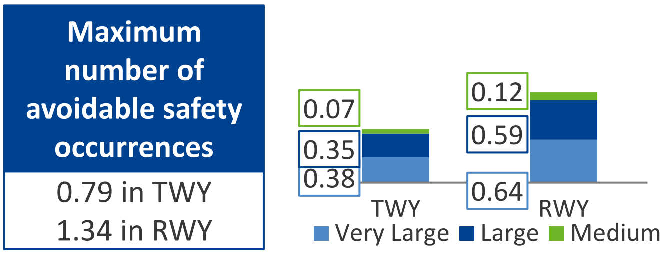


Figure 10: Maximum number of avoidable safety occurrences per year

Given such estimations, the number of occurrences that could be finally avoided with the implementation of the solution and monetised in the next paragraphs is evaluated as the 55.5%[4] for Taxiways and 64.1% for Runways of maximum ones:

- **Taxiway (Ground collision area)**: 0.44 annual occurrences, of which 0.19 accidents and 0.25 serious incidents,
- **Runway (Runway and Airborne collision areas)**: 0.86 annual occurrences, of which 0.37 accidents and 0.49 serious incidents.

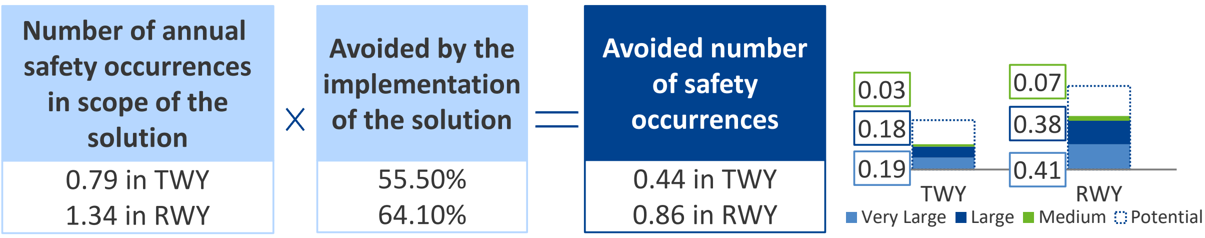


Figure 11: Resulting safety occurrences per year in scope of solution 21.1

[4] Those figures have been obtained from PAR, chapter 4.3.2

4.2.1.1 Taxiway hazardous events

This paragraph presents the methodology used to monetise the impacts related to a hazardous event occurring on the taxiway at an airport in scope of the CBA, for example, a deadlock situation where two aircraft come nose-to-nose or even collide and are unable to get out of the situation without one of them being towed.

The taxiway occurrences monetisation formula is shown in Figure 12. The number of cancellations, diversions and delays used by the formula is estimated and monetised in next paragraph.

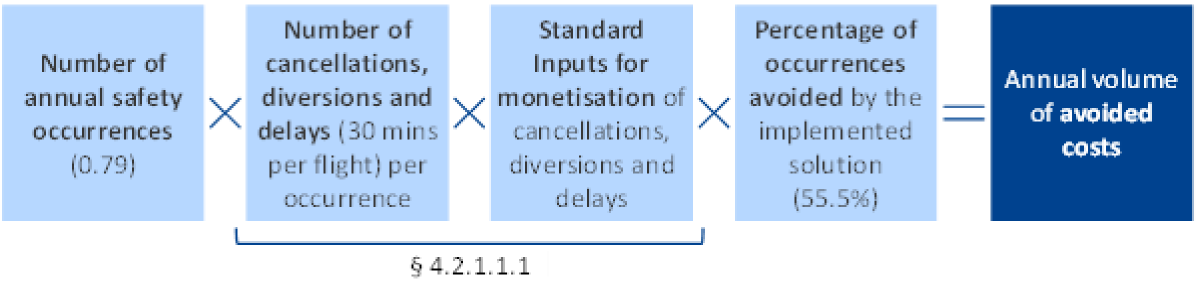


Figure 12: Taxiway occurrences monetisation mechanism

4.2.1.1.1 Number of cancellations, diversions and delays estimation and monetisation

In the CBA, it is assumed the existence of an alternative taxi-route for other aircraft to use to reach the runway or the apron, resulting locally in longer taxi-times. Thus, the loss in airport capacity has been estimated as the half of the loss in the case of accident in runway (-33%, which will be explained more in details in paragraph 4.2.1.2), resulting in an approximate -15% of airport capacity. Additionally, the impact of a safety occurrence is expected to generate impacts extending in time during a 6-hour period.

It should be reminded that these are only assumptions needed to simplify the problem complexity. In fact, actual impacts and duration at a specific airport differs depending on many factors, like the time of day, the demand at the airport, the precise location of the taxiway situation, the taxiway layout, etc. However, as the CBA considers an ECAC-level scenario, it is expected to be sufficient to describe the possible consequences from a more generic point of view.

Figure 13 shows the proposed safety monetisation mechanisms to quantify the impact of the solution in terms of delay, cancellation and deviation costs.

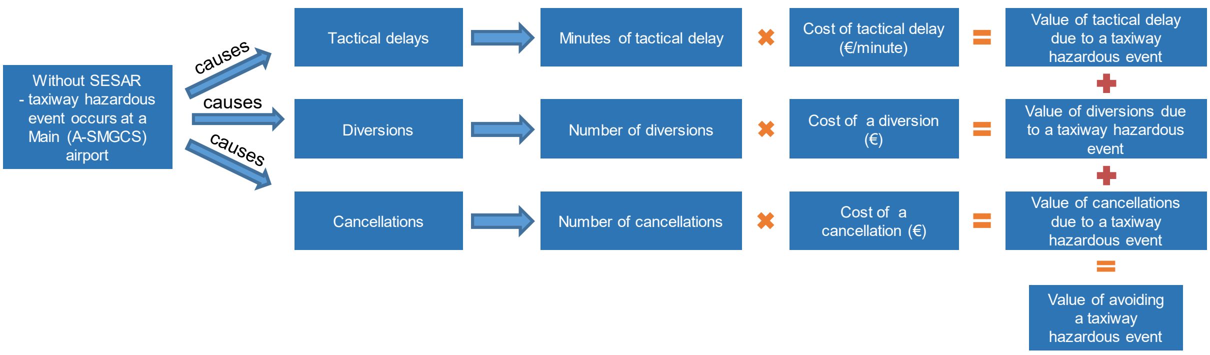


Figure 13: Delays, diversions and cancellations monetisation mechanism for Airspace Users

Figure 14 shows the approach to calculate the number of cancellations, diversions and delay from the capacity reduction value due to a safety occurrence. Taking into account the Annual IFR flight movements in the 28 airports, geographical scope of this CBA, it results a nominal hourly capacity value of 65 flights.

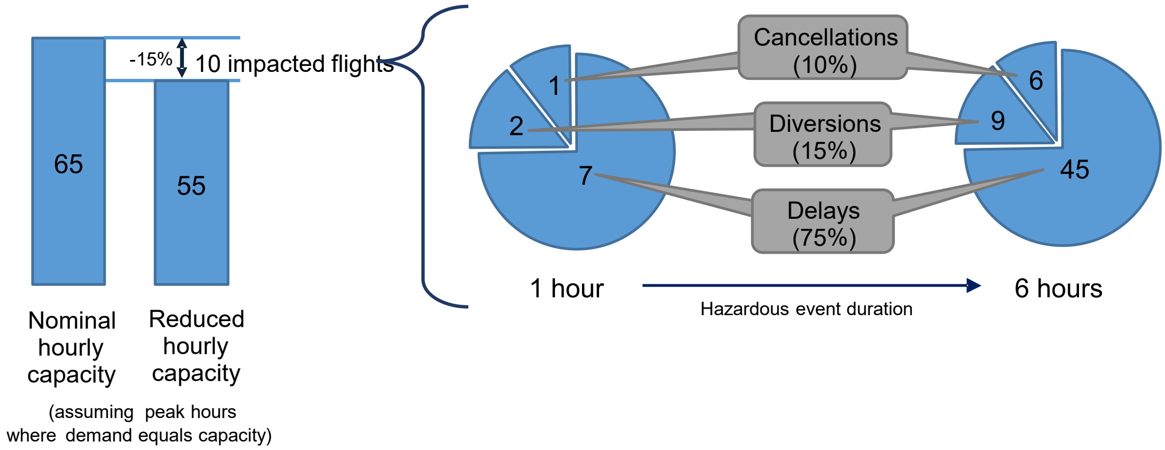


Figure 14: Approach to assess cancellations, diversions and delays – peak hour

Impacts of the safety occurrence are expected to last 6 hours. Monetising these values for such duration gives the value to Airspace Users of 0.236 M€ (see Figure 15). The unitary values for a cancellation, diversion and minute of tactical delay is defined in the EUROCONTROL Standard CBA Inputs [19].

One underlying assumption in this approach is that only the “impacted flights” are effectively considered, i.e. there are no further impacts on the 55 flights of the reduced hourly capacity and their performance would be equivalent to a nominal day.

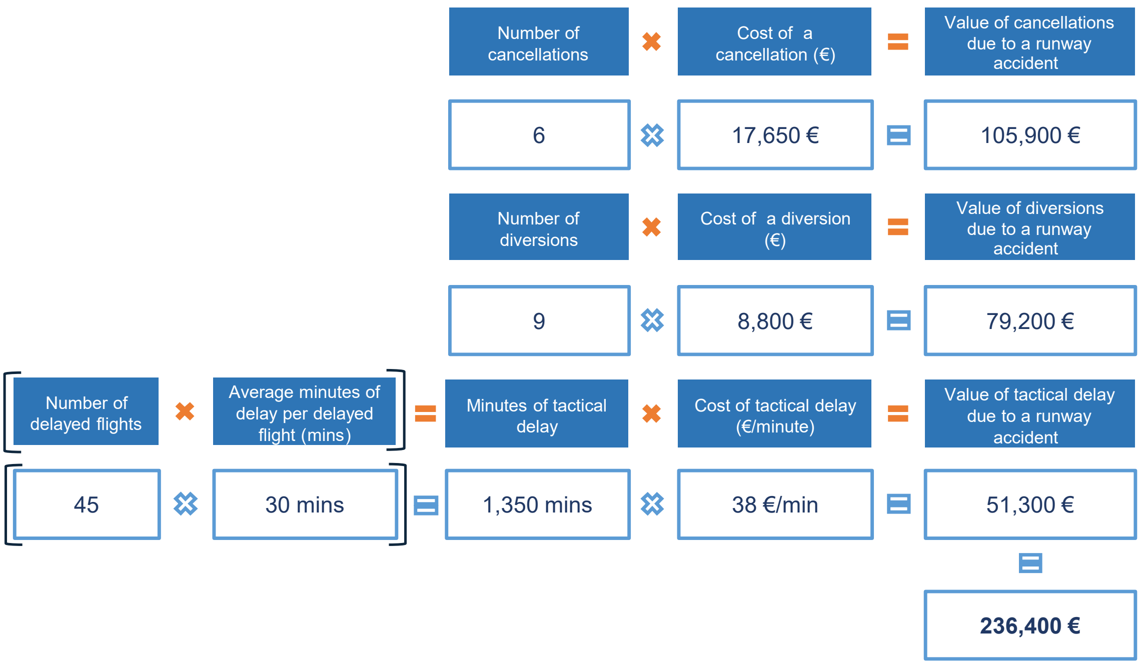


Figure 15: Airspace User Safety Benefit Monetisation Mechanism (peak hours)

The 0.24 M€ benefit is based on the assumption that demand equals capacity at the airport over the whole period of the hazardous event; this maximises the benefits, see the top charts (A) in Figure 16. However, the scale of the benefits will depend on the demand at the airport when the situation occurs and in the following hours. In general:

- High demand (at or close to airport capacity) will cause the scale of the impact to be larger as there is less buffer and delays will start to accrue very quickly, likely leading to diversions and cancellations,
- Lower demand will reduce the benefits as fewer aircraft will be impacted as there will be buffers available to absorb the delays, which will reduce the need for diversions and cancellations.

As presented in the V2 CBA report, Figure 16 shows a view of the impact that airport demand can have on the scale of the benefits. The peaks and troughs in airport demand are not reflected to simplify the figure.

Figure 16: Impact of demand on potential benefits

Figure 17 shows the assumptions used to assess the benefits associated with the middle charts (B) in Figure 16, i.e. when airport demand that is lower than the declared capacity but higher than the reduced capacity following the hazardous event. In this case, there are fewer impacted flights and the percentages of cancellations and diversions are lower, being most of the impacts in terms of delay.

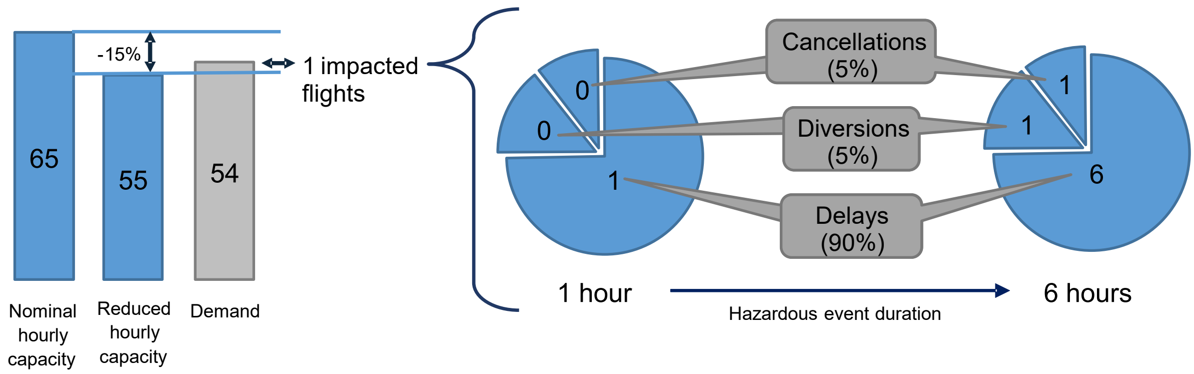


Figure 17: Approach to assess cancellations, diversions and delays – non-peak hour

Monetising these non-peak hour values for the 6-hours duration gives the value to Airspace Users of 0.04 Million Euros (M€), see Figure 18.

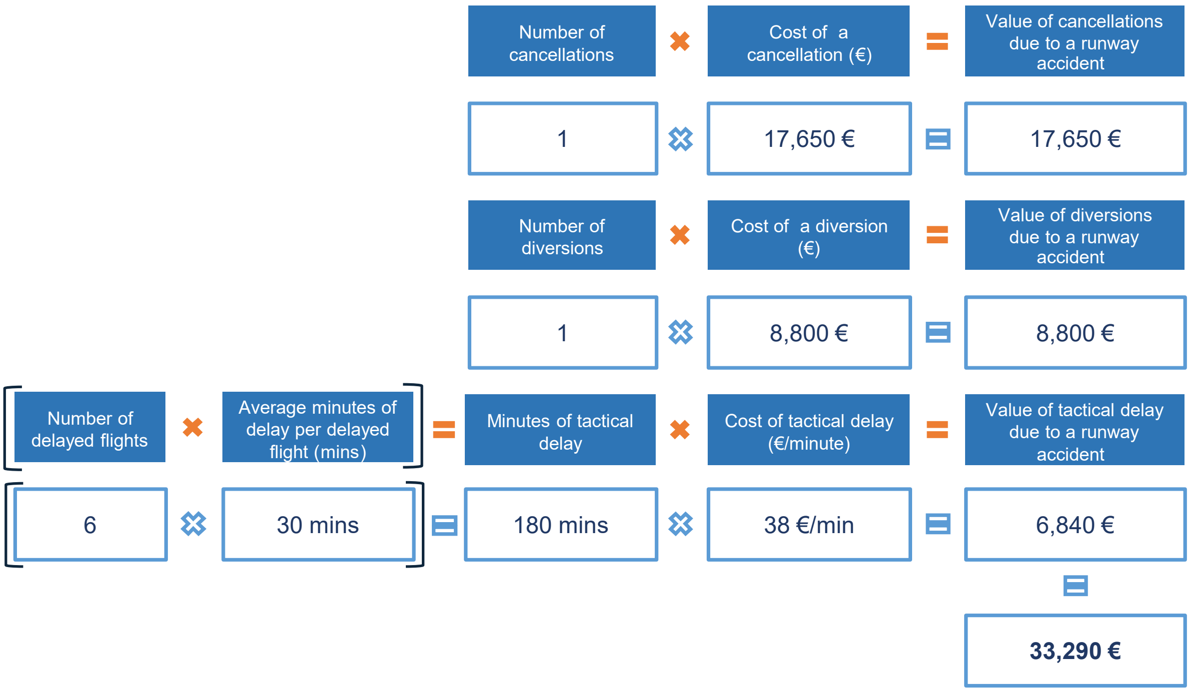


Figure 18: Airspace User Safety Benefit Monetisation Mechanism (non-peak hours)

Within the CBA model, the hazardous events are assumed to be made up of a combination of peak and non-peak hours, being the first case contributing at the 75% and the second at the 25%. See the CBA model in section 6 for more details.

The benefit obtained by the annual number of safety occurrences estimated at the beginning of chapter 4.2 could be now monetised, considering as final assumption that the solution will reduce the total number of safety occurrences by a 55.5% for taxiways and 64.1% for runways (both figures have been obtained from PAR [23] edition 00.01.00, chapter 4.3.2). Figure 19 reports the calculated avoided cost in case of hazardous event in taxiway. Results shown may slightly differ by CBA calculations due to approximation errors.

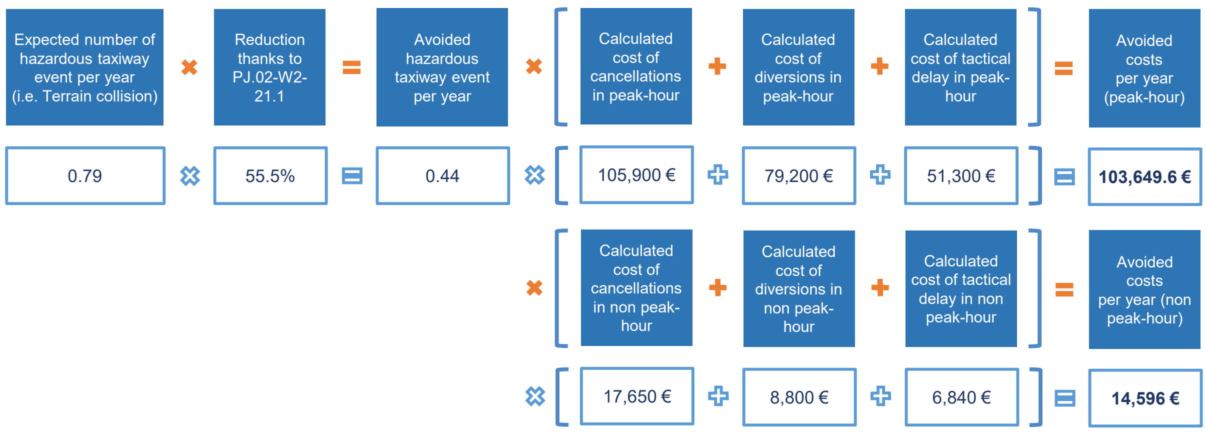


Figure 19: Avoided cost in case of hazardous taxiway event

4.2.1.2 Runway hazardous events

In the case of safety occurrences in a runway of an airport, different scenarios may take place depending on its severity. For the sake of this CBA, two different scenarios are considered, as shown also in the monetisation mechanism of Figure 20:

- **Serious incident**: 30-minutes go-around cost after a missed approach by an AU is estimated, considering that the collision has been avoided,

- **Accident**: the closure of the runway is assumed for a 6-hours period, having a direct impact on the airport capacity, assumed to be linearly proportional to the percentage of runways closed over the total available (e.g. in the case of a 3-runways airport, the closure of one reflects on a 33% of airport capacity reduction).

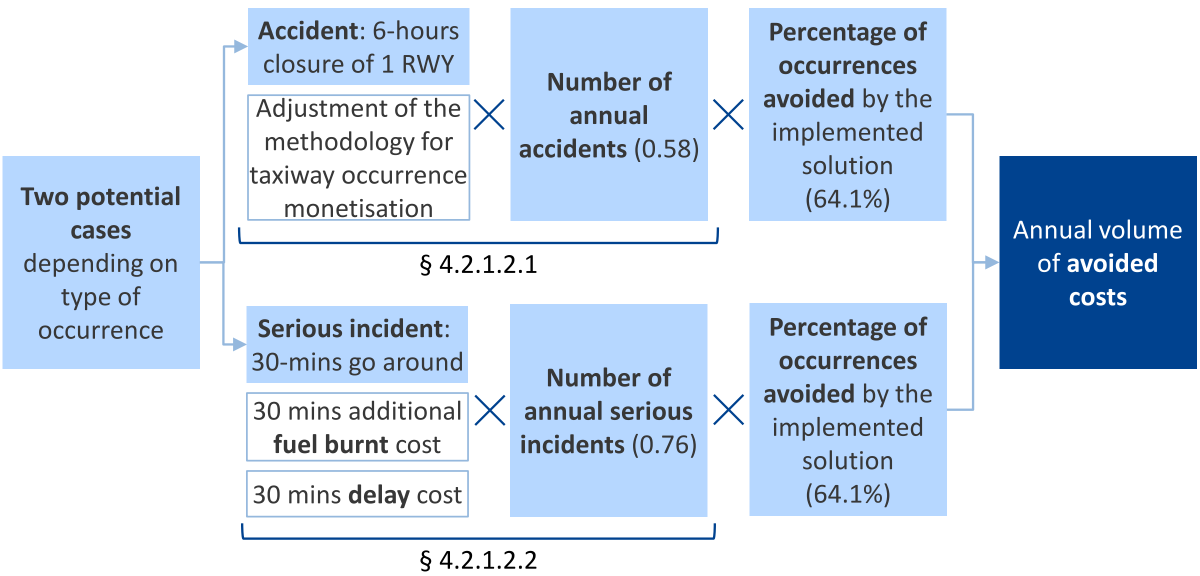


Figure 20: Runway occurrences monetisation mechanism

4.2.1.2.1 Monetisation of runway safety accidents

The first assumption to be done regards the number of runways characterising the sample airport to be considered as reference during the CBA task. From an analysis of the airports in scope of the solution, it has been calculated that the average number of runways is 2.76: thus, a total number of 3 runways has been considered for the sample airport, obtaining slightly more conservative results.

At these conditions, the closure of a runway in case of safety accident will have as consequence the reduction of the airport capacity down to 67%.

The same methodology used for the monetisation of benefits in case of a taxiway occurrence is now used to estimate the benefit in case of a runway accident. Figure 21 reports the number of impacted flights in peak-hour for a runway closure period of 6-hours, whereas Figure 22 the related monetised benefits.

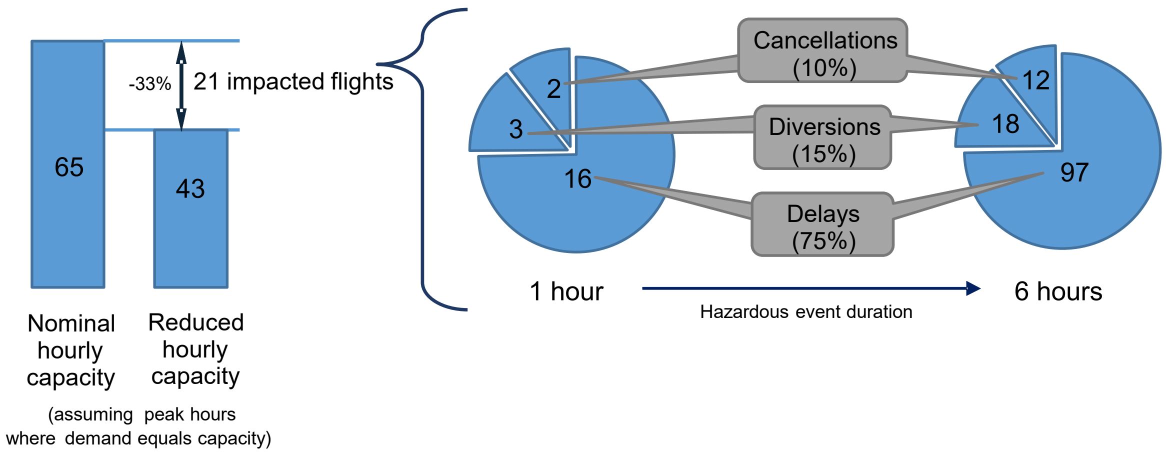


Figure 21: Approach to assess cancellations, diversions and delays – peak hour

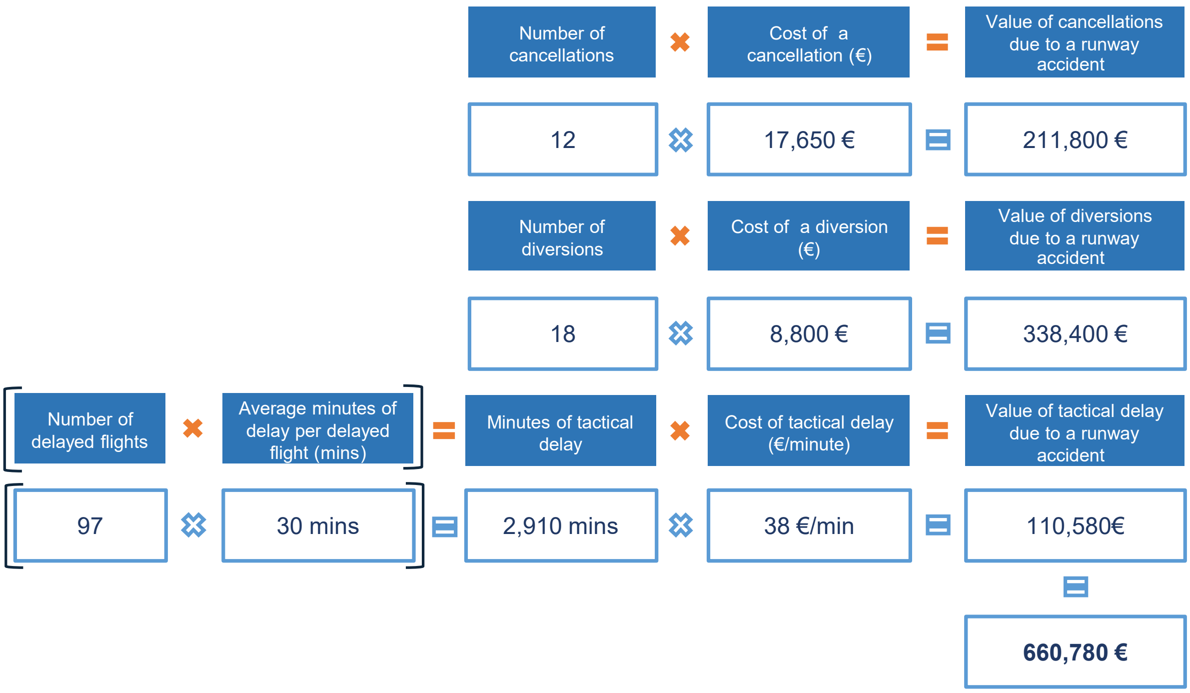


Figure 22: Airspace User Safety Benefit Monetisation Mechanism (peak hours)

Same results are calculated also for the non peak-hour accident case, whose assumptions and calculations are collected in Figure 23 and Figure 24.

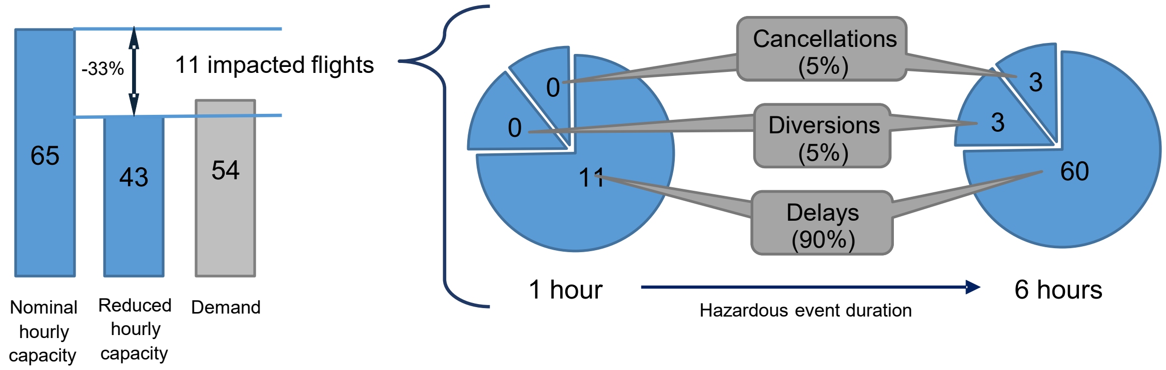


Figure 23: Approach to assess cancellations, diversions and delays – non-peak hour

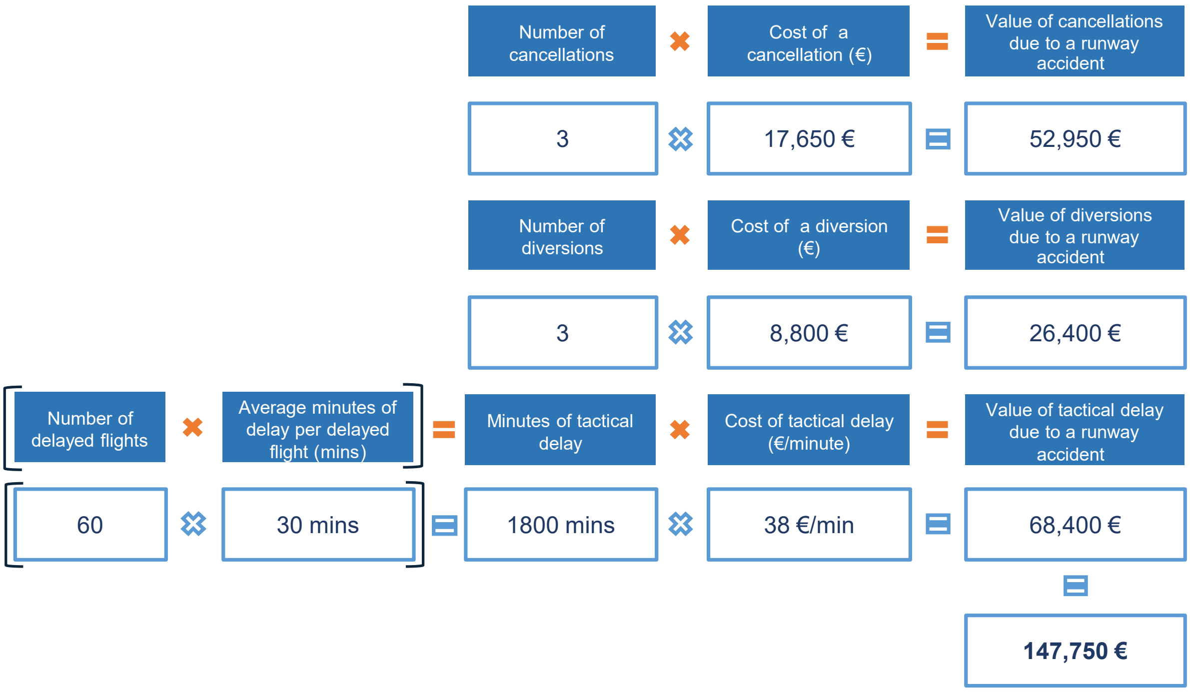


Figure 24: Airspace User Safety Benefit Monetisation Mechanism (non-peak hours)

The benefit obtained by the annual number of safety occurrences estimated at the beginning of chapter 4.2 could be now monetised, considering as final assumption that the solution will reduce the total number of safety occurrences by a 64.1%. Figure 25 reports the calculated avoided cost in case of accident in a runway. Also in this case, the final benefits value is obtained as a combination of the avoided costs in peak-hour and in non-peak-hour cases (75% to 25% contributions).

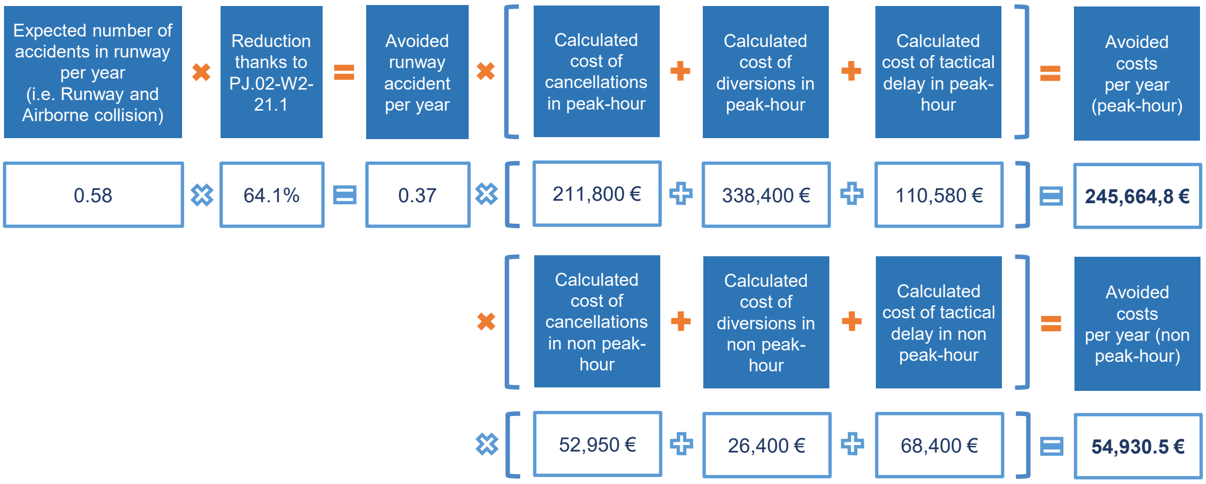


Figure 25: Avoided cost in case of runway accident

4.2.1.2.2 Monetisation of runway safety serious incidents

Serious safety incidents in a runway are assumed to cause the missed approach of a landing aircraft, which will avoid any collision with other objects/vehicles in the runway. The quantifiable benefit is thus equivalent to the cost of fuel burnt in the go-around operation to perform a second tentative approach, after the failure of the first one and the cost of the delay accumulated by the flight. Such operation is assumed to last 30 minutes, average values for cost of fuel and fuel burn rate are extracted from Standard Inputs for CBA by EUROCONTROL.

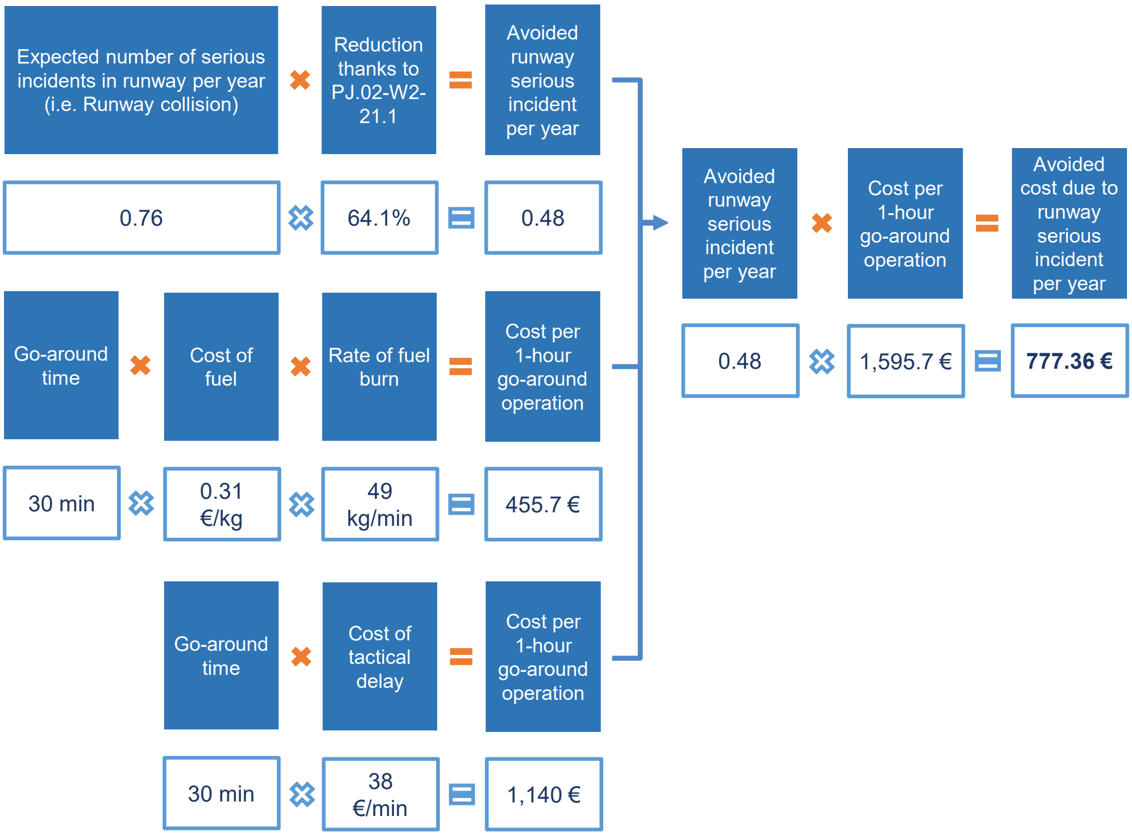


Figure 26: Avoided cost in case of runway serious incident

4.2.1.3 Aircraft damages

The quantification of aircraft physical damages could be assessed correlating the type of occurrence (i.e. accident, serious incident or incident) with the potential degree of damage that correspond to such category. The monetisation mechanism applied for this type of benefits is shown in Figure 27.

Moreover, AU may be covered by a risk-free insurance in the event of accidents. In this sense, the benefits for airspace users would be the reduction of the potential increase of the premium price should an accident occur.

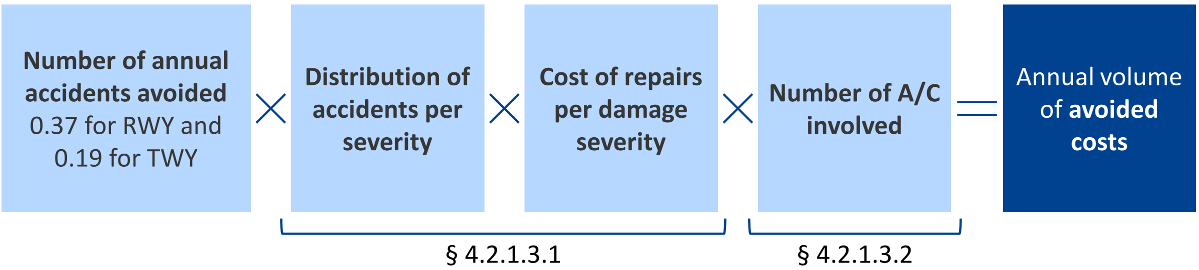


Figure 27: Aircraft damages monetisation mechanism

Figure 28 shows the results of the costs quantification, whereas the main assumptions used are detailed in the following paragraphs.

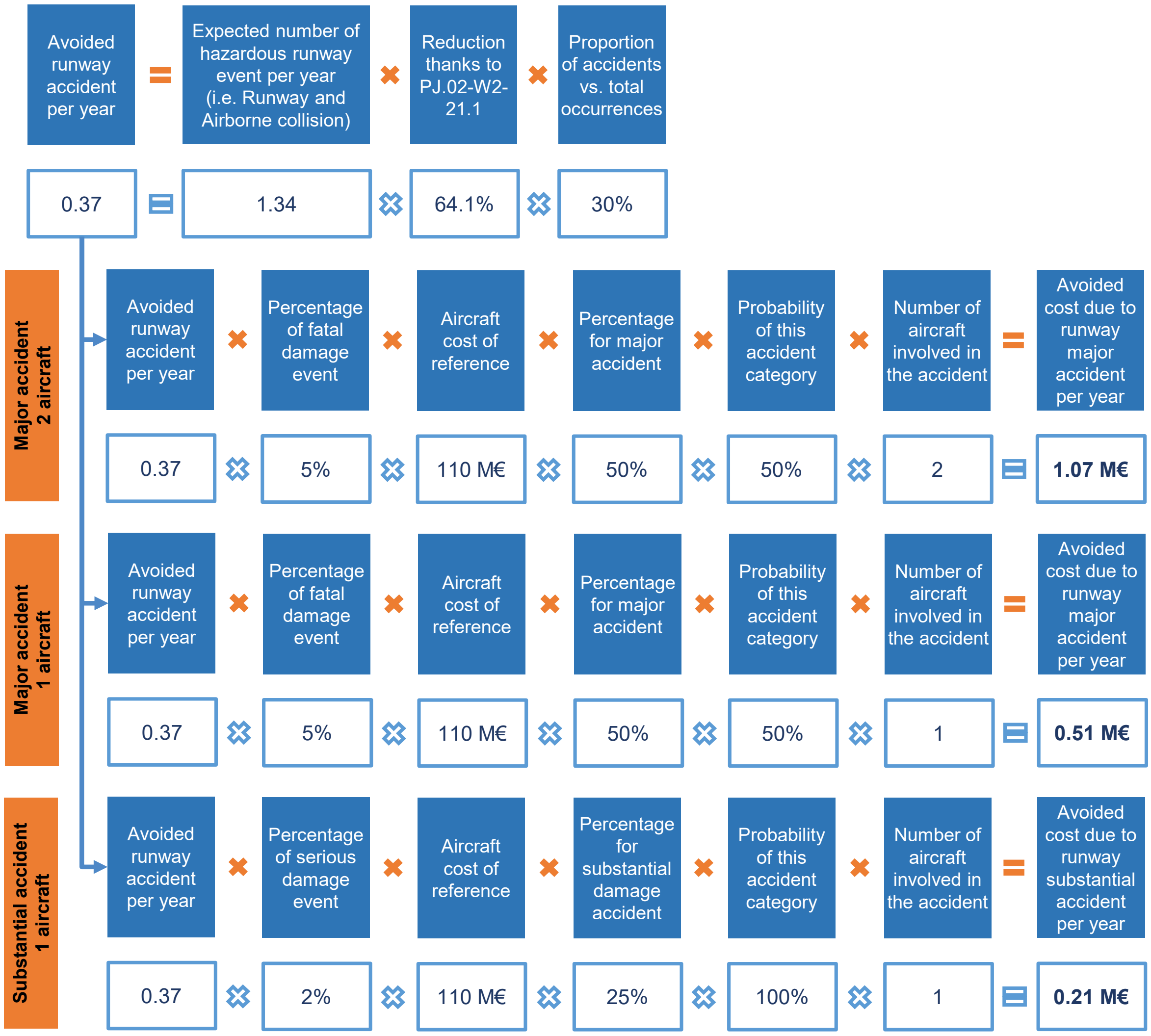


Figure 28: Benefits monetised annually as avoided aircraft damages

4.2.1.3.1 Distribution of accidents per severity

According to ICAO [20], an accident is defined as an occurrence in which an aircraft sustains damages, structural failure or is missing. It should be reminded that injuries to human life are not in scope of this analysis according to SESAR guidelines. On the other hand, a serious incident means that there was a high probability of accident, which has been finally avoided (including related damages to vehicles).

Consequently, accidents could be classified according to their level of damage as defined by ICAO:

- Major accident: the aircraft is destroyed or the cost of repairs exceeds the 50% of value of the aircraft. In the CBA, the 50% of a sample aircraft value is assumed (conservative assumption),
- Substantial damage accident: the aircraft suffers serious damages but its value does not exceeds to 50% in price of the aircraft. In the CBA, it is assumed a 25% of a sample aircraft value (conservative assumption),

- Minor accident: the aircraft sustained a minor damage implying a small cost for repair. In the CBA, these costs have not been estimated due to their potential wide variability and low impact of cash flow calculation.

The sample aircraft price taken as reference is of 110 M€. It has been calculated taking into account the number of main commercial aircraft operating in European airports and their current price, as reported in Table 13.

Aircraft name	Nº of operating A/C (2016)	A/C price [M€]
A320	2386	99.4
B738	1838	85.8
A321	1030	105.7
A319	929	90.3
B77W	716	370.4
GLF5	664	56.0
A332	604	197.8
GLF4	591	38.8
B763	513	180.7
CL60	499	28.9
GLEX	496	50.6
A333	484	197.8
B737	443	85.8
B772	417	370.4
SR22	414	0.7
B744	405	240.3
C172	369	0.3
E190	367	46.1
F900	358	40.7
DA42	355	0.6
F2TH	349	31.6
P28A	340	0.5
B752	328	90.3
FA7X	305	53.3
B788	294	305.4
PC12	288	4.4
PA34	258	1.1
A388	241	433.6
CL30	230	7.2
AT72	220	23.5

Table 13: Aircraft analysis for average price calculation (EUROCONTROL, ALG/Indra analysis)

Estimated safety occurrences should be now distributed according to the presented ICAO classification. Information available for consultation in the ICAO iSTAR tool allows to perform a high-level analysis of safety occurrences per injury level. This has been used as basis for the calculation of the statistical distribution required, as shown in Figure 29.

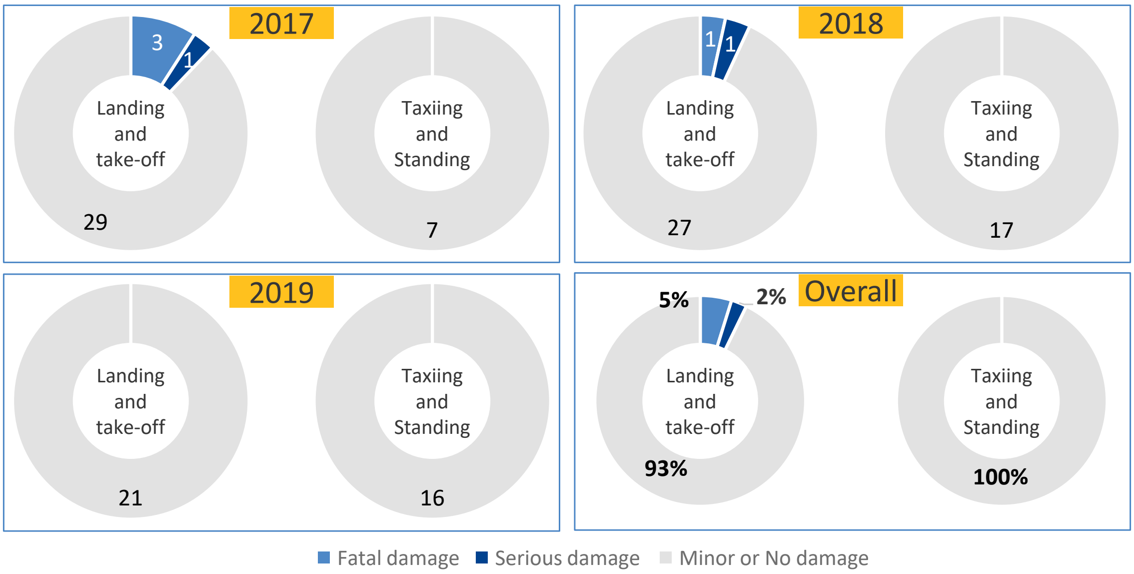


Figure 29: Safety accidents in runway and taxiway classified per grade of damage ([12], ALG/Indra analysis)

Safety accidents had a decreasing trend in the last 3 years, also in terms of grade of damage, although an important area for improvement is still to be covered as demonstrated by the high total number of accidents. According to the outcomes of the analysis, only runway events are considered for the quantification of physical damages, as taxiway events are not statistically characterised by associated costs for damages.

4.2.1.3.2 Estimation of number of aircraft involved in occurrences

A final distinction to be done regards the number of vehicles and types involved in accidents. The following assumptions are considered:

- Major accident:

1. 50% of probability of landing or taking-off aircraft colliding with another taxiing aircraft, resulting in the double counting of aircraft damages,

2. 50% of probability of landing or taking-off aircraft colliding with a ground vehicle entering in the runway, resulting in damages to the aircraft and to the ground vehicle (this last one is accounted in paragraph 4.2.2.2),

- Substantial damage and/or minor accident: a landing or taking-off aircraft colliding with a ground vehicle is considered (also in this case, damage to the ground vehicle is accounted in paragraph 4.2.2.2).

4.2.2 Airport Operators (AOs)

This chapter aims at quantifying the potential benefits the solution may bring to Airport Operators, mainly in terms of avoided loss of airport charges and cost for the repair/replacement of ground vehicles colliding in case of accident with an aircraft, as summarised in Figure 30. Calculations are detailed in the next paragraphs, taking as reference in some cases also results or assumptions introduced for the monetisation of benefits for Airspace Users.

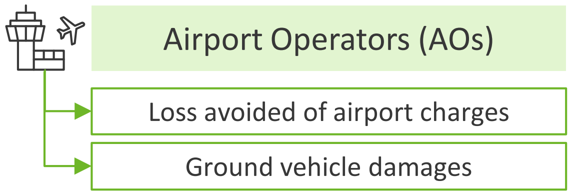


Figure 30: Airport Operators benefits

4.2.2.1 Loss avoided of airport charges

In the case of airport operators, the cancellation of a flight results in the loss of revenues for the airport operator, as not collecting the related charges. Diversions have a local impact on the original arrival airport, which is partially compensated by a positive effect generated on the airport where the diverted aircraft lands. Delays are not expected to generate a relevant benefit variation for Airport Operators.

Moreover, according to the definition of cancellation cost provided by EUROCONTROL in the Standard Inputs for CBA, the operational savings for Airspace Users (among which airport charges) are already accounted in the reference cost used for the estimation of flight cancellation costs.

Airport charges depend on the airport and type of aircraft considered, making it difficult to obtain an appropriate average value representing the majority of potential accident cases. As explanatory example, Table 14 reports the main charges at Amsterdam Schiphol airport and Madrid Barajas airport, showing the wide variability that may exist between Very Large airports.

Airport	Type of charge	Charge formula or price	Notes
Amsterdam Schiphol	Landing and take-off	2.07 – 23.33 € per 1 tonne	Depends on aircraft category
	Parking	1.73€ per 1 tonne/day or part thereof	Not applicable if shorter than 6h 15min
	Passenger service	4.81 – 14.36 €	Per departing passenger
	Security service	7.06 – 12.61 €	Per departing passenger
Madrid Barajas	Landing	8.27 – 19.85 € per 1 tonne	–
	Aerodrome service	3.20 – 7.68 € per 1 tonne	–
	Parking	0.14 € per 1 tonne/quarter of hour	–
	Passenger service	14.24 – 20.86 €	Per departing passenger
	Security service	3.38 €	Per departing passenger

Table 14: Airports charges

Table 15 and Table 16 show the airport charges in the case of a cancelled flight departing from Amsterdam Schiphol at 10:00 and arriving at Madrid Barajas at 12:30 using an Airbus A320 (170 passengers – MTOW 78 tonnes), and vice versa. The difference between the two cases is relevant and variability depending on the airport sequence is very high, having almost 2,000 € of charges differences between the first and second flight case.

Airport	Scheduled flight	Cancelled flight	Delta
Amsterdam Schiphol	5,031.06 €	0.00 €	– 5,031.06 €
Madrid Barajas	894.66 €	0.00 €	– 894.66 €
Flight cost	5,925.72 €	0.00 €	**– 5,925.72 €**

Table 15: Amsterdam Schiphol to Madrid Barajas scheduled and cancelled flight charges

Airport	Scheduled flight	Cancelled flight	Delta
Madrid Barajas	4,249.70 €	100.61 €[5]	– 4,149.09 €
Amsterdam Schiphol	0.00 €	0.00 €	0.00 €
Flight cost	4,249.70 €	100.61 €	**– 4,149.09 €**

Table 16: Madrid Barajas to Amsterdam Schiphol scheduled and cancelled flight charges

For this reason, a simplified approach has been used for the estimation of airport charges, estimating the loss in airport charges as a 30% of cancellation costs (equivalent to 5,295 € per flight) in case of safety occurrence. Figure 31 shows the monetisation mechanism considered for the benefits of airport operators, being the number of cancellations the sum of the ones presented in the Airspace Users chapter. The number presented in the figure is illustrative only.

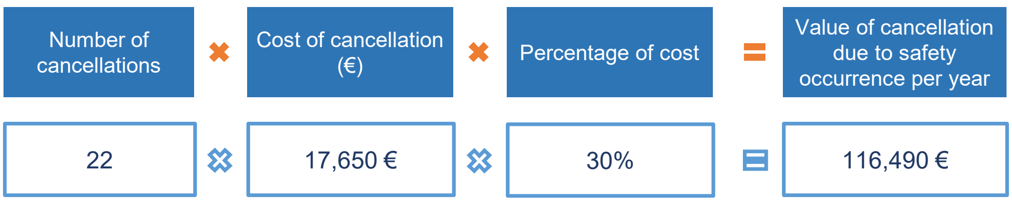


Figure 31: Loss of airport charges monetisation mechanism

4.2.2.2 Ground vehicles damages

Another benefit considered for airport operators in this V3 CBA equals the cost of the ground vehicle colliding with the aircraft in the case a safety accident occurs, being quantified as the avoiding of the cost sustained to buy a new vehicle in replacement of the destroyed one.

The price of ground equipment varies between 20 and 50 k€ depending on the type of vehicle considered (e.g. Air stairs, belt loaders, refueler/defueler, tractors) [21]. An average cost of 35 k€ is thus considered for benefits estimation, to be multiplied by the number of occurrences per year reported in previous paragraph 4.2.1.3, having one ground vehicle involved in the collision. Figure 32 shows the resulting monetisation mechanism in the case of a major accident and substantial damage accident.

[5] Parking fee at departure airport considering the duration of the flight (2h 30min).

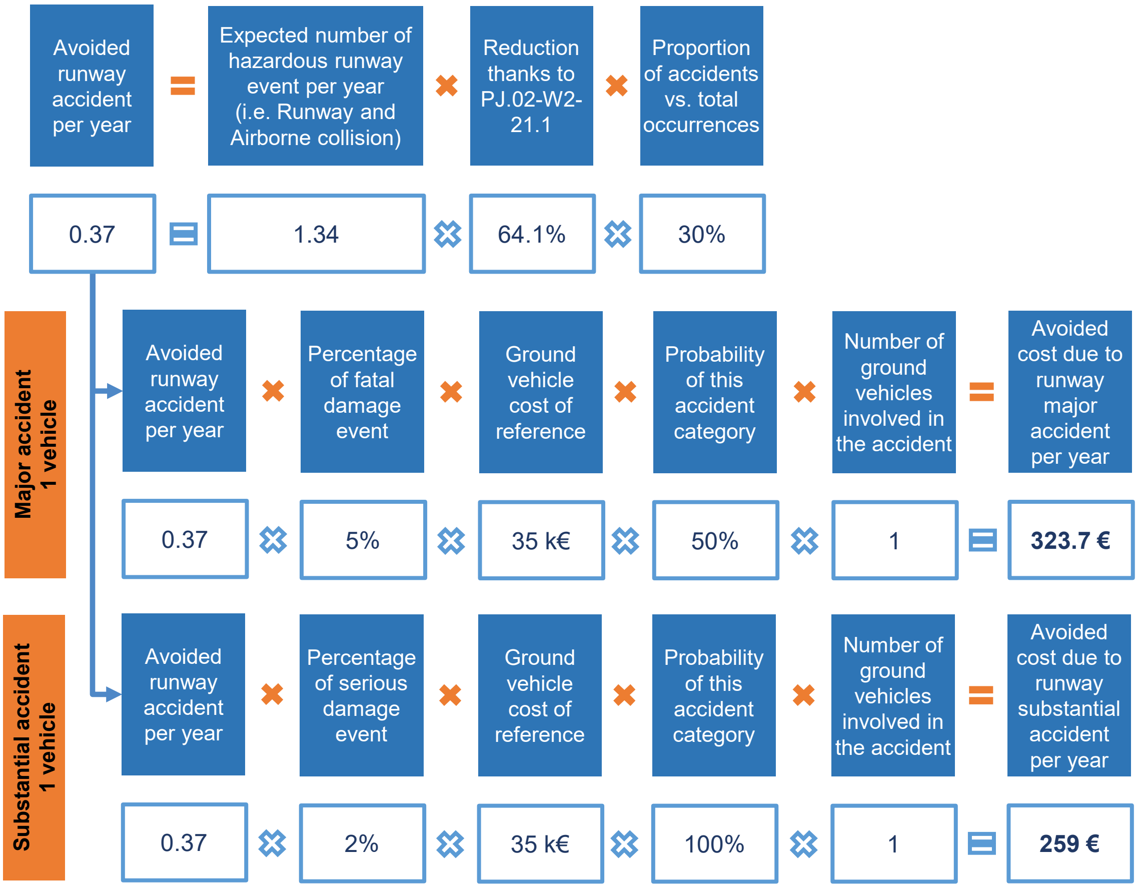


Figure 32: Ground vehicles damages monetisation mechanism

4.2.3 Air Navigation Service Providers (ANSPs)

Similarly to what done for Airport Operators, this chapter quantifies the potential benefits the solution may bring to Air Navigation Service Providers mainly in terms of avoided loss of ANS charges in case of safety occurrence. Cost for the repair/replacement of ground vehicles involved in an accident is not finally accounted in this chapter, further rationale is provided below. Figure 33 summarises the benefits considered in this CBA for ANSPs.

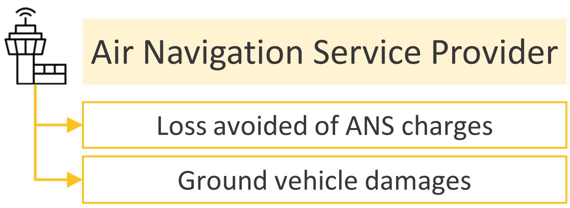


Figure 33: Air Navigation Service Providers benefits

4.2.3.1 Loss avoided of ANS charges

The cancellation of a flight results in the loss of revenues for the ANSP, both in En-Route and in TMA, as not collecting the related charges. Diversions could result in a variation of collected charges but, as the generated impact will be much lower impact and not easily predictable and quantifiable, these are not included in the analysis. Finally, delays are not expected to generate any relevant benefit variation.

Figure 34 reports the monetisation mechanism considered for the quantification of ANS charges, based on the calculation of the average cost of ATM/CNS service provision per flight as the ratio between the total gate-to-gate ATM/CNS provision cost and the number of IFR flights. Such reference values are extracted from the EUROCONTROL PRR 2019 [22]. Unfortunately, the effective volume of revenues generated could not be easily calculated but, considering the ICAO recommendations for ANSP to collect only charges to ensure their not-for-profit financial status, results obtained are expected to be sufficiently reliable.

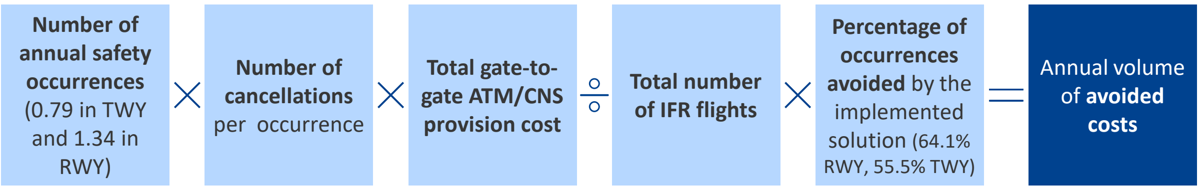


Figure 34: Loss of ANS charges monetisation mechanism

Figure 35 shows an example of monetisation of avoided loss of charges as effect of cancellations due to a safety occurrence, being 764.24 € the average loss of ANS charges per flight.

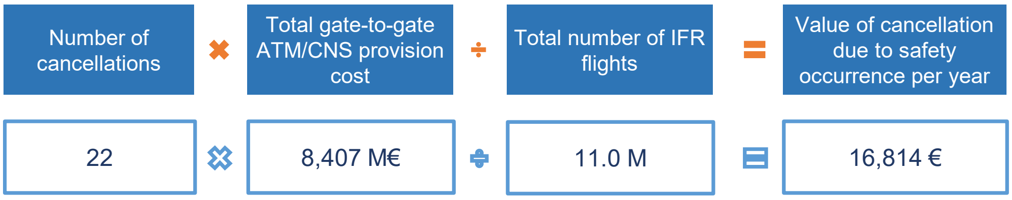


Figure 35: Example of loss of ANS charges

4.2.3.2 Ground vehicles damages

Normally, in the airside of an airport, few ground vehicles are operated by the ANSP. Benefits related to ground vehicles are not expected to be so significant in comparison with other types of benefits or costs. Thus, for simplicity, all potential benefits derived from the avoidance of costs of repair of ground vehicles have been already accounted in the Airport Operator category.

5 Cost assessment

The costs included in the CBA reflect the investments that stakeholders will need to make to deploy the solution and bring it into operation, as part of the proposed solution scenarios. Also, any variation in operating expenditures has been analysed, leading to the conclusion that no changes are expected since the solution will increase or decrease them.

This final version of CBA updates the cost values initially considered in the previous Intermediate version. More in detail, costs have been quantified for ANSPs and Aircraft Operators in terms of ground costs, transition costs and operating costs.

Figure 36 summarises the methodology used in the CBA model, mainly based on a Bottom-Up approach. Cost estimations provided by solution partners, both ANSP and industry partners, are considered as inputs.

Figure 36: Cost assessment methodology

5.1 ANSPs costs

5.1.1 ANSPs cost approach

Costs are distributed in three different categories, depending on their rationale:

1. Ground or implementation costs: collecting those costs incurred for the implementation of new systems and functionalities, which could be further on classified as:

a. One-off: covering the required initial training, project management, administrative costs, certification and installation/commissioning,

b. Capital: related to the buying of the equipment and deployment costs,

2. Transition costs: required to complete the transition from legacy systems to the ones implemented by the solution,

3. Operating costs: identifying the change in the current costs needed to maintain systems operability, including related administration, maintenance, training and supply costs, among others.

Table 17 summarises the main costs considered in the CBA.

Cost Item	One-off or routine cost	Cost assessors
Initial Training	Implementation (One-off)	ANSPs, Industry partners
Project Management		
Administrative costs		
Certification		
Installation/Commissioning		
Purchase of equipment and construction costs	Implementation (Capital)	
Operational and technical trials for entry into operation: - Project management during trials - Human and material resources	Transition cost	
Yearly Equipment maintenance and training	Operating (Maintenance)	
Communication costs Energy, Supplies, Utilities, Property Taxes Rent & Lease Furniture & equipment	Operating (Administration)	

Table 17: Cost categorisation for PJ.02-W2-21.1

5.1.2 ANSPs cost assumptions

Each cost figure is used as input in the cost model. Final values considered are reported in the next paragraphs. Timeframes of each cost figure have been already defined for the solution, starting 2 years before the solution IOC date.

5.1.3 Number of investment instances (units)

As defined in the geographical scope of this CBA, the solution is expected to be potentially implemented at different subsets of airports, as summarised in Table 18.

	Airport			
	VL	L	M	S
Sol 21.1	13	12	3	-

Table 18: Number of investment instances - ANSPs

5.1.4 Cost per unit

OI step AO-0104-B is characterised mainly by costs for the implementation of the airport safety nets systems for controllers at A-SMGCS airports. Costs are reported in Table 19, as extracted from solution partners' estimations:

Cost category	Airport			
	VL	L	M	S
Ground costs	2.28 M€	2.28 M€	2.28 M€	-
Transition costs	0.21 M€	0.21 M€	0.21 M€	

Cost category	Airport			
	VL	L	M	S
Operating costs[6]	0 €	0 €	0 €	

Table 19. Cost per unit - ANSP

5.2 Airport operators costs

No costs are accounted for this type of stakeholders. In fact, the implementation of new functionalities is expected to require investments only by ANSP, whereas the cost for any additional system defined as prerequisite is not accounted in this CBA.

Although it may be argued that the ownership of systems at some airports belongs to the Airport Operator, having cases in which the Airport Operator owns the ATC infrastructure, in this CBA it is assumed that the ANSP bears the full investment required to deploy PJ.02-W2-21.1 functionalities.

5.3 Network Manager costs

The Network Manager is not required to invest in any enabler for this solution.

5.4 Airspace User Costs

Airspace Users are not required to invest in any Enabler for this solution.

5.5 Military costs

According to the PJ.20 Airport OE list [14], only 4 Large airports of the 28 Very-Large, Large and Medium ones in the scope of the CBA are classified per type of operations as Civil/Military, which are currently operated by private or State-owned enterprises. In addition, no implementation and operating cost differences are expected between a civil or military airport, thus all costs have been accounted for under the Airport Operator category umbrella.

5.6 Other relevant stakeholders

No other stakeholders are required to deploy Enablers.

[6] Solution PJ.02-W2-21-1 is an add-on to the Safety Support Tools of Solution #02 and therefore there are no additional operating costs

6 CBA Model

The PJ.02-W2-21.1 V3 CBA Model (.xlsx file) is attached as a supporting document of the CBA report. This CBA Model has been developed starting from the SESAR 2020 CBA model template and aims at calculating the costs and benefits of the implementation of PJ.02-W2-21.1 solution based on the deployment scenario approach that has been defined in the context of the CBA task and in the context of SESAR 2020 Wave 2 Framework.

It should be remembered that all costs are analysed in the form of a "delta", this is the difference between the reference scenario, where operations continue "as usual", and the solution scenario, where the stakeholders implement the solution under analysis.

PJ.02-W2-21.1_D6.1.010.xlsm

6.1 Data sources

The model uses the following main data sources:

- SESAR 2020, PJ03a.01 SPR-INTEROP/OSED for V2 – Part I, IV, V
- SESAR 2020, PJ03a.01 CBA for V2
- SESAR 2020, PJ02-W2-21.1 SPR-INTEROP/OSED for V3 – Final version (including PAR)
- EATMA Dataset 23
- STATFOR Challenges of Growth 2018
- Standard Inputs for EUROCONTROL Cost-Benefit Analyses
- SESAR ATM CBA for Beginners
- Safety guidelines for Solution CBAs

7 CBA Results

This section presents the financial results of the PJ.02-21.1 CBA at V3 Level. The presented results are based on the inputs extracted from the V2 CBA report, the final information reported in the V3 OSED and PAR and a set of assumptions explained in this report. This CBA leverages on three main pillars, defining the main scope of the assessment:

- The impact of the solution in terms of benefits and costs has been estimated on top of what is already considered in the reference scenario. Results shown in this section should be considered as a delta between the solution scenario (where the solution is implemented) and the reference scenario (where the solution is not implemented),

- Quantified benefits are related to the safety KPA (and collaterally on the Resilience one also), which have been monetised for Airspace Users (i.e. scheduled airlines), ANSPs and Airport Operators, in terms of avoided costs due to cancellations, diversions, delays, loss of ANS and airport charges and physical damages to mobiles in case of safety occurrence. Benefit model methodology is based on the extension of the one defined by the PJ.19-04 and previously used in the initial CBA, with the introduction of refined assumptions for taxiway operations and additional benefits quantified for runway occurrences,

- Costs have been quantified for ANSPs that meet prerequisites for the implementation of the solution, based on the cost estimations provided by the solution partners and taking into consideration the costs assumed in the previous CBA. Both capital and operating expenditures have been analysed and quantified.

This CBA report describes the annual costs, benefits and cash flow from the perspective of the different stakeholders impacted by the solution implementation. Specific financial KPIs, like Payback year and NPV evolution, are also analysed to compare solution implementation feasibility and profitability.

CBA results are reported in the following chapter showing on one hand the annual evolution of benefits and costs leading to the creation of the cumulated NPV, to be then deepened from different perspectives, presenting the quantified benefits and assumed costs per type of stakeholder impacted (i.e. ANSPs, Airport Operators and Airspace Users).

7.1 Solution annual results

Table 20 reports the annual results for Solution PJ.02-W2-21.1. It can be observed how:

- Investments required for CAPEX start in 2023, 2 years before the IOC date, with a -9.12 M€ expenditure (undiscounted),
- From 2027, the IOC for solution 21.1, safety benefits start with 0.29 M€, reaching the maximum peak in 2031 with a total amount of 1.43 M€ (undiscounted),
- Maximum negative peaks of NPV (cumulated discounted cash flow) are obtained in 2031, with a total undiscounted value of -55.69 M€. From a rough estimation, it is equivalent to -1.98 M€ for every single airport,
- Payback year is not reached in the time horizon of the solution, finalising the forecast in 2043 with a negative NPV of -50.29 M€.

Annual results [M€]	2023	2024	2025	2026	2027	2028	2029
Performance Framework benefits	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Safety benefits	0.00	0.00	0.00	0.00	0.29	0.57	0.86
CAPEX	0.00	0.00	-9.12	-9.12	-15.04	-15.04	-15.04
OPEX	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cash flow	0.00	0.00	-9.12	-9.12	-14.76	-14.47	-14.18
Cumulated cash flow	0.00	0.00	-9.12	-18.24	-32.99	-47.46	-61.65
Discounted benefits	0.00	0.00	0.00	0.00	0.20	0.36	0.50
Discounted cumulated benefits	0.00	0.00	0.00	0.00	0.20	0.56	1.06
Discounted costs	0.00	0.00	-7.24	-6.70	-10.24	-9.48	-8.78
Discounted cumulated costs	0.00	0.00	-7.24	-13.94	-24.18	-33.66	-42.44
Cumulated NPV	**0.00**	**0.00**	**-7.24**	**-13.94**	**-23.98**	**-33.10**	**-41.38**

Annual results [M€]	2030	2031	2032	2033	2034	2035	2036
Performance Framework benefits	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Safety benefits	1.15	1.43	1.43	1.43	1.43	1.43	1.43
CAPEX	-15.04	-15.04	0.00	0.00	0.00	0.00	0.00
OPEX	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cash flow	-13.90	-13.61	1.43	1.43	1.43	1.43	1.43
Cumulated cash flow	-75.54	-89.15	-87.72	-86.29	-84.85	-83.42	-81.99
Discounted benefits	0.62	0.72	0.66	0.61	0.57	0.53	0.49
Discounted cumulated benefits	1.68	2.39	3.06	3.67	4.24	4.77	5.26
Discounted costs	-8.13	-7.53	0.00	0.00	0.00	0.00	0.00
Discounted cumulated costs	-50.56	-58.09	-58.09	-58.09	-58.09	-58.09	-58.09
Cumulated NPV	**-48.89**	**-55.69**	**-55.03**	**-54.42**	**-53.85**	**-53.32**	**-52.83**

Annual results [M€]	2037	2038	2039	2040	2041	2042	2043
Performance Framework benefits	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Safety benefits	1.43	1.43	1.43	1.43	1.43	1.43	1.43
CAPEX	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OPEX	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cash flow	1.43	1.43	1.43	1.43	1.43	1.43	1.43
Cumulated cash flow	-80.56	-79.12	-77.69	-76.26	-74.83	-73.39	-71.96
Discounted benefits	0.45	0.42	0.39	0.36	0.33	0.31	0.28
Discounted cumulated benefits	5.71	6.13	6.51	6.87	7.20	7.51	7.80
Discounted costs	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Discounted cumulated costs	-58.09	-58.09	-58.09	-58.09	-58.09	-58.09	-58.09
Cumulated NPV	**-52.38**	**-51.96**	**-51.58**	**-51.22**	**-50.88**	**-50.58**	**-50.29**

Table 20: Annual results summary

7.2 Results per stakeholders perspectives

7.2.1.1 Air Navigation Service Providers

The cash flow for ANSPs is negative. Implementation costs are distributed between the start of the deployment year (i.e. 2 years before IOC, 2025) and the FOC year (i.e. 2031). The maximum peak of costs is reached in 2027 with a total amount of -10.24 M€ (discounted values). No changes in operating costs take place. Figure 37 reports the cost distribution and NPV up to 2043, taking into consideration also the impact of the annual discount rate (8%).

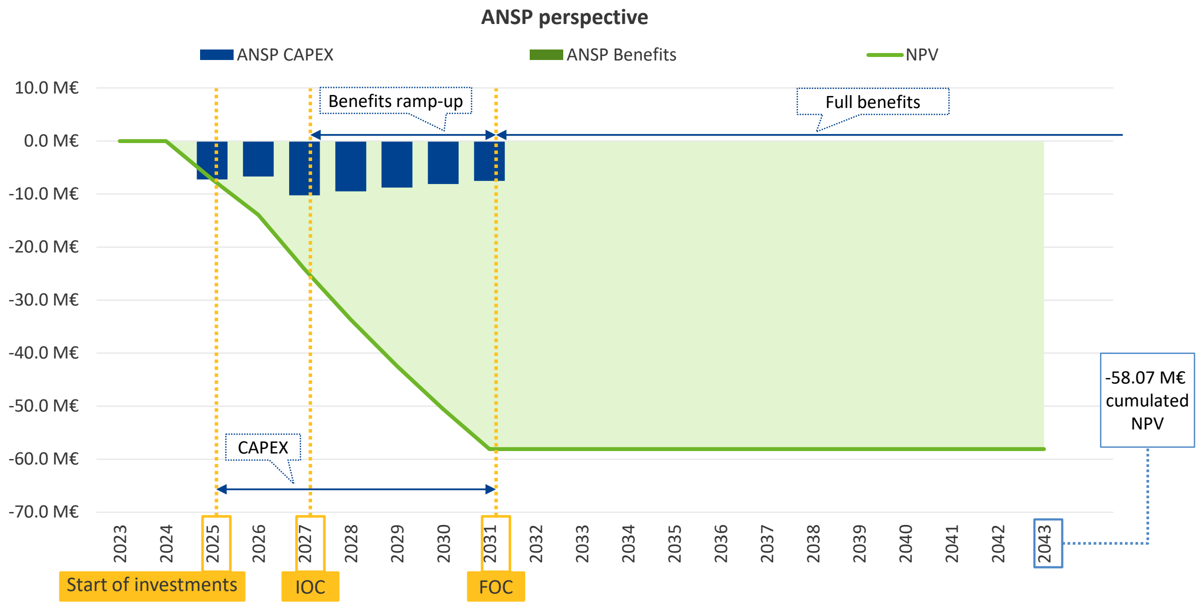


Figure 37: Solution 21.1 - ANSP perspective (discounted values)

7.2.1.2 Airport Operators

The solution is not expecting any investments on airport operators. The total NPV is almost 0.13 M€ for 2043. Having a look at the local perspective, it would be equivalent to a positive cash flow of 4.65 k€ for every single airport.

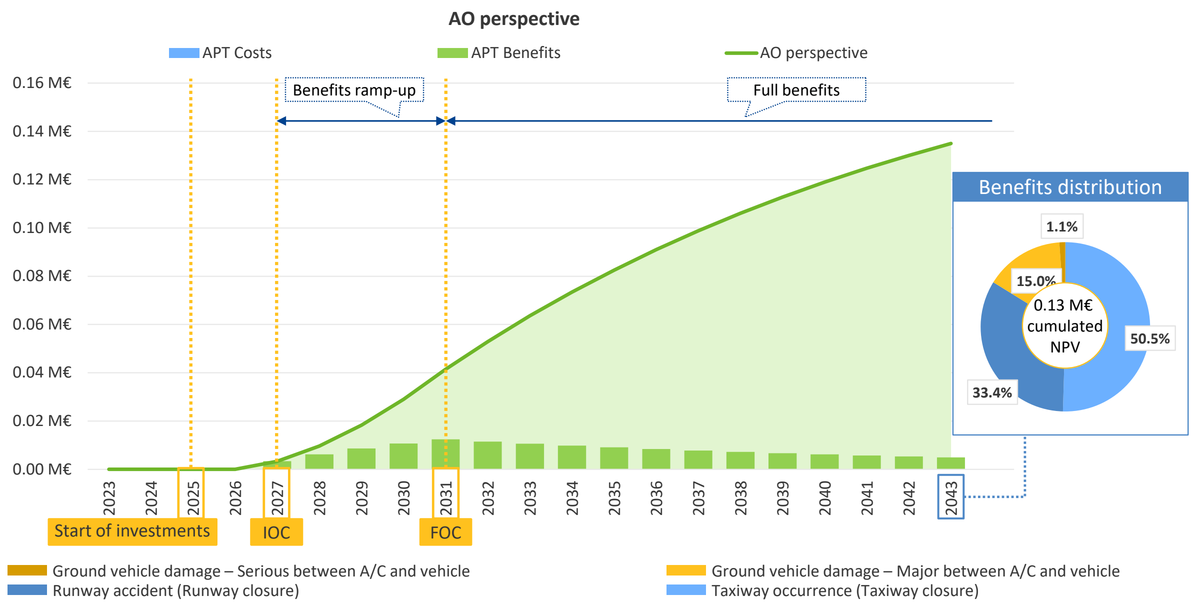


Figure 38: Solution 21.1 – AO perspective (discounted values)

EUROPEAN PARTNERSHIP

Co-funded by the European Union

7.2.1.3 Airspace Users

The cash flow for Airspace Users is positive. It is expected to reach a NPV of 7.64M€ for 2043. Having a look at the local perspective, it would be equivalent to a positive cash flow of 272.9 k€ for every single airport.

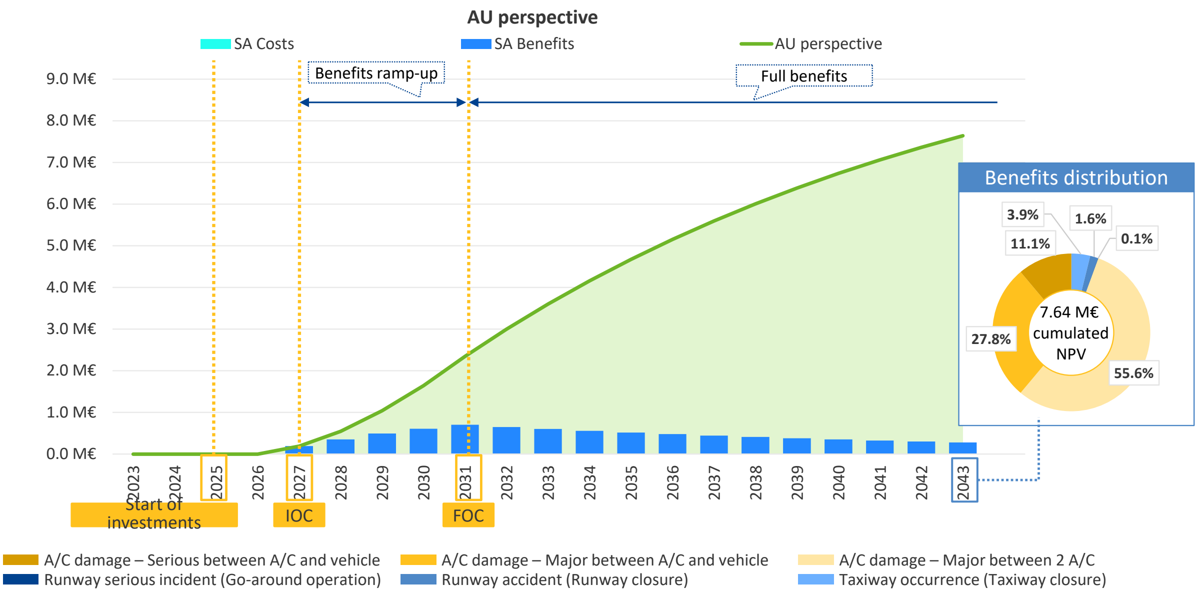


Figure 39: Solution 21.1 - AU perspective (discounted values)

7.2.1.4 Overall solution perspective

Figure 40 shows the overall NPV obtained for solution 21.1. A negative cumulated NPV of -55.69 M€ is found in 2031, weakly decreasing in the long-term.

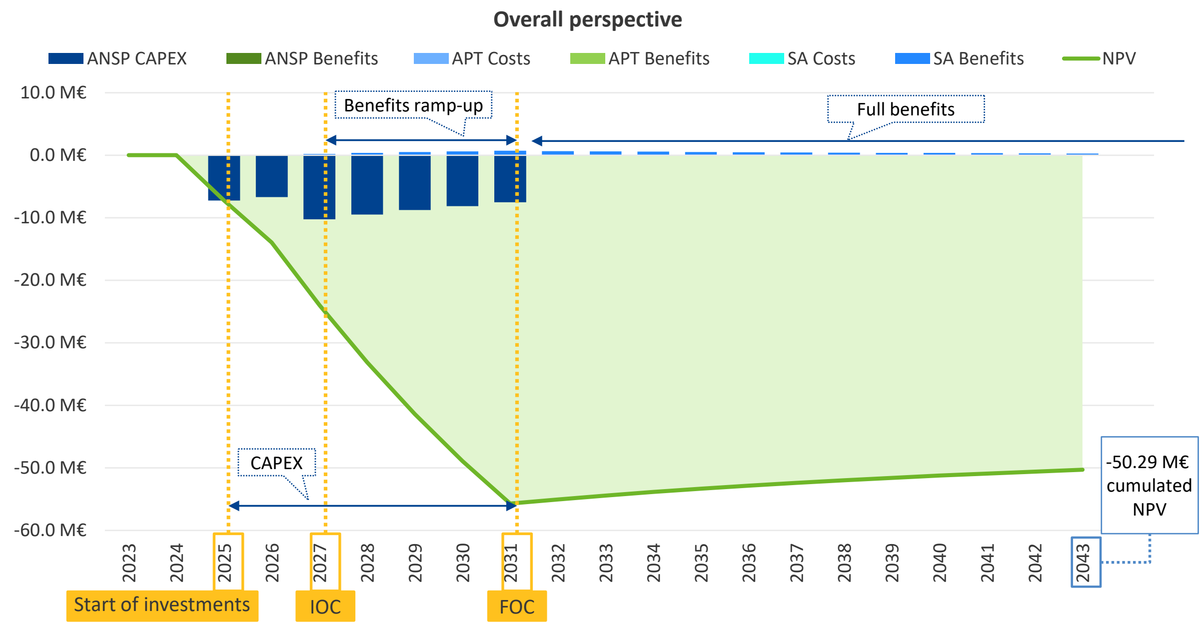


Figure 40: Solution 21.1 – Scenario perspective (discounted values)

8 Sensitivity and risk analysis

The following section provides an initial analysis of which impacts may have the uncertainties related to the main variables identified during the modelling of the PJ.02-W2-21.1 CBA on the outcomes of the model.

All the variables presented in this section are analysed by applying a "*ceteris paribus*" criteria, meaning that only the impacts of one variable are evaluated at each time, leaving the other variables constant facilitating the comparison between the evaluated variables.

8.1 Sensitivity analysis

Sensitivity analysis is based on the evaluation of the impacts that a set of variables have on the NPV at 2040, being evaluated separately by applying a range of variations around their initial value. The list of variables analysed the range of variation and a brief description of the expected impacts are reported in Table 21 below.

Sensitivity variables	Range[7]	Impact description
Airport Capacity	±10%	Evaluates the impact of a variation in Airport Capacity (CAP3), which evaluates the peak runway throughput.
Airspace Capacity	±10%	CAP1 and CAP2 evaluate the TMA throughput, in challenging airspace per unit time and the en-route throughput, in challenging airspace, per unit. This variable evaluates the impact of a variation on these KPIs.
Fuel Efficiency	±10%	This variable applies a variation in the KPIs of: FEFF3 evaluates the reduction in average flight duration FEFF2 evaluates de CO2 emissions FEFF1 evaluates the average fuel burn per flight.
Delay	±10%	It applies a variation in the tactical delay and evaluates its impact on the overall NPV.
Time Savings	±10%	It applies a variation in the time saving and evaluates its impact on the overall NPV.
Predictability	±10%	This variable applies a variation in the KPI PRD1, which evaluates the variance of difference in actual & Flight Plan or RBT durations.
ATCO Productivity	±10%	The ATCO productivity is automatically calculated by the SESAR CBA model v7.3.8, considering the embedded assumptions from the STATFOR Accommodated demand ("Traffic"), the average flight duration and the ATCO hours in the base year (ACC and APP + TWR). The sensitivity analysis evaluates the variation in the ATCO productivity change (CEF2 – benefit of the solution) that will generate a variation in the NPV of the CBA.

[7] Variable variation is applied to the baseline value assumed for the nominal scenario, for example for the discount rate factor: [7.2% - lower limit; 8% - baseline value; 8.8% - upper limit].

Sensitivity variables	Range[7]	Impact description
Ground OPEX	±10%	It evaluates the impact on the operating expenditure of Ground costs, generated by a variation in the sensitivity factor.
Ground Capex	±10%	It evaluates the impact that a variation in capital ground costs has on the NPV, generated by a variation in the sensitivity factor.
AU Airborne Capex	±10%	It evaluates the impacts on the NPV of a variation of Airborne costs for Airspace Users.
AU Ground Capex	±10%	It evaluates the impacts on the NPV of a variation of Ground costs for Airspace Users.
AU Ground Opex	±10%	It evaluates the impact on the NPV of a variation of operating costs for Airspace Users.

Table 21: Sensitivity analysis variables

In this final version of CBA, only the CAPEX factor and Safety occurrences factor have an impact on the sensitivity analysis. The CAPEX factor causes a -11.6%/+12.2% variation in the NPV in 2040 given a +/-10% variation of the related sensitivity variable. Safety occurrences variation has a much lower effect on the NPV at 2040, showing how the model is much more dependent on any variation in costs encountered than on benefits generated.

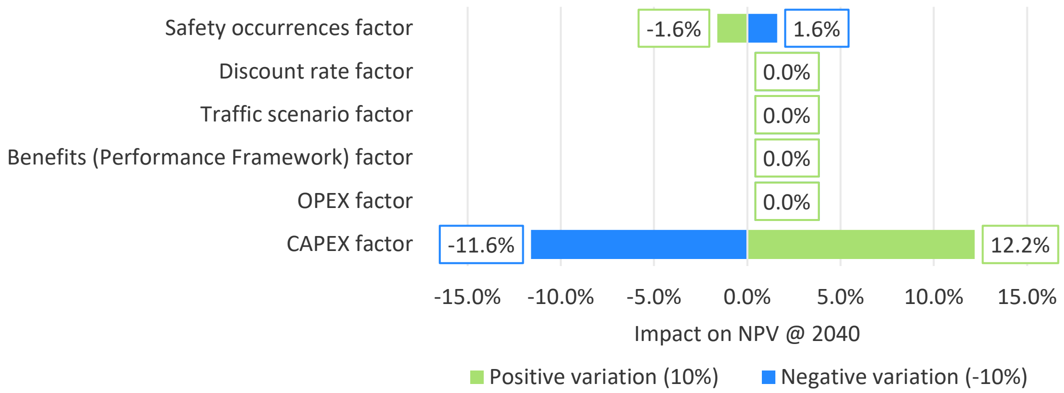


Figure 41. Sensitivity analysis

8.2 Risk analysis

NPV risk modelling is an extension of the basic NPV method in which input variables are allowed to vary between defined maximum and minimum values through a predefined probability distribution, to calculate the risk effects around the most probable and expected variable value. As the inputs vary during the simulation, the output varies as well.

The model is run using Monte Carlo algorithms and applying a triangular probability density function to represent the risk associated with each of the selected variables. Such distribution is shown in Figure 42. During each iteration of the simulation, a random value is selected for each input variable (i.e. the same used in the sensitivity analysis) according to the probability density function, thus obtaining a random combination of costs and benefits that will be used to evaluate the solution NPV.

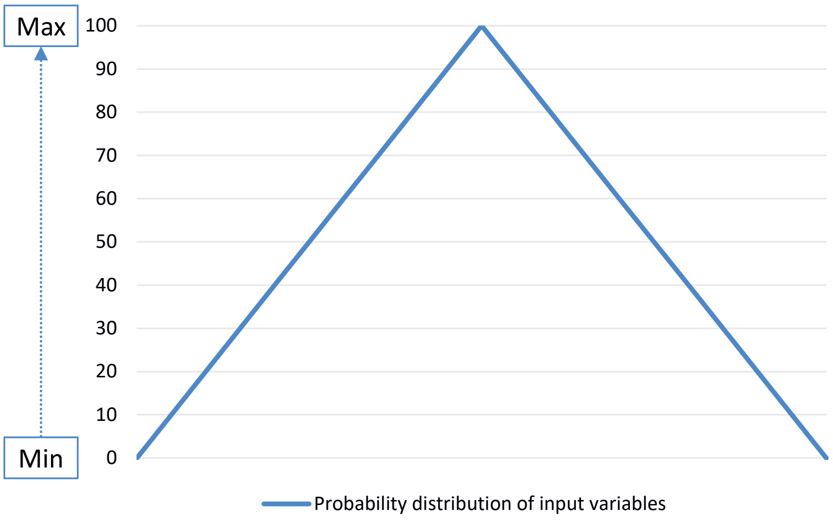


Figure 42: Combined solution scenario – Risk variable profile

The output of the risk analysis is an NPV risk profile, as shown in Figure 43 representing the probability of obtaining that value of NPV in 2043 and showing the distribution of the values through the cumulated probability. Such NPV distribution is mainly influenced by the probability distribution function, thus maintaining the triangular shape.

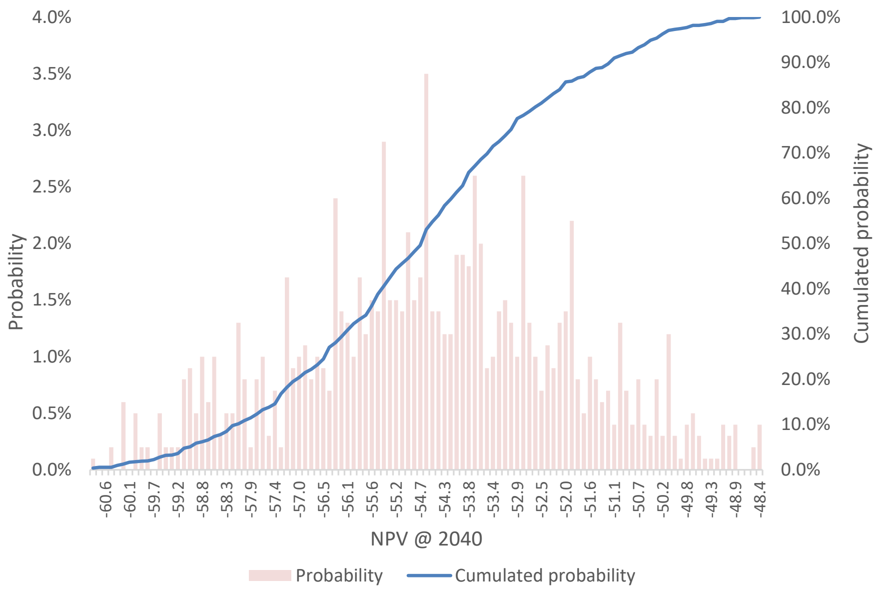


Figure 43 Combined solution scenario – Risk analysis results

Additional statistical results are also provided by the risk modelling exercise, which are collected in Table 22.

Results description	Value
Mean NPV	-54.08 M€
Maximum NPV	-60.77 M€
Minimum NPV	-48.35 M€

Results description	Value
NPV standard deviation	2.57
Variance	6.62
Skewness	-0.021

Table 22: Risk analysis statistical results

9 Recommendations and next steps

The analysis performed in the scope of this CBA highlighted how the implementation of solution PJ.02-W2-21.1 will be fruitful in the enhancement of safety for Airport Operators and Airspace Users of Very Large, Large and Medium airports at ECAC level. Additionally, it is expected to increase also controllers' situational awareness, which at the same time may support the avoidance of dangerous safety occurrences.

This CBA report describes the annual costs, benefits and cash flow from the perspective of the different stakeholders impacted by the solution implementation. Specific financial KPIs, like Payback year and NPV evolution, are also analysed to compare solution implementation feasibility and profitability.

The CBA shows that the deployment of solution 21.1 at 28 airports would positively impact the European aviation industry in terms of safety, resilience, and human performance. However, it would develop a negative -50.29 M€ net present value in 2043 (8% discount rate). This CBA provides the final estimation of the potential benefits introduced by the solution, although it should be remarked that Safety is not a KPA that can be fully monetized, meaning that benefits will go far beyond the ones estimated by the CBA model.

The level of confidence on results is considered low/medium, considering the results obtained from validation activities and the cost estimations received from solution partners.

9.1 Recommendations

The deployment of the PJ.02-W2-21.1 solution is considered a complex task. One possible approach to simplify this task is the specification of a Minimum Viable Product (MVP). This MVP provides an initial installation for a limited number of alerts on which the required deployment steps can be practiced.

9.2 Next steps

- Conduct a cost-benefit analysis for deployment at CP1 airports. It shall include a sufficiently detailed planning of the required solution support according to local needs to get a better picture of the costs.
- Identify an MVP that provides a high safety benefit, i.e., assists the controller with known local safety issues.

10 References and Applicable Documents

10.1 Applicable Documents

[1] SESAR Project Handbook;

[2] Guidelines for Producing Benefit and Impact Mechanisms;

[3] Methods to Assess Costs and Monetise Benefits.

[4] SESAR Cost-Benefit Analysis Model[8]

[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

[9] EASA ASR 2020

[10] Environment Dataset

10.2 Reference Documents

[11] Common assumptions

[12] ICAO iSTAR tool

[13] European ATM Master Plan Portal https://www.atmmasterplan.eu/

[14] Performance Framework

[15] SESAR Solution PJ.02-W2-21.1 – D6.1.002 - SPR/INTEROP OSED for V3 – Part I, Edition 00.02.02, 24 May 2023.

[16] SESAR Solution PJ.02-W2-21.1 - D6.1.009 - CBA Intermediate version, Edition 00.00.03, 9 December 2020

[17] Airport OE Dataset, 02/2019

[18] EASA Annual Safety Review 2020, 31/07/2020

[19] Standard Inputs for EUROCONTROL Cost-Benefit Analyses, v8.0, 01/2018

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

EUROPEAN PARTNERSHIP

Co-funded by the European Union

[20] Accident Classification https://www.skybrary.aero/index.php/Accident_Classification

[21] Global GSE https://www.globalgse.com

[22] Performance Review Report 2019, EUROCONTROL, June 2020

[23] SESAR Solution PJ.02-W2-21.1- D6.1.002 - SPR-INTEROP/OSED for V3 - Part V-PAR, Edition 00.01.02, 24 May 2023.

[24] SESAR Solution PJ.02-W2-21.1 – D6.1.006 - Validation Report (VALR) for V3, edition 00.01.02, 24 May 2023.

[25] SESAR Solution PJ.02-W2-21.1- D6.1.002 - SPR-INTEROP/OSED for V3 -Part II-SAR, Edition 00.01.02, 24 May 2023.

11 Appendix A

Mapping between ATM Master Plan Performance Ambition KPAs and SESAR Performance Framework KPAs, Focus Areas and KPIs, source reference *[14]*

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 CO_2 emissions			(FEFF2)	CO_2 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 23: Mapping between ATM Master Plan Performance Ambition KPAs and SESAR Performance Framework KPAs, Focus Areas and KPI

12 Appendix B

12.1 Benefit Impact Mechanisms (BIM)

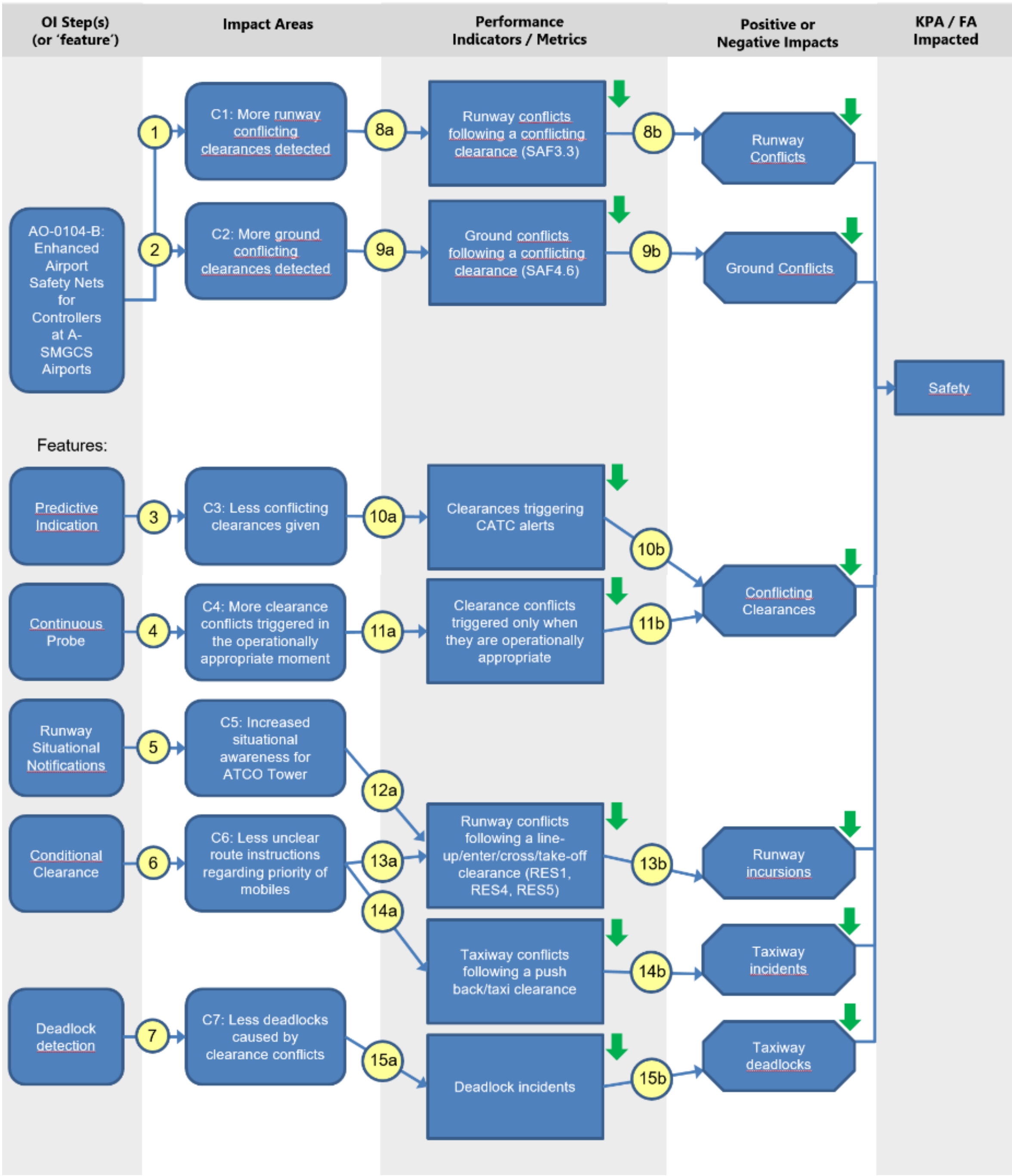
12.1.1 Solution PJ.02-W2-21.1

This Appendix provides the BIMs included in the OSED and used for the monetisation of benefits.

EUROPEAN PARTNERSHIP

Co-funded by
the European Union

PJ.02-W2-21.1: Enhanced Airport Safety Nets for Controllers at A-SMGCS Airports **Version**: 003 **Production Date**: 02/2023
Stakeholder: ANSP

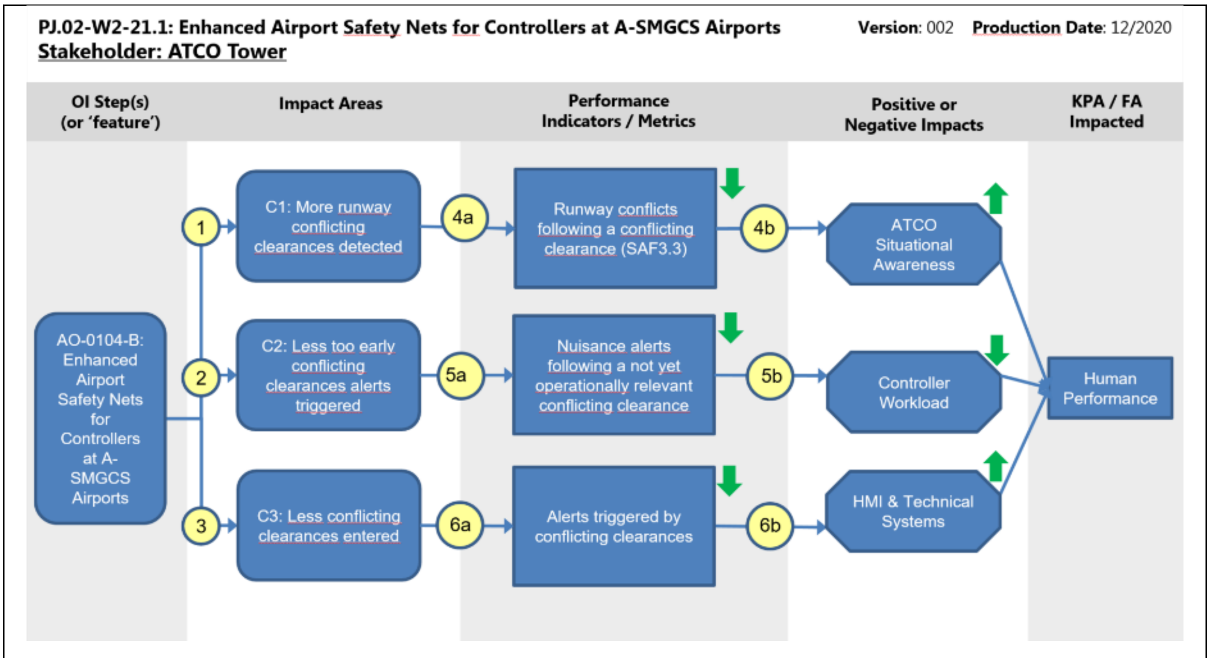


1	C1: **More runway conflicting clearances detected** The CATC for Runway Operation will detect more runway conflicting clearances: The alert will be triggered only in cases when the system – based on data available – assumes that the separation on the RWY will be infringed at the time the landing aircraft crosses the RWY threshold.

	A TOF/TOF (converging SIDs) alert will be triggered when the trajectories of departing aircraft are detected to be converging immediately after take-off and the second aircraft is cleared for take-off (and still on the ground). A RMCA/CMAC vs. ATC Clearance alert will be triggered when an aircraft is cleared to use a runway although a runway incursion has been detected (and still needs to be resolved).
2	C2: **More ground conflicting clearances detected** The CATC for Ground Operation will detect more conflicting clearances in ground operations, e.g., an alert will be triggered when a push-back or taxi clearance is given and is predicted to lead to conflicting trajectories with another aircraft already cleared for Push-back or Taxi.
3	Feature: **Predictive Indication** C3: Less conflicting clearances given The Predictive Indication is a decision support tool that gives notice of a potential conflicting clearance before it is given to the flight crew.
4	Feature: **Continuous Probe** C4: More clearance conflicts triggered in the operationally appropriate moment The new safety net continuously checks the active clearances for potential conflicts to account for changing traffic conditions and triggers alerts only when operationally appropriate, i.e., not too early and not too late to give the controller the time to solve the conflict.
5	Feature: **Runway Situational Notifications** C5: Increased situational awareness for ATCO Tower The Runway Situational Notifications act as awareness support tool that indicates current runway usage status (Runway Busy Notification) and alert status for active RMCA, CMAC, and CATC alerts (Runway In Conflict).
6	Feature: **Conditional Clearance** C6: Less unclear route instructions regarding priority of mobiles Controllers use Conditional Clearances to clearly state the priority of mobiles when communicating the cleared route to the flight crew via R/T. The new safety net considers conditional clearances in monitoring and detection of potential conflicts.
7	Feature: **Deadlock Detection** C7: Less deadlocks caused by clearance conflicts The new safety net recognizes potential deadlock situations caused by conflicting clearances.
8a	Detecting more runway conflicting clearances will result in fewer conflicts to occur on the runway (or in the immediate vicinity of the runway) as the delivery of a clearance could lead to a conflict with another aircraft already cleared for a movement.
8b	Fewer conflicts following a conflicting runway clearance will decrease the overall number of conflicts, which leads to Safety.
9a	Detecting more ground conflicting clearances will result in fewer conflicts happening on taxiways and apron areas as the delivery of a push-back or taxi clearance could lead to a conflict with another aircraft already cleared for push-back or taxi.
9b	Fewer conflicts following a conflicting ground clearance will decrease the overall number of conflicts, which affects Safety.

EUROPEAN PARTNERSHIP
Co-funded by the European Union

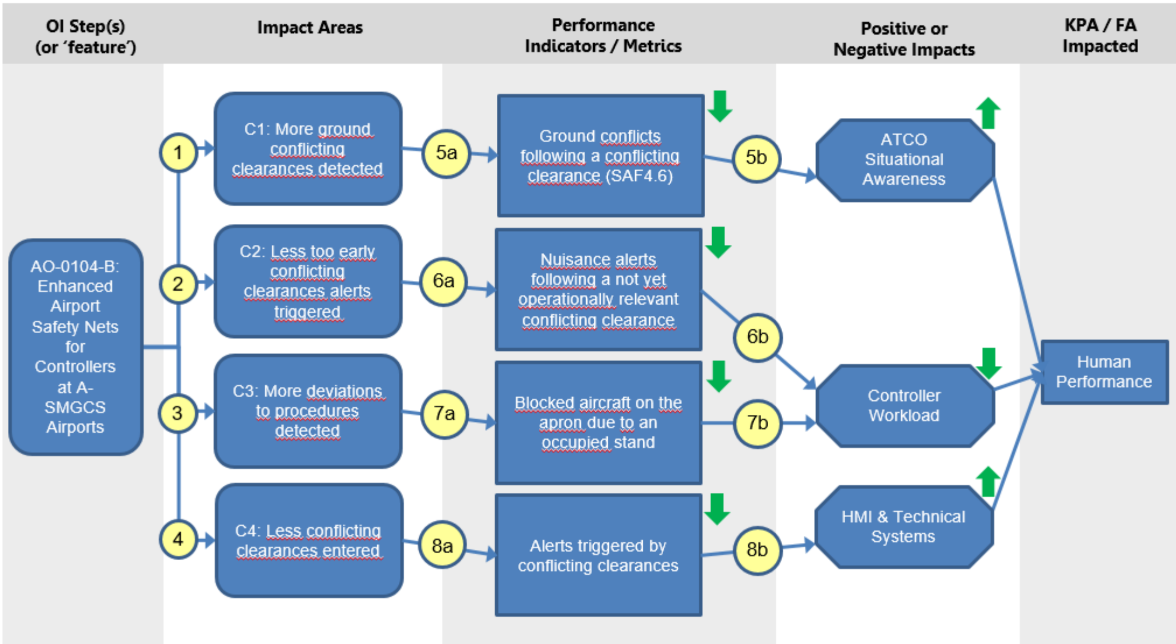
10a	Prediction of conflicting clearances along the planned route supports the decision making by the controller and, if a potential conflict of clearances is detected, the controller may wait until the situation clears.
10b	If the controller considers the predictive indication display this reduces the number of conflicting clearances given to the flight crew. Reducing the number of conflicting clearances given to the flight crew affects Resilience.
11a	The ATC system is continuously checking the active clearances and, if it detects a clearance conflict, it takes in account time or distance to the location of the predicted conflict (or other condition-depended rules) to reduce the number of nuisance alerts.
11b	Reducing the number of nuisance alerts reduces the total number of triggered alerts. Reducing the number of nuisance alerts affects Resilience.
12a	The controller perceives the Runway Busy or Runway In Conflict notification and has the opportunity to decide whether or not to issue an Enter/Cross/Line Up/Take Off clearance. In the case of a Runway Busy notification, the controller could link the clearance to a condition.
13a	Conditional clearances are used to constitute the priority of mobiles at runway entries and between parking positions and taxiways.
13b	If the controller uses conditional clearances (enter, cross, line-up) at runway entries, this reduces the number of conflicting clearances with aircraft landing or taking off. Reducing the number of conflicting clearances at runway entries affects Resilience.
14a	Conditional clearances are used to constitute the priority of mobiles between parking stands and between parking stands and taxiways.
14b	If the controller uses conditional clearances to constitute the priority of mobiles between parking stands and between parking stands and taxiways this reduces the number of conflicting clearances given to the flight crew. Reducing the number of conflicting clearances given to the flight crew affects Resilience.
15a	Depending on the airport layout it is possible that clearances given by different controllers (responsible for different AoR) cause a deadlock situation with the aircraft ending up nose to nose. Deadlocks are also possible if route trajectories overlap on a taxiway without alternative routes.
15b	The safety net conflict detection recognizes potential deadlock situations caused by conflicting clearances. This reduces the number of deadlocks and avoids impact on the surrounding traffic flow. Reducing the number of deadlocks affects Resilience.



1	C1: **More runway conflicting clearances detected** The CATC for Runway Operation will detect more runway conflicting clearances: The alert will be triggered only in cases when the system – based on data available – assumes that the separation on the RWY will be infringed at the time the landing aircraft crosses the RWY threshold. A TOF/TOF (converging SIDs) alert will be triggered when the trajectories of departing aircraft are detected to be converging immediately after take-off and the second aircraft is cleared for take-off (and still on the ground). A RMCA/CMAC vs. ATC Clearance alert will be triggered when an aircraft is cleared to use a runway although a runway incursion has been detected (and still needs to be resolved).
2	C2: **More ground conflicting clearances detected** The CATC for Ground Operation will detect more conflicting clearances in ground operations, e.g., an alert will be triggered when a push-back or taxi clearance is given and is predicted to lead to conflicting trajectories with another aircraft already cleared for Push-back or Taxi.
3	Feature: **Predictive Indication** C3: Less conflicting clearances given The Predictive Indication is a decision support tool that gives notice of a potential conflicting clearance before it is given to the flight crew.
4a	Detecting more runway conflicting clearances will result in fewer conflicts to occur on the runway (or in the immediate vicinity of the runway) as the delivery of a clearance could lead to a conflict with another aircraft already cleared for a movement.
4b	Providing predictive indications about potentially conflicting clearances (if given/input) and having fewer conflicts following a conflicting runway clearance will increase the Controller's situational awareness, which leads to Human Performance.
5a	Not triggering alerts on non-conflicting runway clearances will result in fewer nuisance alerts for the Controllers.

5b	Having fewer nuisance alerts to be managed by the Controllers will keep the controller's workload (related to this solution) on a neutral level, which links to Human Performance.
6a	The predictive indication supports the ATCO in assessing the current situation and to decide whether it is safe to enter the next clearance (according to the planned route) or not.
6b	If the controller considers the predictive indication in his decision whether to enter a clearance or not this reduces the number of CATC Alerts (see C5 above). The use of this HMI tool links to Human Performance.

PJ.02-W2-21.1: Enhanced Airport Safety Nets for Controllers at A-SMGCS Airports **Version**: 003 **Production Date**: 12/2022
Stakeholder: ATCO Ground

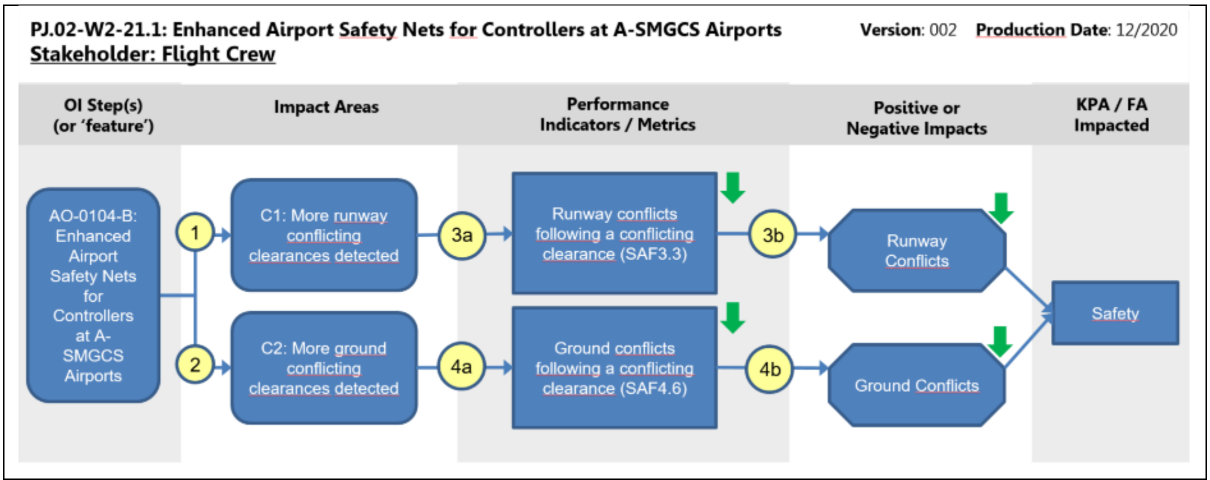


1	C1: More ground conflicting clearances detected The new safety net will detect more conflicting clearances in ground operations, e.g. an alert will be triggered when a push-back or taxi clearance is given and is predicted to lead to conflicting trajectories with another aircraft already cleared for push-back or taxi.
2	C2: Less too early conflicting clearances alerts triggered An alert triggered before the conflicting clearances become operationally remarkable (i.e. needs attention) would be considered as a nuisance alert by the controller. The new safety net is configured to avoid nuisance alerts. For example: No alert will be triggered when … … the preceding aircraft is predicted to have vacated the runway when the landing one will be at the runway threshold; … a taxiing aircraft is still far away from the potentially conflicting mobile, e.g. another aircraft in pushback.

3	C3: More deviations to procedures detected The controller will be alerted by more deviations to procedures detected by the new safety net: To complement the set of CMAC alerts already defined in SESAR 1 Solution #02, an alert will be triggered when an aircraft is arriving to an occupied stand;
4	C4: Less conflicting clearances entered The controller is supported by the Predictive Indication in his decision whether it is safe to enter the next clearance according to the planned route of a mobile. If the Predictive Indicator on the HMI predicts that entering the clearance will trigger a CATC Alert it is the controller´s decision what the appropriate next action is, for instance, … … to ignore the prediction because the controller´s assessment of the situation is that it is safe to enter the clearance; … to wait until the Predictive Indicator predicts that entering the clearance will not trigger a CATC Alert; … to enter the clearance as Conditional Clearance; … to alter the planned route before entering the next clearance. This results in significant fewer conflicting clearances entered.
5a	Detecting more ground conflicting clearances will result in fewer conflicts happening on taxiways and apron areas as the delivery of a push-back or taxi clearance could lead to a conflict with another aircraft already cleared for push-back or taxi.
5b	Providing predictive indications about potentially conflicting clearances (if given/input) and having fewer conflicts following a conflicting ground clearance will increase the Controller's situational awareness, which leads to Human Performance.
6a	Not triggering alerts on non-conflicting runway clearances will result in fewer nuisance alerts for the Controllers.
6b	Having fewer nuisance alerts to be managed by the Controllers will keep the controller's workload (related to this solution) on a neutral level, which links to Human Performance.
7a	Detecting more deviations to procedures will result in that case (through the provision of a specific alert to warn the Controller on an occupied stand) in fewer blocked aircraft on the apron areas due to an occupied stand.
7b	Providing an early warning of an occupied stand will facilitate the management of that situation by the Controller as it will give more time to coordinate for another stand and there will be fewer situations with blocked aircraft on the apron areas due to an occupied stand. This will decrease the controller’s workload (in case the blocking has to be managed), which links to Human Performance.
8a	The predictive indication supports the ATCO in assessing the current situation and to decide whether it is safe to enter the next clearance (according to the planned route) or not.
8b	If the controller considers the predictive indication in his decision whether to enter a clearance or not this reduces the number of CATC Alerts (see C5 above). The use of this HMI tool links to Human Performance.

EUROPEAN PARTNERSHIP

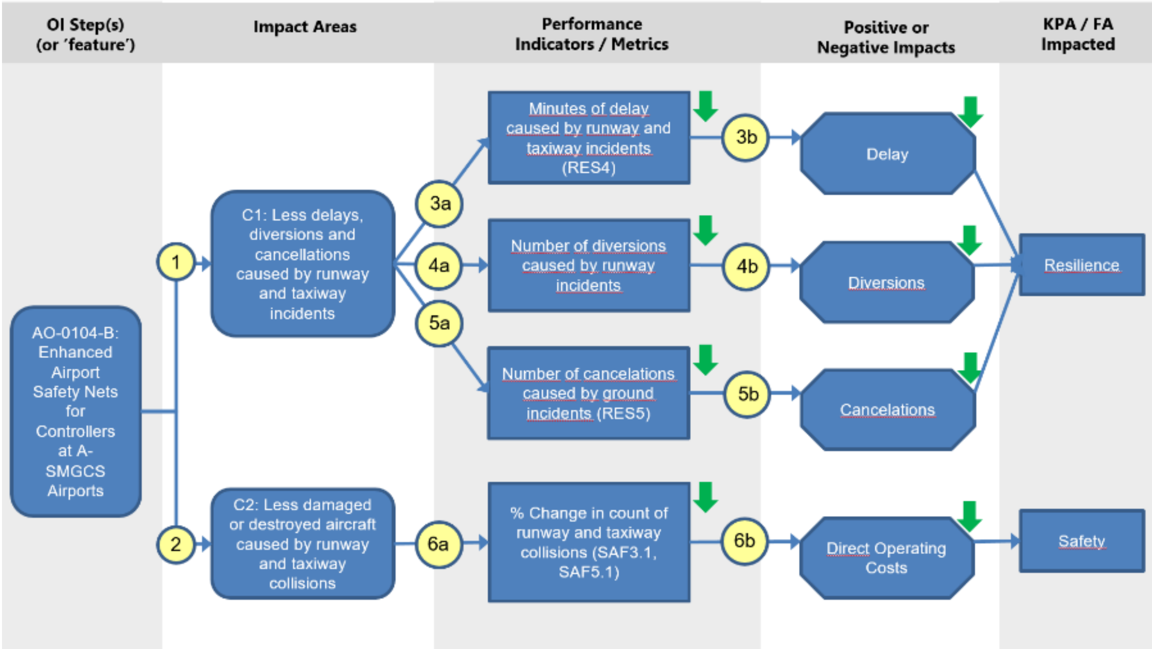
Co-funded by the European Union



1	C1: More runway conflicting clearances detected The new safety net will detect more runway conflicting clearances: The alert will be triggered only in cases when the system – based on data available – assumes that the separation on the RWY will be infringed at the time the landing aircraft crosses the RWY threshold. An alert will be triggered when the trajectories of departing aircraft are detected to be converging immediately after take-off and the second aircraft is cleared for take-off (and still on the ground). An alert will be triggered when an aircraft is cleared to use a runway although a runway incursion has been detected (and still needs to be resolved).
2	C2: More ground conflicting clearances detected The new safety net will detect more conflicting clearances in ground operations, e.g. an alert will be triggered when a push-back or taxi clearance is given and is predicted to lead to conflicting trajectories with another aircraft already cleared for push-back or taxi.
3a	Detecting more runway conflicting clearances will result in fewer conflicts to occur on the runway (or in the immediate vicinity of the runway) as the delivery of a clearance could lead to a conflict with another aircraft already cleared for a movement.
3b	Fewer conflicts following a conflicting runway clearance will decrease the overall number of conflicts, which leads to Safety.
4a	Detecting more ground conflicting clearances will result in fewer conflicts happening on taxiways and apron areas as the delivery of a push-back or taxi clearance could lead to a conflict with another aircraft already cleared for push-back or taxi.
4b	Fewer conflicts following a conflicting ground clearance will decrease the overall number of conflicts, which leads to Safety.

PJ.02-W2-21.1: Enhanced Airport Safety Nets for Controllers at A-SMGCS Airports **Version**: 001 **Production Date**: 12/2020

Stakeholder: Airspace User



1	C1: **More runway conflicting clearances detected** The CATC for Runway Operation will detect more runway conflicting clearances: The alert will be triggered only in cases when the system – based on data available – assumes that the separation on the RWY will be infringed at the time the landing aircraft crosses the RWY threshold. A TOF/TOF (converging SIDs) alert will be triggered when the trajectories of departing aircraft are detected to be converging immediately after take-off and the second aircraft is cleared for take-off (and still on the ground). A RMCA/CMAC vs. ATC Clearance alert will be triggered when an aircraft is cleared to use a runway although a runway incursion has been detected (and still needs to be resolved).
2	C2: **More ground conflicting clearances detected** The CATC for Ground Operation will detect more conflicting clearances in ground operations, e.g., an alert will be triggered when a push-back or taxi clearance is given and is predicted to lead to conflicting trajectories with another aircraft already cleared for Push-back or Taxi.
3	Feature: **Predictive Indication** C3: Less conflicting clearances given The Predictive Indication is a decision support tool that gives notice of a potential conflicting clearance before it is given to the flight crew.
4	Feature: **Continuous Probe** C4: More clearance conflicts triggered in the operationally appropriate moment The new safety net continuously checks the active clearances for potential conflicts to account for changing traffic conditions and triggers alerts only when operationally appropriate, i.e., not too early and not too late to give the controller the time to solve the conflict.

5	Feature: **Runway Situational Notifications** C5: Increased situational awareness for ATCO Tower The Runway Situational Notifications act as awareness support tool that indicates current runway usage status (Runway Busy Notification) and alert status for active RMCA, CMAC, and CATC alerts (Runway In Conflict).
6	Feature: **Conditional Clearance** C6: Less unclear route instructions regarding priority of mobiles Controllers use Conditional Clearances to clearly state the priority of mobiles when communicating the cleared route to the flight crew via R/T. The new safety net considers conditional clearances in monitoring and detection of potential conflicts.
7	Feature: **Deadlock Detection** C7: Less deadlocks caused by clearance conflicts The new safety net recognizes potential deadlock situations caused by conflicting clearances.
8a	Detecting more runway conflicting clearances will result in fewer conflicts to occur on the runway (or in the immediate vicinity of the runway) as the delivery of a clearance could lead to a conflict with another aircraft already cleared for a movement.
8b	Fewer conflicts following a conflicting runway clearance will decrease the overall number of conflicts, which leads to Safety.
9a	Detecting more ground conflicting clearances will result in fewer conflicts happening on taxiways and apron areas as the delivery of a push-back or taxi clearance could lead to a conflict with another aircraft already cleared for push-back or taxi.
9b	Fewer conflicts following a conflicting ground clearance will decrease the overall number of conflicts, which affects Safety.
10a	Prediction of conflicting clearances along the planned route supports the decision making by the controller and, if a potential conflict of clearances is detected, the controller may wait until the situation clears.
10b	If the controller considers the predictive indication display this reduces the number of conflicting clearances given to the flight crew. Reducing the number of conflicting clearances given to the flight crew affects Resilience.
11a	The ATC system is continuously checking the active clearances and, if it detects a clearance conflict, it takes in account time or distance to the location of the predicted conflict (or other condition-depended rules) to reduce the number of nuisance alerts.
11b	Reducing the number of nuisance alerts reduces the total number of triggered alerts. Reducing the number of nuisance alerts affects Resilience.
12a	The controller perceives the Runway Busy or Runway In Conflict notification and has the opportunity to decide whether or not to issue an Enter/Cross/Line Up/Take Off clearance. In the case of a Runway Busy notification, the controller could link the clearance to a condition.
13a	Conditional clearances are used to constitute the priority of mobiles at runway entries and between parking positions and taxiways.

13b	If the controller uses conditional clearances (enter, cross, line-up) at runway entries, this reduces the number of conflicting clearances with aircraft landing or taking off. Reducing the number of conflicting clearances at runway entries affects Resilience.
14a	Conditional clearances are used to constitute the priority of mobiles between parking stands and between parking stands and taxiways.
14b	If the controller uses conditional clearances to constitute the priority of mobiles between parking stands and between parking stands and taxiways this reduces the number of conflicting clearances given to the flight crew. Reducing the number of conflicting clearances given to the flight crew affects Resilience.
15a	Depending on the airport layout it is possible that clearances given by different controllers (responsible for different AoR) cause a deadlock situation with the aircraft ending up nose to nose. Deadlocks are also possible if route trajectories overlap on a taxiway without alternative routes.
15b	The safety net conflict detection recognizes potential deadlock situations caused by conflicting clearances. This reduces the number of deadlocks and avoids impact on the surrounding traffic flow. Reducing the number of deadlocks affects Resilience.

1	C1: Less delays, diversions and cancellations caused by runway and taxiway incidents The new safety net informs the controller of potential runway and taxiway incidents caused by conflicting clearances. This reduces delays, diversions and cancellations.

2	C2: Less damaged or destroyed vehicles caused by runway and taxiway collisions The new safety net informs the controller of potential runway and taxiway incidents caused by conflicting clearances. This reduces the number of runway and taxiway collisions.
3a	Impact on Airport measured through delays resulting from capacity degradation due to runway and taxiway incidents.
3b	Less runway and taxiway incidents reduce the minutes of delay. This improves the resilience of Airport planning and operation.
4a	Impact on Airport measured through delays resulting from capacity degradation due to runway and taxiway incidents.
4b	Less runway and taxiway incidents reduce the number of diversions. This improves the resilience of Airport planning and operation.
5a	Impact on Airport measured through delays resulting from capacity degradation due to runway and taxiway incidents.
5b	Less runway and taxiway incidents reduce the number of cancelations. This improves the resilience of Airport planning and operation.
6a	Detecting more conflicting clearances will result in fewer collisions on runways and taxiways.
6b	Less runway and taxiway collisions reduce the cost of repair or replacement (AUC3)

13 Appendix C

13.1Applicable deployment locations

The following table reports the applicable deployment locations (13 Very Large, 12 Large and 3 Medium) for the OI steps AO-0104-B, according to the SESAR Airport OE [14].

Airport	APT Sub-OE	Number of movements (2018)
Frankfurt/Main	Very large	511,773
Amsterdam/Schiphol	Very large	510,966
Paris-Charles De Gaulle	Very large	488,038
London Heathrow	Very large	477,464
Muenchen	Very large	410,301
Madrid/Adolfo Suarez Madrid-Barajas	Very large	409,455
Barcelona/El Prat	Very large	335,521
Roma/Fiumicino	Very large	307,873
London Gatwick	Very large	283,804
Zurich	Very large	271,348
Kobenhavn/Kastrup	Very large	265,977
Oslo/Gardermoen	Very large	257,638
Wien-Schwechat	Very large	256,343
Stockholm/Arlanda	Large	243,690
Dublin	Large	232,449
Paris-Orly	Large	232,369
Brussels/Brussels-National	Large	229,847
Palma De Mallorca	Large	220,242
Duesseldorf	Large	218,429
Manchester	Large	201,110
London Stansted	Large	200,252
Milano/Malpensa	Large	194,355
Chopina W Warszawie	Large	187,263
Berlin-Tegel	Large	185,269
Praha/Ruzyne	Large	150,961
Nice-Cote D'azur	Medium	143,779
Budapest Liszt Ferenc International Airport	Medium	114,454
Luxembourg/Luxembourg	Medium	74,947

Table 24: SESAR Solutions PJ.02-W2-21.1 Deployment airports

-END OF DOCUMENT-