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PJ.14-W2-84f TRL6 Cost Benefit Analysis for Surveillance Performance Monitoring - End-to-end

Deliverable ID:	**D12.7.500**
Dissemination Level:	**PU**
Project Acronym:	**PJ.14 W2 I-CNSS**
Grant:	**874478**
Call:	**H2020-SESAR-2019-1**
Topic:	**SESAR-IR-VLD-WAVE2-12-2019**
Consortium coordinator:	**Leonardo**
Edition date:	**10 November 2022**
Edition:	**00.01.02**
Template Edition:	**02.00.07**

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Authoring & Approval

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Thales Air Systems	10/11/2022

Reviewers internal to the project

Beneficiary	Date
Eurocontrol	10/11/2022
Thales Air Systems	10/11/2022

Reviewers external to the project

Beneficiary	Date

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

Beneficiary	Date
Eurocontrol	10/11/2022
Thales Air Systems	10/11/2022

Rejected By - Representatives of beneficiaries involved in the project

Beneficiary	Date

Document History

Edition	Date	Status	Beneficiary	Justification
00.00.01	21/07/2022	Draft	Eurocontrol	Initial CBA model taken TRL4 CBAT
00.00.02	22/08/2022	Draft	All contributors	Update after internal review of contents
00.01.00	31/08/2022	Released	All contributors	Update after final review
00.01.01	10/10/2022	Released	All contributors	Updated to address SJU comments
00.01.02	10/11/2022	Released	All contributors	Updated to address PJ.19-04 comments during maturity gate

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SURVEILLANCE PERFORMANCE MONITORING FOR END-TO-END

This Cost Benefit Analysis is part of a project that has received funding from the SESAR3 Joint Undertaking under grant agreement No 874478 under European Union's Horizon 2020 research and innovation programme.

Abstract

This document presents the Cost Benefit Analysis (CBA) for the deployment of the SESAR technological solution PJ.14-W2-84f targeting a maturity level of TRL6. Solution PJ.14-W2-84f has the OI step POI-0062-SUR (Surveillance performance monitoring for end-to-end surveillance chain) and provides the enabler CTE-S07e (SUR Chain SPM Tool – ER & TMA). The solution targets ANSPs in TMA & En-route operational environments for deployment.

CBA objectives, scope and cost-benefit analysis have been developed in line with CBA guidelines in addition to checking with the PJ19-04 CBA experts and in collaboration with Solution PJ.14-W2-84e already during the TRL4 phase. The cost-benefit analysis for the current TRL6 phase is in line with the CBA for TRL4 phase; the assumptions and methodology used for the cost-benefit analysis in both phases are quite similar. The main change is the operating and investment costs that are updated in order to take into account TRL6 development, namely QRT functionality and comprehensive crosscheck of the SPM Tools.

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1 Executive Summary

This document provides the Cost Benefit Analysis (CBA) related to the deployment of SESAR Technological Solution PJ.14-W2-84f that has performed the validation activities at TRL6 maturity level. The CBA focuses on deployment of the solution and is not limited to the scope of the validation activities. Within Wave 2, PJ.14-W2-84f has first achieved maturity level TRL4 and currently aims to achieve TRL6 by the end of Wave 2.

Communications, Navigation and Surveillance (CNS) systems provide the invisible and often unappreciated infrastructure, which is essential for Air Traffic Management. CNS enables efficient navigation and safe separation in all phases of flight. In Surveillance, several SESAR solutions are being developed in line with Performance Based Surveillance (PBS) approach to enhance, harmonize, and integrate cooperative and emerging non-cooperative sensors, advanced multi-sensors data fusion capabilities, security related functionality together with the methods and tools for Surveillance Performance Monitoring.

The performance assessment tools and methods for the End-to-end Surveillance Chain are currently considered inadequate and not aligned with the latest standards, namely ESASSP Ed 1.2. The main objective of the Technological Solution PJ.14-W2-84f is to enable a harmonized performance monitoring for the End-to-end Surveillance Chain. Such monitoring aims to identify degradation trends early, using both off-line and quasi-real time processes. The solution will be deployed by ANSPs in TMA & En-route operational environments. ANSPs will receive the following benefits:

- Compliance with the latest standards,
- Cost efficiency through increased automation,
- Increased trustworthiness of the performance assessments.

Principle assumption related to the reference and solution scenarios is that ANSPs would have to deploy new SPM Tools for end-to-end surveillance chain in order to comply with latest standards. They will deploy either tools available on the market or those developed by this solution. The costs are quantized as technical personnel (ATSEP) effort associated to the tool selection process and to tool's operational use. This analysis provided the cost difference between reference and solution scenarios, and then converted to quantitative results using the PJ19-04 CBA model. Using this approach, the Net Present Value is calculated as 1,12 M€ for ANSPs with a discount rate of 8%.

Regarding the payback period, as the delta between the ground implementation costs in the Solution Scenario and the Reference Scenario is negative (i.e. higher ground costs expected in the Reference Scenario), the solution will be net positive as of deployment, i.e. 2023. In other words, the main benefits of this solution are the avoided costs. The ANSPs will benefit mainly from the less time spent during the selection process and operation of the SPM Tools due to validation by a larger community and automated operation.

The main uncertainty for the CBA is the number of SDPD systems per ANSP and the amount of time spent by ATSEP to test the tools for deployment and to perform performance assessments. The influences of these uncertainties and the discount rate on NPV are studied through a sensitivity analysis. We can conclude that the NPV always remains positive, which indicates that the solution is a good candidate for deployment by the stakeholders. This should be expected as the solution provide net benefits from the start.

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2 Introduction

This project is part of the SESAR 2020 Multi Annual Program for the period 2019-2022. It is part of the Industrial Research & Validation developed under the SJU Private Public Partnership. Solution PJ.14-W2-84f is a continuation of the work initiated by PJ.14-04-01 Task 3, which reached TRL2 maturity at the end of Wave 1. The solution has already achieved TRL4 and currently aims TRL6 maturity at the end of Wave 2.

Communications, Navigation and Surveillance (CNS) systems provide the invisible and often unappreciated infrastructure, which is essential for Air Traffic Management. CNS enables efficient navigation and safe separation in all phases of flight. In Surveillance, several SESAR solutions are being developed in line with a performance-based surveillance (PBS) approach to enhance, harmonize, and integrate cooperative and emerging non-cooperative sensors, advanced multi-sensors data fusion capabilities, security related functionality together with the methods and tools for Surveillance Performance Monitoring.

The objective of the solution PJ.14-W2-84f is to enable a harmonised performance monitoring of surveillance systems. Such monitoring will seek to identify degradation trends early, using both off-line and in continuous quasi real-time processes. These will be applied at the output of the entire surveillance chain. It is to be noted that performance assessment methods for the surveillance chain are still developing and that the available classical methods and tools are considered to be inadequate. In this regard, recognising there is a trend of the standards towards harmonisation, the choice has been made to harmonise the various metric assessment methods in line with ESASSP Ed 1.2 [12]. This approach is also expected to provide useful feedback to the standards under development and to their future updates.

PJ.14-W2-84f has performed the CBA study using similar assumptions and methodology as used by PJ.14.-W2-84e. Since ANSPs are required to provide proof of compliance with applicable standards for their end-to-end surveillance chain, they will need to deploy new surveillance performance assessment tools that provide the required performance metrics. This solution aims to provide such tools that are developed, harmonised and validated through a common framework. Principle assumption as basis of CBA related to the reference and solution scenarios is that ANSPs would have to deploy new SPM Tools for end-to-end surveillance chain in order to comply with the latest standards. They will deploy either tools available on the market or those developed by this solution. The costs are quantized for the technical personnel (ATSEP) effort associated to the tool selection process and operational use.

2.1 Purpose of the document

This document provides the Cost Benefit Analysis (CBA) related to the deployment of the SESAR Technological Solution PJ.14-W2-84f that has performed technological validation activities (see TVALR [14]) for TRL6 maturity. CBA objectives, scope and cost-benefit analysis have been developed in line with CBA guidelines and by checking with the PJ19-04 CBA experts already during the TRL4 phase. The cost-benefit analysis for the current TRL6 phase is in line with the CBA for TRL4 phase [13]; the assumptions and methodology used for the cost-benefit analysis in both phases are quite similar. The main change is the operating and investment costs that are updated in order to take into account TRL6 development, namely QRT functionality and comprehensive crosscheck of the SPM Tools.

2.2 Scope

Reference time period for the CBA is from October 2023 to October 2043, which assumes the start of deployment at 2023, 3 years before IOC in 2026, FOC in 2030 and accruing benefits until 2043. The geographical scope is the entire ECAC region and main stakeholder is ANSPs at TMA & En-route operational environments.

2.3 Intended readership

ANSPs operating in TMA & En-route operational environments are the principal audience. Solution PJ.14-W2-84f follows the CBA methodology developed by PJ.14-W2-84e, specifically ANSP partners in that solution. In this respect, both solutions share common assumptions and methodology. Similarly, the guidance provided by PJ19-04 CBA experts was common to both solutions. Solution PJ.14-W2-84a might have an interest as it uses the SPM Tools developed by PJ.14-W2-84f. Therefore, the intended audience are the following:

- ANSPs operating in TMA & En-route operational environments,
- Solution PJ.14-W2-84a,
- Solution PJ.14-W2-84e,
- PJ19-04 CBA Experts.

2.4 Structure of the document

This document is organized as follows:

- Section 1 Executive summary,
- Section 2 Introduction,
- Section 3 CBA objectives and scope,
- Section 4 provides the identified benefits,
- Section 5 provides the overall cost assessment,
- Section 6 provides the CBA model,
- Section 7 provides the CBA results,
- Section 8 provides the sensitivity and risk analysis,
- Section 9 provides the recommendations and next steps,
- Section 10 provides the reference and applicable documents.

2.5 Background

Solution PJ.14-W2-84f is a continuation of the work initiated by PJ.14-04-01 Task 3, which reached TRL2 maturity at the end of Wave 1. PJ.14-04-01 Task 3 developed and delivered a qualitative “High-Level Economic Appraisal” in Wave 1. The solution has already achieved TRL4 maturity in the first part of Wave 2 and has provided a CBA study.

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2.6 Glossary of terms

Term	Definition	Source of the definition
Capital Expenditure	Capital expenditures (Capex) are funds used by a company to acquire, upgrade, and maintain physical assets such as property, plants, buildings, technology, or equipment.	Investopedia
Operational expenditure	An operational expenditure (Opex) is an expense a business incurs through its normal business operations.	Investopedia
Net Present Value	Net Present Value (NPV) is the sum of all discounted cash inflows and outflows during the time horizon period.	*Investopedia*

Table 1: Glossary of terms

2.7 List of Acronyms

Acronym	Definition
ACC	Area Control Centre
ANSP	Air Navigation Service Provider
ATM	Air Traffic Management
ATSEP	Air Traffic Safety Electronics Personnel
CAPEX	Capital expenditure
CBA	Cost Benefit Analysis
CNS	Communication, Navigation and Surveillance
ECAC	European Civil Aviation Conference
EATMA	European ATM Architecture
ESASSP	EUROCONTROL Specification for ATM Surveillance System
FOC	Full Operational Capability
FTE	Full-time equivalent
IOC	Initial Operational Capability
OI	Operational Improvement
OPEX	Operational expenditure
OSED	Operational Service and Environment Definition
PIRM	Programme Information Reference Model
PAR	Performance Assessment Report

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QRT	Quasi Real Time
SDPD	Surveillance Data Processing and Distribution
SESAR	Single European Sky ATM Research Programme
SJU	SESAR Joint Undertaking (Agency of the European Commission)
SPM	Surveillance Performance Monitoring
SPR	Safety and Performance Requirements
SUR	Surveillance
TMA	Terminal Manoeuvring Area

Table 2: List of acronyms

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3 Objectives and scope of the CBA

3.1 Problem addressed by the solution

This document provides the Cost Benefit Analysis (CBA) related to the deployment of the SESAR Technological Solution PJ.14-W2-84f that has gone through validation activities at TRL6 maturity. The CBA focuses on deployment of the solution and is not limited to the scope of the validation activities. This solution has already achieved TRL4 maturity in the first part of Wave 2 and currently aims TRL6 at the end of Wave 2.

The solution addresses the development of new tools that needs to be used for compliance demonstration with respect to latest standards. ANSPs would need to deploy new SPM Tools for end-to-end surveillance chain in order to demonstrate compliance with latest standards. The SPM Tools developed by this solution will provide standards compliant, validated and harmonised performance monitoring of end-to-end surveillance chain. Through development and validation under SESAR, this solution will facilitate ANSPs to deploy validated and cost effective SPM Tools for end-to-end surveillance chain.

3.2 SESAR Solution description

PJ.14-W2-84f enables an improved performance monitoring of surveillance systems in line with the Performance-Based Surveillance (PBS) approach. The Solution focuses on the development of Surveillance Performance Monitoring Tools for end-to-end surveillance chain. One of the objectives of the Solution is the harmonisation of the tools. The solution aims to align tools specification with existing and developing Surveillance Standards and development of quasi real-time functionality. Tools verification results are a potential input to standardisation, in particular ESASSP specification. Quasi real-time operation enables continuous automated monitoring to identify performance degradation and increases robustness of the overall surveillance chain.

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.14-W2-84f Surveillance Performance Monitoring – end-to-end	POI-0062-SUR	Surveillance performance monitoring for end-to-end surveillance chain	Fully	EATMA (No applicable SPR-INTEROP/OSED)

Table 3: SESAR Solution PJ.14-W2-84f Scope and related OI steps

OI Steps ref.	Enabler ref.	Enabler definition	Enabler coverage	Applicable stakeholder	Source reference
POI-0062-SUR	CTE-S07e	SUR Chain SPM Tool – ER & TMA	Fully	ANSP	EATMA (No applicable SPR-INTEROP/OSED)

Table 4: SESAR Solution PJ.14-W2-84f OI steps and related Enablers

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PJ19-04 has identified CEF3 (Technology Cost per flight) as the only Validation Target for this solution. The following table provides an overview of the scope of the coverage for the validation target:

Validation target	Direct/Indirect impact	Validation activities	CBA activities	Limitations
Technology Cost per flight	Direct impact (CEF3, medium impact expected)	Not measured during validation activities	Evaluated during CBA activities	Certain assumptions made at ECAC level to build the CBA (see Section 3.5)

Table 5: SESAR Solution PJ.14-W2-84f validation targets

3.3 Objectives of the CBA

The objectives of this CBA is to facilitate and support decision-making for key investment decisions related to the deployment of the SESAR Technological Solution PJ.14-W2-84f. ANSPs can use the current CBA to support their decision in the choice of the SPM Tools that they will deploy for the performance assessment of their end-to-end surveillance chain. This is achieved by:

- identifying the reference and solution scenarios,
- identifying the assumptions that will be used for cost-benefit analysis,
- identifying and quantifying the costs and benefits for stakeholders,
- calculating the economic value of the project,
- presenting the cash flow projections for the expected IOC & FOC,
- performing sensitivity analysis for the factors with the most influence on the results.

The CBA results will be used to support the decision to move to the next stage of life-cycle at the maturity gate. The economic feasibility of the solution is assessed by comparing to reference scenario of choosing an SPM Tool available on the market. The output is a quantitative assessment of both costs and benefits with a first order of magnitude of benefits of the reference and solution scenario compared.

3.4 Stakeholders identification

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	All TMA & En-route OEs	Invest and enjoy benefits in operations	Indirect involvement through common methodology used in PJ.14-W2-84e; common assumptions and methodology	Yes, on both costs and benefits

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Table 6: SESAR Solution PJ.14-W2-84f CBA Stakeholders and impacts

3.5 CBA Scenarios and Assumptions

Solution PJ.14-W2-84f is a Technological Solution, without an associated Operational Solution. Therefore, the scenarios used for CBA are not derived from any SPR-INTEROP/OSED, but using the specific assumptions made by Solution PJ.14-W2-84e and adapted by Solution PJ.14-W2-84f.

It is important to note that ANSPs will have to deploy new SPM Tools for end-to-end surveillance chain in order to comply with the latest standards, namely ESASSP Ed 1.2. They will deploy either SPM Tools available on the market or those developed by this solution. The relevant costs/benefits for deployment and operations for the selected SPM Tools are quantized as the technical personnel (ATSEP) effort associated to the tool selection process and to operational use.

3.5.1 Reference Scenario

In the reference scenario, ANSP would choose an SPM Tool for end-to-end that is available on the market. The following assumptions are made for the reference scenario:

- 3 to 5 SPM tools are available that are developed by industry,
- 3 SPM tools are assessed for deployment,
- the tools support the performance assessment as given by ESASSP Ed 1.2,
- basic or no automated performance assessment is available.

3.5.2 Solution Scenario

In the solution scenario, ANSP would choose an SPM Tool for end-to-end that is developed by this solution. The following assumptions are made for the solution scenario:

- 2 SPM tools are developed within SESAR (Eurocontrol & Thales),
- both SPM tools are assessed for deployment,
- the tools support the performance assessment as given by ESASSP Ed 1.2,
- automated performance assessment and monitoring is available through Quasi Real-Time functionality.

Time horizon is with start of deployment from October 2023, IOC from October 2026 and FOC from October 2030. The geographical scope is the entire ECAC region and main stakeholder is ANSPs at TMA & En-route operational environments. Standard discount rate of 8% is used.

3.5.3 Assumptions

ANSPs will have to deploy new SPM Tools for end-to-end surveillance chain for compliance demonstration with respect to the latest standards, namely ESASSP Ed 1.2. They will deploy either SPM Tools available on the market or those developed by this solution. The relevant costs/benefits for deployment and operations for the selected SPM Tools are quantized as the technical personnel (ATSEP) time/effort associated to the tool selection process and use in operations.

The following assumptions are made for both scenarios:

- tools are split equally among ECAC countries,

- ANSP costs are considered for tool selection and operational use,
- same hardware and license costs for the tools in both reference and solution scenarios,
- same training costs assumed for the tools in both reference and solution scenarios,
- same maintenance costs for the tools in both reference and solution scenarios.

Detailed assumptions are provided in Assumptions sheet of “CBA_Methodology_for_84f_TRL6.xlsx” in Section 6.

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4 Benefits

For Solution PJ.14-W2-84f, the benefits are basically net positive gains during deployment and operational use. PJ19-04 has identified only CEF3 (Technology cost per flight) with expected medium impact. Rather than showing the results for Year N, Year N+x and Year N+y in the table below, these results are provided in the form of Capex-Opex charts in Section 7.

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Performance Framework KPA[1]	Focus Area	KPI/PI from the Performance Framework	Unit	Metric for the CBA	Unit	Year N	Year N+x	Year N+y
	ANS Cost efficiency	**CEF2** Flights per ATCO-Hour on duty	Nb	ATCO employment Cost change	€/year			
				Support Staff Employment Cost Change	€/year			
				Non-staff Operating Costs Change	€/year			
		CEF3 Technology cost per flight	EUR / flight	G2G ANS cost changes related to technology and equipment	€/year	(see Capex-Opex Charts in Section 7)	(see Capex-Opex Charts in Section 7)	(see Capex-Opex Charts in Section 7)
	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 cabin salary, handling prices at Base Stations	€/year			

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

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Performance Framework KPA[1]	Focus Area	KPI/PI from the Performance Framework	Unit	Metric for the CBA	Unit	Year N	Year N+x	Year N+y
		AUC5 Overhead costs for an airspace user	EUR / flight	Impact on overhead costs. Examples: dispatchers, training, IT infrastructure, sales.	€/year			
	Airspace capacity	**CAP1** TMA throughput, in challenging airspace, per unit time	% and # movements	Tactical delay cost (avoided-; additional +)	€/year			
			% 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	**RES4a** Minutes of delays	Minutes	Tactical delay cost (avoided-; additional +)	€/year			
		RES4b Cancellations	% and # movements	Cost of cancellations	€/year			
		Diversions	% and # movements	Cost of diversions	€/year			

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Performance Framework KPA[1]	Focus Area	KPI/PI from the Performance Framework	Unit	Metric for the CBA	Unit	Year N	Year N+x	Year N+y
	Predictability	**PRD1** Variance of Difference in actual & Flight Plan or RBT durations	Minutes^2	Strategic delay cost (avoided-; additional +)	€/year			
	Punctuality	**PUN1** % Departures < +/- 3 mins vs. schedule due to ATM causes	% (and # movements)	Tactical delay cost (avoided-; additional +)	€/year			
	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			
	Time Efficiency	**FEFF3** Reduction in average flight duration	% and minutes	Strategic delay: airborne: direct cost to an airline excl. Fuel (avoided-; additional +)	€/year			
	Fuel Efficiency	**FEFF1** Average fuel burn per flight	Kg fuel per movement	Fuel Costs	€/year			
	Fuel Efficiency	**FEFF2** CO2 Emissions	Kg CO2 per movement	CO2 Costs	€/year			
	Civil-Military Cooperation & Coordination	**CMC2.1a** Fuel saving (for GAT operations)	Kg fuel per movement	Fuel Costs	€/year			

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Performance Framework KPA[1]	Focus Area	KPI/PI from the Performance Framework	Unit	Metric for the CBA	Unit	Year N	Year N+x	Year N+y
		CMC2.1b Distance saving (for GAT operations)	NM per movement	Time Costs	€/year			

Table 7: Results of the benefits monetisation per KPA

5 Cost assessment

The SPM Tools End-to-end Surveillance Chain developed by Solution PJ.14-W2-84f targets ANSPs in the TMA and En-route operating environments. Therefore, the costs are assessed only for ANSPs. Principle costs would be budgeted for candidate tool assessment, hardware, license, training, maintenance and operational use.

5.1 ANSPs costs

Due to the requirements for compliance demonstration, ANSPs would need to choose for deployment either an SPM Tool that is available on the market or developed by this solution. Three categories of costs have been identified and estimated for the ANSPs: the pre-implementation costs, the implementation costs and the operating costs.

Pre-implementation costs are mainly related to the procurement of an SPM Tool: for preparation of a call for tender, tool assessment and procurement. Implementation costs are related to hardware, tool installation and ATSEP training. As operating costs, regular operational usage, tool maintenance and continued ATSEP training are considered.

5.1.1 ANSPs cost approach

The cost figures are obtained using expert judgment (from ANSPs involved in Solution PJ.14-W2-84e, surveillance industry partners and community). Several brainstorms have been organized to define a reasonable set of assumptions having a direct impact on the costs, like number licenses, ATSEP effort for performance assessments, average ATSEP FTE salary, etc.

5.1.2 ANSPs cost assumptions

For cost assessment, it is assumed that hardware, license, training and maintenance costs would be similar for a tool that is available on the market or that developed by this solution. For the CBA, the cost differential between the reference and solution scenarios are assumed to come from the effort related to the selection and operational use of the SPM Tool. The principal cost efficiencies for the solution scenario are the following:

- ANSPs will spend less effort for SPM Tool specification and acceptance testing prior to deployment due to availability of tools harmonised and validated through a common framework,
- ATSEP will spend considerably less time for the regular use of the tool for performance assessment and monitoring of their surveillance chain.

For both reference and solution scenarios, a single SPM Tool license is assumed to be needed for each ANSP. The investments costs and annual operating costs are calculated per stakeholder (i.e. ANSPs and Airport Operators).

The following assumptions are made for the ANSP costs:

- same hardware and license costs for the tools in both reference and solution scenarios,
- same training costs for the tools in both reference and solution scenarios,
- same maintenance costs for the tools in both reference and solution scenarios.

Detailed assumptions are provided in Assumptions sheet of “CBA_Methodology_for_84f_TRL6.xlsx” in Section 6.

5.1.3 Number of investment instances (units)

The basic assumption of this CBA is that one SPM Tool license would be needed for each ANSP or ECAC country. ANSPs would use the SPM Tool for the performance assessments of end-to-end surveillance chain in TMA and En-route with all complexity sub operating environments. A single investment instance is expected per ANSP/ECAC Country, but at ECAC level, this investment period is considered to be from IOC to FOC to allow for different ANSPs deploying at different periods.

5.1.4 Cost per unit

The ECAC level figures provided in this section are those from the CBA input given in DELTA sheet of "CBA_Methodology_for_84f_TRL6.xlsx" in Section 6. This cost difference between the solution and reference scenario is used as input to the CBA model provided by the PJ19-04 (parameters "Ground Costs - MEUR" and "Ground Change in operating costs (M€, annual)" for Scenario 1 in the Sol_Info sheet of "s7_2_11_for_S84f_TRL6.xlsm" in Section 6).

For ANSPs, the cost differential (delta) at ECAC level when comparing the solution and the reference Scenarios is:

- overall investment costs (pre-implementation + implementation): -137 K€, i.e. higher ground costs expected in the Reference Scenario,
- annual operating costs: -183 K€, i.e. higher operating costs expected in the Reference Scenario.

As the assumption is that each ANSP of the ECAC region would buy a license (44 ANSPs in total), the cost per ANSP or cost per unit would then be:

- overall investment costs (pre-implementation + implementation): -3.1 K€ (net benefits due to higher costs expected in the Reference Scenario),
- annual operating costs: -4.2 K€ (net benefits due to higher costs expected in the Reference Scenario).

5.2 Airport operators costs

No applicable costs.

5.2.1 Airport operators cost approach

Not applicable.

5.2.2 Airport operators cost assumptions

Not applicable.

5.2.3 Number of investment instances (units)

Not applicable.

5.2.4 Cost per unit

Not applicable.

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5.3 Network Manager costs

No applicable costs.

5.3.1 Network Manager cost approach

Not applicable.

5.3.2 Network Manager cost assumptions

Not applicable.

5.3.3 Network Manager cost figures

Not applicable.

5.4 Airspace User costs

No applicable costs.

5.4.1 Airspace User cost approach

Not applicable.

5.4.2 Airspace User cost assumptions

Not applicable.

5.4.3 Number of investment instances (units)

Not applicable.

5.4.4 Cost per unit

Not applicable.

5.5 Military costs

No applicable costs.

5.5.1 Military cost approach

Not applicable.

5.5.2 Military cost assumptions

Not applicable.

5.5.3 Number of investment instances (units)

Not applicable.

5.5.4 Cost per unit

Not applicable.

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5.6 Other relevant stakeholders

No other stakeholders.

5.7 Cost mechanism summary

This section provides a summary of how the data in the previous sections is used to feed the CBA model. For both the Investment Costs and the Annual Operating Costs, the tables below give the difference between the costs in the Solution Scenario (SOL) and the Reference Scenario (REF) per country and at ECAC level.

Stakeholder	Cost per-unit (Delta SOL & REF)	x	Deployment Locations	=	Investment Costs (Delta SOL & REF)
ANSP (TMA & En-route)	- 3.1 K€	x	1 ANSP x 44 countries	=	- 136 K€

Table 8: SESAR Solution PJ.14-W2-84f difference between REF and SOL scenarios for Investment Costs

Stakeholder	Cost per-unit (Delta SOL & REF)	x	Deployment Locations	=	Annual Operating Costs (Delta SOL & REF)
ANSP (TMA & En-route)	- 4.2 K€	x	1 ANSP x 44 countries	=	- 183 K€

Table 9: SESAR Solution PJ.14-W2-84f difference between SOL and REF scenarios for Annual Operating Costs

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6 CBA Model

The CBA model “s7_2_11_for_S84f_TRL6.xlsm” and “CBA_Methodology_for_84f_TRL6.xlsx” used as input are attached below:


CBA_Methodology_for_84f_TRL6.xlsx


s7_2_11_for_S84f_TRL6.xlsm

6.1 Data sources

The data used to build the CBA consist mainly of several assumptions and expert judgements captured and recorded during specific brainstorming sessions, especially:

- estimation of ATSEP time for assessing the tools and carrying-out the performance assessments,
- number of SPM tool licences per ECAC country,
- average number of SDPD systems per ECAC country.

The assumptions and associated data sources are included in the CBA input (“CBA_Methodology_for_84f_TRL6.xlsx”) and are input into the CBA model from PJ19-04. The confidence in the expert judgements is pretty high, with a group of 5 to 8 skilled ANSPs representatives (ENAIRE, COOPANS, NavPortugal) from Solution PJ.14-W2-84e and from the industrial partners developing the tools (Thales, Eurocontrol). Furthermore, PJ19-04 CBA experts have reviewed the CBA input methodology used by Solution PJ.14-W2-84e and PJ.14-W2-84f, through several review meetings.

This CBA identifies and takes into account the main uncertainties of the project related to the assumptions by using ranges for uncertain input data in the sensitivity analysis:

- the number of SDPD systems in the ECAC region compared to the forecast in 2030: +/- 20% applied,
- the average time spent by ATSEP to assess the tools (pre-implementation and implementation phases) and to carry out the performance assessments (operational phase): +/- 25% and +/- 50% applied.

The average ATSEP annual employment costs is used as one full-time equivalent (FTE) in the ECAC area, using per country figures from the EUROCONTROL Standard Inputs for Economic Analyses [15].

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7 CBA Results

The following tables and figures are extracted from the CBA-model and provide the relevant results from the CBA.

Table 10 and Table 11 give the overall investment costs and the benefits up to 2043, when a discount rate of 8% is applied and without any discount rate respectively. Actually, positive value for Net Present Value (NPV) indicates that the solution is net positive from the start.

PJ.14-W2-84f TRL6 - 2022-2043 (discount rate 8%) (M€)				
	NPV	Capex	Opex	Benefits
ANSP	1,12	0,09	1,08	0,0
Overall	**1,12**	**0,09**	**1,08**	**0,0**

Table 10: SESAR Solution PJ.14-W2-84f Investment Discounted Costs and Benefits

PJ.14-W2-84f - 2022-2043 (undiscounted) (M€)				
	Net Benefits	Capex	Opex	Benefits
ANSP	3,06	0,14	2,92	0,0
Overall	**3,06**	**0,14**	**2,92**	**0,0**

Table 11: SESAR Solution PJ.14-W2-84f Investment Undiscounted Costs and Benefits

Figure 1 and Figure 2 give the yearly Opex-Capex evolution from 2023 up to 2043, without any discount rate and when a discount rate of 8% is applied respectively.

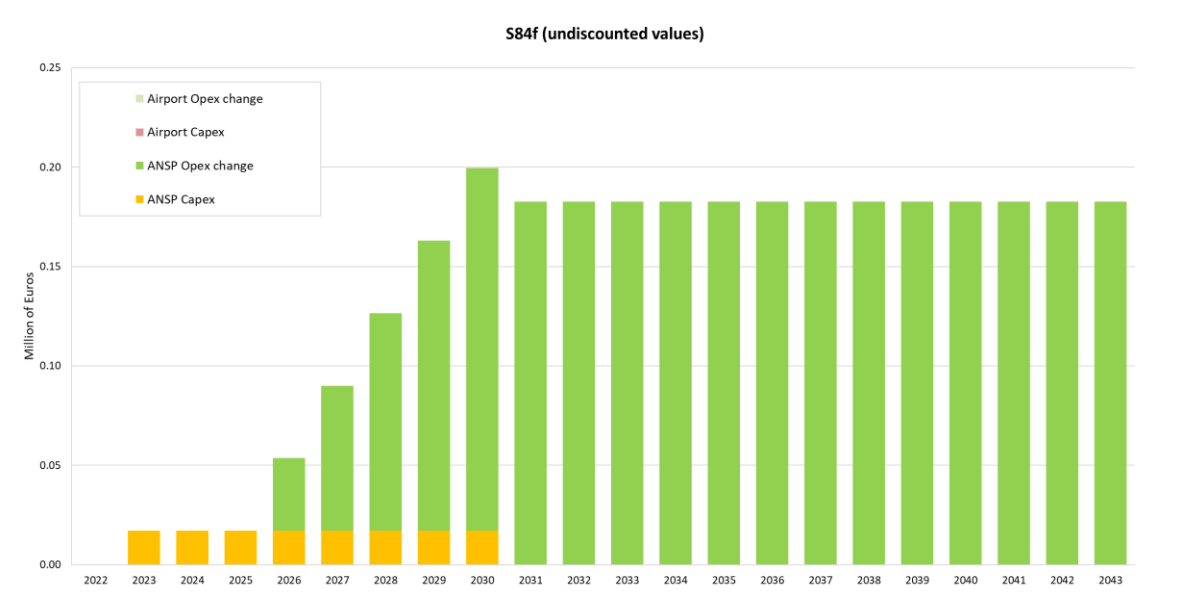

Figure 1: SESAR Solution PJ.14-W2-84f Undiscounted Opex-Capex

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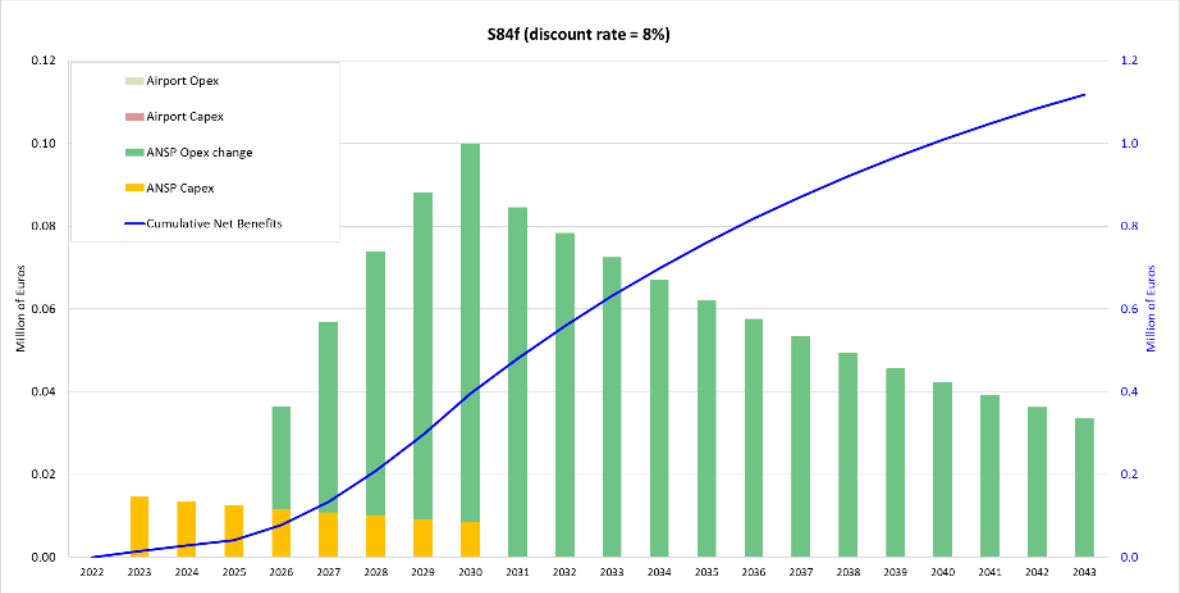

Figure 2: SESAR Solution PJ.14-W2-84f Discounted Opex-Capex

The payback period is actually from the start of deployment. In other words, the main benefits of this solution are mainly the “avoided costs”. By deploying the harmonised SPM Tools, the stakeholders will still have to invest, but they will invest less than with the current approach of deciding for a suitable SPM Tool that would be available on the market.

8 Sensitivity and risk analysis

8.1 Influence of the discount rate on NPV

The following graph is extracted from the CBA model and provides the impact of the Discount Rate on the NPV given in M€. The NPV is always positive, which is expected as the solution provides net benefits from the start. In the worst case of 10% borrowing costs, the solution still provides benefits of nearly 1 M€.

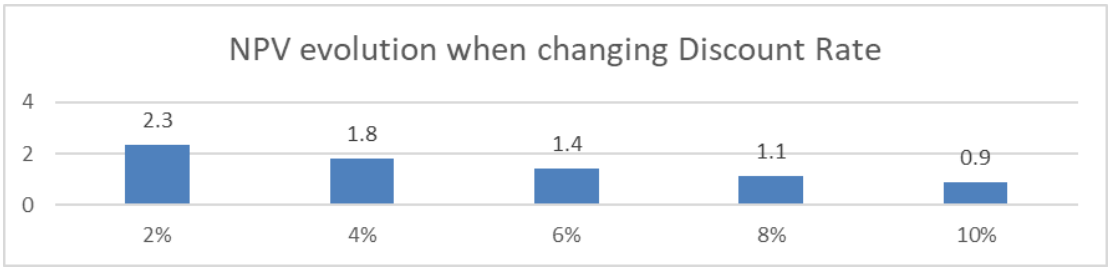

Figure 3: SESAR Solution PJ.14-W2-84f NPV and Discount Rate

8.2 Variation of the input to the CBA model

The following graphs are also extracted from the CBA-model and depict the impact of a variation of the input to the model (input variations +/- 25% and +/- 50%) on the Ground Opex/Capex.

Effectively, this variation represent the cost/benefit differential percentage in case capital and operating expenses are varied by 50% and 25%. This provides the cases for cost/benefits overruns and underruns in the estimated Opex/Capex values.

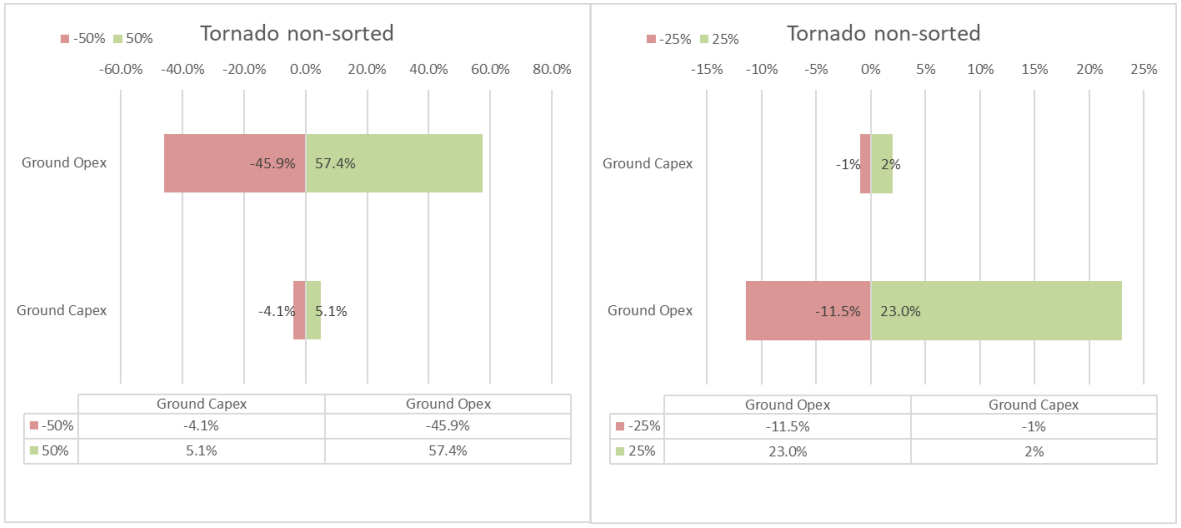

Figure 4: SESAR Solution PJ.14-W2-84f Tornado Diagrams for Discount Rate Variations

8.3 Influence of the number of SDPD systems and ATSEP effort

The sensitivity analysis is performed by varying the values used in the main assumptions taken for the CBA in order to observe their influence on the NPV. The main parameters used for the sensitivity analysis are the following:

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- the number of SDPD systems per ECAC country checked with a variation of +/- 20%,
- the average time spent by ATSEP to assess the tools (pre-implementation and implementation phases) and to carry out the performance assessments (operational phase) checked with variation of +/- 25% and +/- 50%.

These two parameters are varied in the CBA input ("CBA_Methodology_for_84f_TRL6.xlsx") in order to re-calculate the costs. The results are then inserted in the CBA model in order to calculate the NPV.

Changing the values used for these assumption have considerable impact on the NPV, but the NPV remains always positive. This should be expected as the solution provides a net positive value both at deployment and during operational use.

8.3.1 Influence of the number of SDPD Systems

The average number of SDPD systems per ECAC country is taken as 2 systems per country. In order to calculate the sensitivity of NPV with respect to this assumption, this value is varied by 20%, i.e., 1,8 and 2.2 is taken as base values. The following tables depict the impact of the number of SDPD systems deployed in the ECAC area on the NPV values:

NPV in M€ (DISCOUNTED)	-20% SDPD Systems	Baseline	+20% SDPD Systems
ANSP	0,91	1,12	1,32
Overall	**0,91**	**1,12**	**1,32**
Variation	**-19%**	**-**	**+18%**

Table 12: SESAR Solution PJ.14-W2-84f Impact of the number of SDPD Systems on Discounted NPV

Net benefits in M€ (UNDISCOUNTED)	-20% SDPD Systems	Baseline	+20% SDPD Systems
ANSP	2,47	3,06	3,64
Overall	**2,47**	**3,06**	**3,64**
Variation	**-19%**	**-**	**+19%**

Table 13: SESAR Solution PJ.14-W2-84f Impact of the number of SDPD Systems on Undiscounted NPV

8.3.2 Influence of the ATSEP effort

The average time spent by ATSEP to assess the tools prior to deployment and to carry out regular performance assessments checked with variation of +/- 25% and +/- 50%. The following tables depict the impact of the ATSEP effort on the NPV. As it can be seen from the results, ATSEP effort has a one-to-one impact on the NPV.

NPV in M€ (DISCOUNTED)	-50% ATSEP effort	-25% ATSEP effort	Baseline	+25% ATSEP effort	+50% ATSEP effort
ANSP	0,56	0,84	1,12	1,40	1,68
Overall	**0,56**	**0,84**	**1,12**	**1,40**	**1,68**
Variation	**-50%**	**-25%**	**-**	**+25%**	**+50%**

Table 14: SESAR Solution PJ.14-W2-84f Impact of the ATSEP effort on discounted NPV

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Net benefits in M€ (UNDISCOUNTED)	-50% ATSEP-time	-25% ATSEP-time	Baseline	+25% ATSEP-time	+50% ATSEP-time
ANSP	1,53	2,29	3,06	3,82	4,59
Overall	**1,53**	**2,29**	**3,06**	**3,82**	**4,59**
Variation	**-50%**	**-25%**	**-**	**+25%**	**+50%**

Table 15: SESAR Solution PJ.14-W2-84f Impact of the ATSEP effort on undiscounted NPV

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9 Recommendations and next steps

The CBA analysis has been concentrated in defining the reference and the solution scenario, and identifying the difference in the costs and benefits expected by the solution scenario with respect to the reference scenario. The quantifications used in the CBA model have been based mainly on the ATSEP time needed for tool selection and operational use.

Based on the performed CBA moderate cost-savings can be achieved by deploying the solution scenario compared to the reference scenario. This holds also true if influencing factors (discount rate, SDPD per ANSP and ATSEP effort) vary. Considering the fact that ANSPs would have to deploy new SPM Tools for end-to-end surveillance chain in order to demonstrate compliance with latest standards, SPM Tools developed by PJ.14-W2-84f provide a validated and crosschecked option.

10 References and Applicable Documents

10.1Applicable Documents

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

[2] Guidelines for Producing Benefit and Impact Mechanisms

[3] Methods to Assess Costs and Monetise Benefits

[4] SESAR 2020 Cost-Benefit Analysis Model

[5] Cost Benefit Analyses – Standard Input

[6] Cost Benefit Analyses – Method to assess costs

[7] ATM CBA Quality checklist

[8] Methods to Assess Costs and Benefits for CBAs

10.2 Reference Documents

[9] Common assumptions

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

[11] Performance Framework

[12] EUROCONTROL Specification for ATM Surveillance System Performance (ESASSP), Edition 1.2, April 2021

[13] PJ.14-W2-84f Cost Benefit Analysis for Surveillance Performance Monitoring - End-to-end at TRL4, D12. 6.500, Edition: 00.01.00, September 2021

[14] Technological Validation Report for Solution PJ.14-W2-84f Surveillance Performance Monitoring - End-to-end at TRL6, D12.7.400, Edition: 00.01.00, July 2022

[15] EUROCONTROL Standard Inputs for Economic Analyses, Ed. 9.0, December 2020

11 Appendix

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

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

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ATM Master Plan SESAR Performance Ambition KPA	ATM Master Plan SESAR Performance Ambition KPI	Performance Framework KPA	Focus Area	#KPI / (#PI) / <Design goal>	KPI definition
Operational Efficiency	PA5 - Arrival predictability: 2 minute time window for 70% of flights actually arriving at gate		Variance of actual and reference business trajectories	PRD1	Variance of differences between actual and flight plan or Reference Business Trajectory (RBT) durations
	PA2 - 3-6% reduction in flight time	Environment	Fuel efficiency	(FEFF3)	Reduction in average flight duration
	PA3 - 5-10% reduction in fuel burn			FEFF1	Average fuel burn per flight
Environment	PA8 - 5-10% reduction in CO2 emissions			(FEFF2)	CO2 Emissions
Safety	PA9 - Safety improvement by a factor 3-4	Safety	Accidents/incidents with ATM contribution	<SAF1>	Total number of fatal accidents and incidents
Security	PA10 - No increase in ATM related security incidents resulting in traffic disruptions	Security	Self- Protection of the ATM System / Collaborative Support	(SEC1)	Personnel (safety) risk after mitigation
				(SEC2)	Capacity risk after mitigation
				(SEC3)	Economic risk after mitigation
				(SEC4)	Military mission effectiveness risk after mitigation

Table 16: Mapping between ATM Master Plan Performance Ambition KPAs and SESAR Performance Framework KPAs, Focus Areas and KPIs

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