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PJ.14-W2-84a Cost Benefit Analysis for Multi-Sensor Data Fusion at TRL6

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PJ.14 W2 I-CNSS

PJ.14-W2-84A MULTI-SENSOR DATA FUSION

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Abstract

This document presents the Cost Benefit Analysis (CBA) for the deployment of the SESAR technological solution PJ.14-W2-84a targeting a maturity level of TRL6. Solution PJ.14-W2-84a has the OI step POI-0007-CNS (Surveillance Chain Data Fusion) and provides the enablers CTE-S08a (SUR Chain ER & TMA MSPSR) and CTE-S08b (SUR Chain ER & TMA Space-based ADS-B). The solution targets ANSPs in TMA & En-route operational environments for deployment.

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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-W2-84a that has performed the validation activities at TRL6 maturity level. The CBA focuses on deployment of the solution.

It is essential that the surveillance data output from new and emerging surveillance techniques and technologies can be seamlessly integrated in to the ATM infrastructure. Mechanisms to elaborate on existing means to assess the performance of the new sensors are being developed within SESAR Solutions PJ.14-W2-84e and PJ.14-W2-84f.

The first part of the Solution PJ14-W2-84a is to adapt multi-sensor tracker systems for the new input data characteristics, especially MSPSR (EN: CTE-S08a) and ADS-B data sourced from satellite (EN: CTE-S08b)

The second part of the Solution PJ14-W2-84a is to develop a performance-based data fusion based on an advanced monitoring of the tracker coherence. The benefit for the ANSPs is to provide continuously the level of performance of the multi sensor data fusion for ATM system supporting 3 and 5 NM horizontal separation applications. The system will raise alerts on degradation of the surveillance Quality of Service (QoS).

The indirect benefits for improving the safety, security are complex to assess qualitatively and monetized. However, such emerging innovations in ATM as Green flight applications or interoperability between the manned and the unmanned traffics will rely on the integrity performance of the Surveillance Data Processing and Distribution (SDPD) systems. The direct benefits will be monetized as avoided efforts based on a better performance of the ATSEP. The continuous assessment of a surveillance quality of service for the SDPD systems and sensors will change the way of operating the surveillance systems.

The stakeholders potentially impacted/concerned by the deployment of this SESAR solution are:

- ANSP (TMA and En-route OEs),

These stakeholders will receive the benefits thanks to the technological evolution introduced by this solution. Key benefits are:

- Improving the non-cooperative coverage in TMA areas integrating new independent non cooperative surveillance sources (MSPSR) in ASTERIX Category 015 for primary coverage in TMA (EN: CTE-S08a),
- Improving the surveillance coverage in oceanic areas integrating ADS-B data sourced from satellite for oceanic coverage (EN:CTE-S08b).
- Cost efficiency and safety improvement through continuous evaluation of the sensors and tracker performance assessing their surveillance quality of service (QoS),
- Increased automation,

PJ.14-W2-84a has performed the CBA study using the following assumptions related to the reference and solution scenarios:

- ANSPs would have to provide a better non-cooperative coverage for a better Air situation awareness within TMA control volumes for avoiding air proximity conflicts between manned and unmanned traffic. The purpose is to manage safely high-density traffic extended to heterogeneous vehicles at low altitudes (small unmanned aerial vehicles, electric vertical take-off and landing eVTOLs - and conventional manned aircraft), including operations over populated urban areas and within controlled airspace.
- ANSPs would have to operate in oceanic areas reducing the flight separations using an ADS-B surveillance coverage sourced from satellite and improving the interoperability between oceanic and continental En Route airspaces.
- ANSPs would have to provide more often performance assessment reports as part of investigation of surveillance incidents raised by ATCOs or in regular basis for renewing the compliance with the 3nm and 5nm minima separations.

In the reference scenario, ANSPs will deploy legacy multi-sensor data fusion units from the market without additional feature. The sensor and tracker performance evaluations will be performed offline by tracker experts on request or on regular basis for providing evidences requested by the regulator.

There are some limitations in the legacy multi-sensor data fusions and performance tools for addressing the needs:

- Related to the geographical reference frames used for the track position estimation that does not allows managing areas more than 2Knmx2Knm. Separate units are used for extend the surveillance coverage to additional areas.
- Related to the Non-conventional Non-cooperative radar such as MSPSR, AESA (Active Electronically Scanned Array) radar or extracted-plot from camera sensor that cannot be properly integrated in legacy multi-sensor data fusion. Those sensors are promoted as gap-filler solutions for mitigating the loose of detections in gaps created by the urban obstacles in the TMA(s) caused by the multiplication of business and commercial centres near the airports.
- Related to the workload of ATSEP or tracker experts for issuing performance assessment reports in absence of on-line surveillance performance assessment.

Alternatively, the solution scenario will deploy an integrated solution based on the multi-sensor data fusion developed by this solution associated with the continuous sensors and tracker performance evaluation function.

The benefits of this solution are mainly based on the following capabilities:

- Operating oceanic and continental areas using the same multi-sensor data fusion fed by the spaced-based ADS-B. The tracking is the same, which improves the interoperability between the two areas.
- Integrating non-conventional non-cooperative sensors is cost and safety effective in TMA for the surveillance of some hotspots poorly detected by classical rotating radar.
- The continuous surveillance monitoring will reduce the workload of the ATSEPs replacing manual performance assessment previously performed by the ATSEP. Early detection of tracking issues improves the overall safety of the system.

As part of the CBA-work, the Sol.84a project-team has developed a pre-CBA Model (Excel-file "CBA_Methodology_PJ14W284a.xlsx") to gather all the information and assumptions related to the Reference and Solution Scenarios, and convert them into quantitative input feeding the CBA-model provided by the SJU. ***Using this approach, the Net Present Value calculated by the CBA-model is 2.2 M€.***

Regarding the payback year: 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 payback year is actually from the start of deployment, i.e. 2023***. In other words, the main benefits of this Solution are what we can call the "avoided costs".

The main uncertainty/limitation identified in this CBA is mainly linked to an assumptions made at ECAC level to build the analysis:

- the amount of time - in average - spent by ATSEP-resources to carry out the surveillance monitoring and eventually troubleshooting investigation (= post-implementation phase).

In consequence, the level of confidence on the CBA is medium. Their influences on e.g. the NPV has been investigated as part of the sensitivity analysis (§8), as well as the impact of the discount rate on the NPV.

The NPV is low mainly because the indirect benefits cannot be assessed in the frame of this solution CBA.

The investment costs for implementing the solution are low because all ECAC ANSPs are using one or two of the two SDPD products (ECTL ARTAS and THALES TopSky-Tracking) that have been developed within the wave 1 or wave 2 of the solution. Both roadmaps of the two SDPDs have been updated with the features developed by the solution. ANSPs will benefit of the solution features through update of software product version without addition cost.

2 Introduction

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-W2-84a that has been matured through validation activities at TRL6 level. CBA objectives, scope and cost benefit analysis have been provided in accordance with CBA programme guidance and in close collaboration with PJ.19-04 (incl. Eurocontrol's CBA experts) considering the solution type (technological solution) and specificities.

2.2 Scope

The time period for the analysis is from October 2023 (= start of deployment, 3 years before IOC as assumption) to October 2030 (= FOC). The geographical scope is the entire ECAC-region, and the main stakeholders are Airport Operators and ANSPs.

2.3 Intended readership

The intended audience of this document is:

- The SESAR Joint Undertaking
- PJ.14-W2-84a: to share assumptions and methodology that could be applicable to the end-to-end part,
- PJ.19-04 project: having a particular interest on CBA outcomes.

2.4 Structure of the document

This document is organized as follows:

- Chapter 1 Executive summary,
- Chapter 2 Introduction: general introduction, scope, and purpose of the document. This chapter also provides the glossary of terms, acronyms and terminology used in this document,
- Chapter 3 CBA objectives and scope,
- Chapter 4 provides the identified benefits,
- Chapter 5 provides the overall cost assessment,
- Chapter 6 provides the CBA model,
- Chapter 7 provides the CBA results,
- Chapter 8 provides the sensitivity and risk analysis,
- Chapter 9 provides the recommendations and next steps,
- Chapter 10 provides the reference and applicable documents.

2.5 Background

Solution PJ.14-W2-84a is a continuation of the work initiated by PJ.14-04-03 Task 3, which reached TRL4 maturity at the end of Wave 1. Solution PJ.14-W2-84a targets TRL6 maturity at the end of Wave 2.

2.6 Glossary of terms

Term	Definition	Source of the definition
Baseline scenario	A point of reference. The Scenario at a specific date to be used in the validation in order to perform measurements from a well-known and consistent origin. The Baseline year has been set as 2012, which is in line with the start point of the Performance Ambitions defined in the ATM Master Plan and in line with performance validation targets defined in PJ19.04	*SESAR 2020 Performance Framework*
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*
Cost benefit analysis	A cost-benefit analysis is a systematic process that businesses use to analyze 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*
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*
Reference scenario	To measure the performance impact of a SESAR Solution, at least two different situations must be assessed and compared: a Reference Scenario and a Solution Scenario. One situation should be a scenario that does not have the concept element (the	*SESAR 2020 Performance Framework* *TVALP Template guidances*

	reference scenario) and, then, a second situation that equals the first except that it includes the new concept element (the Solution scenario). The descriptions of the reference scenario(s) and of the solution scenario(s) can include, depending on the scope of the validation exercise, airport information, airspace information, traffic information, etc. The reference scenario is matched in time with the solution scenario but DOES NOT include the SESAR solution(s) that is the subject of the validation. The only difference between the solution and the reference scenario is that the former includes the SESAR solution(s) that is the subject of the validation.	
Sensitivity analysis	Sensitivity analysis determines how different values of an independent variable affect a particular dependent variable under a given set of assumptions. In other words, sensitivity analyses study how various sources of uncertainty in a mathematical model contribute to the model's overall uncertainty. This technique is used within specific boundaries that depend on one or more input variables.	*Investopedia*
Solution scenario	See Reference scenario	*SESAR 2020 Performance Framework* *TVALP Template guidances*

Table 1: Glossary of terms

2.7 List of Acronyms

Acronym	Definition
ADS-B	Automatic Dependent Surveillance - Broadcast
ANSP	Air Navigation Service Provider
ATM	Air Traffic Management

ATSEP	Air Traffic Safety Electronics Personnel
AU	Airspace Users
CAPEX	Capital expenditure
CBA	Cost Benefit Analysis
CNS	Communication, Navigation and Surveillance
ECAC	European Civil Aviation Conference
EATMA	European ATM Architecture
FOC	Full Operational Capability
FTE	Full-time equivalent
INTEROP	Interoperability Requirements
IOC	Initial Operational Capability
KPA	Key Performance Area
KPI	Key Performance Indicator
MLAT	Multilateration
NPV	Net Present Value
OE	Operational Environment
OI	Operational Improvement
OPEX	Operational expenditure
OSED	Operational Service and Environment Definition
OSV	Operational service Volume
QoS	Qality of Service
QRT	Quasi Real Time
SESAR	Single European Sky ATM Research Programme
SDPD	Surveillance Data Processing and Distribution
SJU	SESAR Joint Undertaking (Agency of the European Commission)
SPM	Surveillance Performance Monitoring
SPR	Safety and Performance Requirements
SQoS	Sensor Quality of Service
SUR	Surveillance
TMA	Terminal Manoeuvring Area
TQoS	Tracking Quality of Service
WAM	Wide Area Multilateration

Table 2: List of acronyms

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-W2-84a that has been matured 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.

The deployment of the solution enables new features that will allows ANSPs to integrate:

- new independent non-cooperative surveillance sources (MSPSR) in ASTERIX Category 015 for primary coverage in TMA(s).
- ADS-B data sourced from satellite for oceanic coverage.

The Multi Sensor Data Fusion developed by this solution will provide seamless integration of these new emerging surveillance sources into SDPD systems

The continuous assessment of the SQoS and TQoS developed as part of this solution also makes it possible to reduce the costs linked to the maintenance of the SDPD systems.

3.2 SESAR Solution description

SESAR Solution ID	OI Steps ref. (coming from the Integrated Roadmap)	OI Steps definition (coming from the Integrated Roadmap)	OI step coverage	Source reference
PJ14-W2-84a: Multi sensor Data Fusion	POI-0007-CNS	Surveillance Chain Data Fusion	Fully	EATMA

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

OI Steps ref.	Enabler ref.	Enabler definition	Enabler coverage	Applicable stakeholder	Source reference
POI-0007-CNS	CTE-S08a	SUR Chain ER&TMA (MSPSR)	Fully	ANSP	EATMA
	CTE-S08b	SUR Chain ER&TMA (MSPSR)	Fully	ANSP	EATMA

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

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-W2-84a validation targets

3.3 Objectives of the CBA

This document provides the Cost Benefit Analysis (CBA) related to the deployment of the SESAR technological solution PJ.14-W2-84a that has been matured through validation activities at TRL6 level. The main purpose of this CBA is to facilitate and support better informed decision-making for key investment decisions. This is achieved by:

- identifying all costs and benefits per stakeholders,
- quantifying in economic terms the costs and benefits,
- calculating the economic value of the project,
- making a cash flow projection,
- Identifying the factors/assumptions having the most influence on the results.

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	Provide inputs, participate to the brainstorms on elaboration of assumptions, review the results	Yes, on both costs and benefits

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

3.5 CBA Scenarios and Assumptions

PJ.14-W2-84a has performed the CBA study using the following assumptions related to the reference and solution scenarios:

- ANSPs will have to provide a better non-cooperative coverage for a better Air situation awareness within TMA control volumes for avoiding air proximity conflicts between manned and unmanned traffic.
- ANSPs would have to operate in oceanic areas reducing the flight separations using an ADS-B surveillance coverage sourced from satellite and improving the interoperability between oceanic and continental En Route airspaces.

- ANSPs would have to supervise the quality of the tracking as part of investigation on surveillance incidents raised by ATCOs or in regular basis for renewing the compliance with the 3nm and 5nm minima separations.

3.5.1 Reference Scenario

The Reference Scenario can be summarised as follows:

- Additional multi-sensor units are deployed for oceanic coverage fed by the space-based ADS-B,
- Airspace will be designed for avoiding the hotspots that cannot be detected by conventional radar or exemptions for non-cooperative coverage of some areas will be proposed to regulator.
- Performance assessment and incident investigation will be performed manually by ATSEP staff on a regular basis as proof of compliancy for the minimum of performance requirements for operating with 3 or 5 Nm minima separations.

3.5.2 Solution Scenario

In the solution scenario, ANSP would choose multi sensor data fusion, SQOSM and TQOSM functions that are developed by this solution. The following assumptions are made for the solution scenario:

- The space-based ADS-B is connected to the SDPD with all other sensors improving the sensor overlapping between oceanic and continental areas and providing a unique track object for an aircraft for the oceanic OSV and continental OSV.
- Non-conventional non-cooperative sensors are connected ensuring non-cooperative coverage at low altitude without gaps.
- The SQoS and TQoS features are deployed in quasi-real time (QRT) mode.

3.5.3 Assumptions

It is assumed that the solution features will be deployed through the product policy of the existing SDPD systems without additional investment costs. These features will improved the performance of the SDPD systems and avoid some costs related to some danger areas for the unmanned traffics and mitigation investigations for managing the poor coverage at low altitude. The advanced surveillance monitoring solution will help to harmonize the ATSEP practice for a better monitoring of the surveillance, less costly based on the automation. The solution deploys an integrated data fusion allowing to cover oceanic and continental areas using the same servers.

Detailed assumptions are provided in Assumptions sheet of “CBAT_Methodology_PJ14W284a.xlsx” in Section 6.

4 Benefits

For this Solution, the benefits are equivalent to the “negative” costs. The only KPI identified is CEF3.

Performance Framework KPA[1]	Focus Area	KPI/PI from the Performance Framework	Unit	Metric for the CBA	Unit	Benefits from IOC to end of CBA timeline		
Cost Efficiency	ANS Cost efficiency	**CEF2** Flights per ATCO-Hour on duty	Nb	ATCO employment Cost change	€/year	N/A	N/A	N/A
				Support Staff Employment Cost Change	€/year	N/A	N/A	N/A
				Non-staff Operating Costs Change	€/year	N/A	N/A	N/A
		CEF3 Technology cost per flight	EUR / flight	G2G ANS cost changes related to technology and equipment	€/year	2.2 M€ discounted 4.1 M€ undiscounted		
	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	N/A	N/A	N/A
		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	N/A	N/A	N/A

[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	Benefits from IOC to end of CBA timeline		
		AUC5 Overhead costs for an airspace user	EUR / flight	Impact on overhead costs. Examples: dispatchers, training, IT infrastructure, sales.	€/year	N/A	N/A	N/A
Capacity	Airspace capacity	**CAP1** TMA throughput, in challenging airspace, per unit time	% and # movements	Tactical delay cost (avoided-; additional +)	€/year	N/A	N/A	N/A
			% and # movements	Strategic delay cost (avoided-; additional +)	€/year	N/A	N/A	N/A
		CAP2 En-route throughput, in challenging airspace, per unit time	% and # movements	Tactical delay cost (avoided-; additional +)	€/year	N/A	N/A	N/A
			% and # movements	Strategic delay cost (avoided-; additional +)	€/year	N/A	N/A	N/A
	Airport capacity	**CAP3** Peak Runway Throughput (Mixed mode)	% and # movements	Value of additional flights	€/year	N/A	N/A	N/A
	Resilience	**RES4a** Minutes of delays	Minutes	Tactical delay cost (avoided-; additional +)	€/year	N/A	N/A	N/A
		RES4b Cancellations	% and # movements	Cost of cancellations	€/year	N/A	N/A	N/A
		Diversions	% and # movements	Cost of diversions	€/year	N/A	N/A	N/A

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

Performance Framework KPA[1]	Focus Area	KPI/PI from the Performance Framework	Unit	Metric for the CBA	Unit	Benefits from IOC to end of CBA timeline		
Civil-Military Cooperation & Coordination	Civil-Military Cooperation & Coordination	**CMC2.1a** Fuel saving (for GAT operations)	Kg fuel per movement	Fuel Costs	€/year	N/A	N/A	N/A
		CMC2.1b Distance saving (for GAT operations)	NM per movement	Time Costs	€/year	N/A	N/A	N/A

Table 7: Results of the benefits monetisation per KPA

5 Cost assessment

All ANSPs will benefit of the features from the solution seamlessly either from ARTAS ECTL SDPD product policy, ARTAS being which is license free for ECAC members, or from THALES TopSky-Tracking SDPD product policy that equips 17 ECAC ANSPs. For that reason, no extra licenses, HW and efforts are taken into account for SDPD units already operating.

5.1 ANSPs costs

2 categories of costs have been identified and estimated for the ANSPs: the implementation costs and the operating costs.

5.1.1 ANSPs cost approach

The cost figures were obtained using expert judgment (SUR-Industry partners and SUR-Community). Several "brainstorms" were organized to define a reasonable set of assumptions having a direct impact on the costs (e.g. ,ATSEP-time to operate SDPD systems in OSVs, ATSEP-FTE, …).

5.1.2 ANSPs cost assumptions

As previously written, the complete list of assumptions is available in the pre-CBA Model (Excel-file "CBAT_Methodology_PJ14W284d.xlsx") and converted into quantitative input feeding the CBA-model provided by the SJU.

5.1.3 Number of investment instances (units)

The basic assumption of this CBA is that 5 ANSPs will purchase additional SDPD units for deploying spaced-based ADS-B in the reference scenario. Upgrading existing SDPD units are either licence free within ECAC or included in licences in the frame of the SDPD product policy.

5.1.4 Cost per unit

The figures at ECAC level provided in this section are the ones calculated in the pre-CBA Model (Excel-file "CBAT_Methodology_PJ14W284a.xlsx", spreadsheet DELTA) and used as direct input to the CBA-model provided by the SJU (parameters "***Ground Costs - MEUR***" and "***Ground Change in operating costs (M€, annual)***" for Scenario 1 in the spreadsheet Sol_Info).

For ANSPs, the "delta" at ECAC level when comparing the Solution and the Reference Scenario is:

- overall investment costs (implementation): -2431745 €, i.e. higher ground costs expected in the Reference Scenario,
- annual operating costs: -105225 €, i.e. higher operating costs expected in the Reference Scenario.

In the reference scenario, 5 SDPD additional units are purchases that are duplicated units of existing one for cost reduction on licenses, HW, validation, documentation, training and acceptance efforts.

5.2 Airport operators costs

No applicable costs.

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.

5.6 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-OSV (Delta SOL & REF)	x	Deployment Locations	=	Investment Costs (Delta SOL & REF)

ANSP Oceanic areas	- 500.000 €	x	5 Oceanic OSVs	=	- 2500.000 €
ANSP More effort in Safety case for managing gaps at low altitude for some TMAs	- 34.113,5 €	x	10 complex TMA OSVs	=	- 341.135 €

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

Stakeholder	Cost per-OSV	x	Deployment Locations	=	Annual Operating Costs (Delta SOL & REF)
ANSP (TMA & En-route)	- 568,784 €	x	5 Oceanic OSVs + 60 ER OSVs + 120 ER OSVv	=	- 105.225 €

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

6 CBA Model

The CBA model “CBAT_Model_PJ14W284a.xlsm” and “CBAT_Methodology_PJ14W284a.xlsx” used as input are attached below:

CBAT_Methodology_PJ14W284a.xlsx CBAT_Model_PJ14W284a.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 OSVs that the solution would be deployed within ECAC countries,

The assumptions and associated data sources are included in the CBA input (“CBAT_Methodology_PJ14W284a.xlsx”) and are input into the CBA model from PJ19-04. Although no ANSP representatives are contributing, the confidence in the expert judgements is acceptable from the industrial partners developing the SDPD systems (Thales, Eurocontrol) and contribution from SUR community thanks to ARTAS User Group (AUG) or MSTS User Group (MUG) .

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 average time spent by ATSEP to assess the SDPD system(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 **Error! Reference source not found.**.

7 CBA Results

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

PJ14-W2 PJ14-W2-84a - 2022-2043 (discounted) (M€)							
Discounted		NPV	Capex	Opex	Benefits	Discount rate	Discounted
	ANSP	2,2	1,6	0,6	0,0	8%	
	Airports	0,0	0,0	0,0	0,0	8%	
	Network Manager	0,0	0,0	0,0	0,0	8%	
	Business Aviation	0,0	0,0	0,0	0,0	8%	
	Scheduled Aviation	0,0	0,0	0,0	0,0	8%	
	Overall	**2,2**	**1,6**	**0,6**	**0,0**		

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

PJ14-W PJ14-W2-84a - 2022-2043 (undiscounted) (M€)						
Undiscounted		Net Benefits	Capex	Opex	Benefits	Undiscounted
	ANSP	4,1	2,4	1,7	0,0	
	Airports	0,0	0,0	0,0	0,0	
	Network Manager	0,0	0,0	0,0	0,0	
	Business Aviation	0,0	0,0	0,0	0,0	
	Scheduled Aviation	0,0	0,0	0,0	0,0	
	Overall	**4,1**	**2,4**	**1,7**	**0,0**	

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

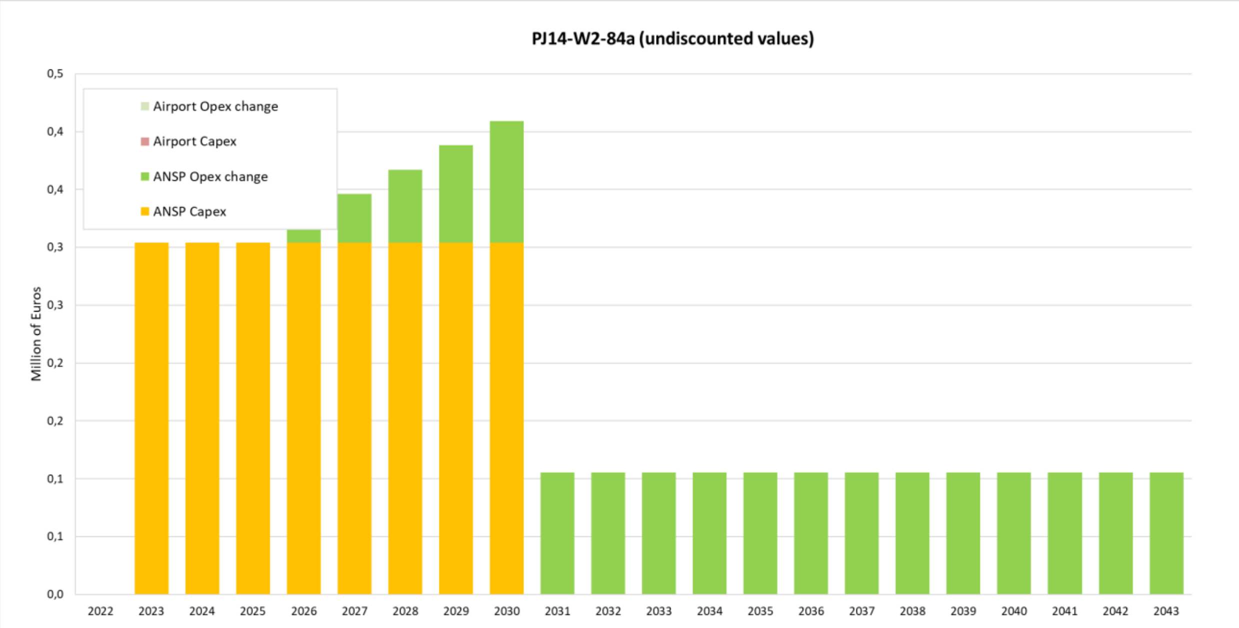

Figure 1: SESAR Solution PJ.14-W2-84a Undiscounted Opex-Capex

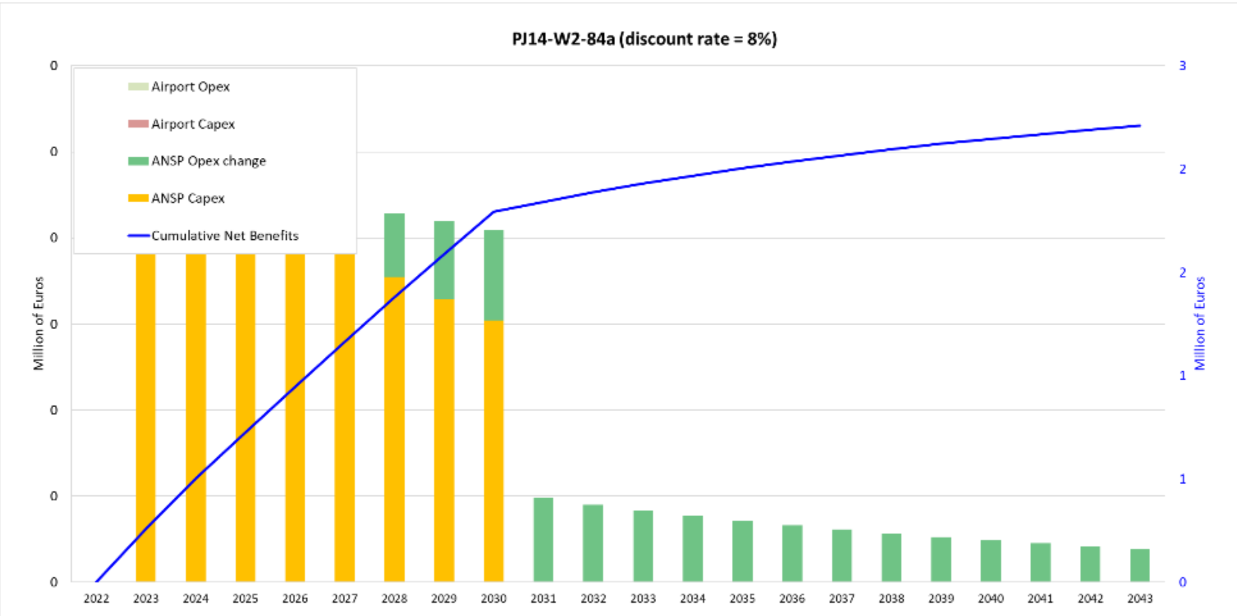

Figure 2: SESAR Solution PJ.14-W2-84a Discounted Opex-Capex

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.

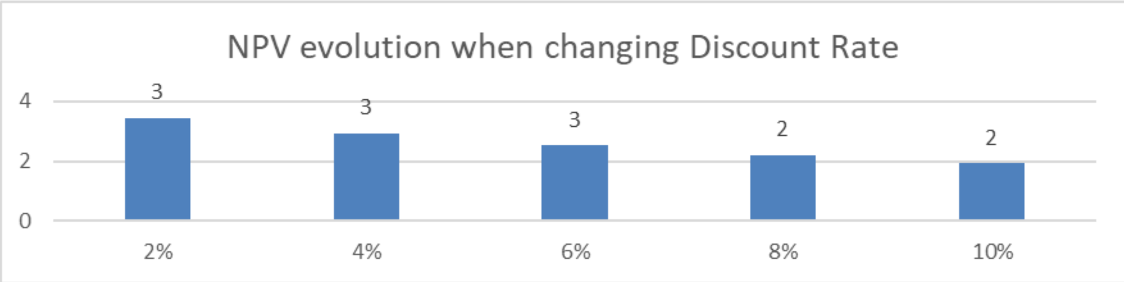

Figure 3: SESAR Solution PJ.14-W2-84a NPV and Discount Rate

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.

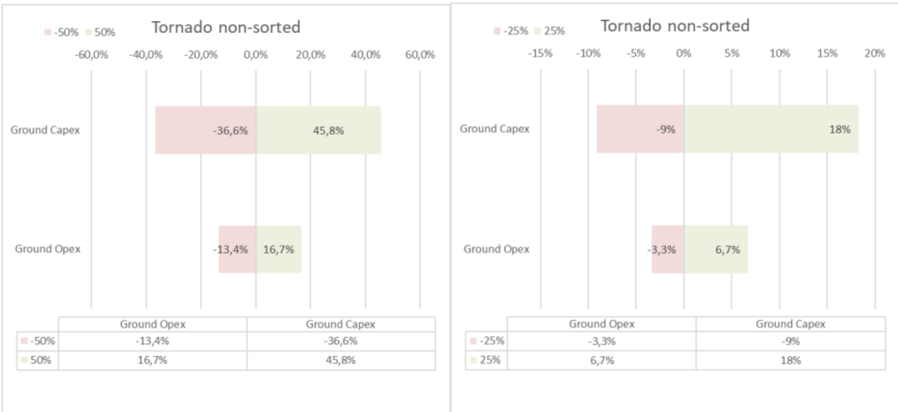

Figure 4: SESAR Solution PJ.14-W2-84f Tornado Diagrams for Discount Rate Variations

8.3 Influence of the 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:

- 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 parameters are varied in the CBA input (“CBAT_Model_PJ14W284a.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 assumptions 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 ATSEP effort

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 (DISCOUNTED)	-50% ATSEP effort	-25% ATSEP effort	Baseline	+25% ATSEP effort	+50% ATSEP effort
ANSP	1,1	1,6	2,2	2,7	3,3
Overall	**1,1**	**1,6**	**2,2**	**2,7**	**3,3**
Variation	**-50%**	**-25%**	**-**	**+25%**	**+50%**

Table 12: SESAR Solution PJ.14-W2-84a Impact of the ATSEP effort on discounted NPV

Net benefits (UNDISCOUNTED)	-50% ATSEP-time	-25% ATSEP-time	Baseline	+25% ATSEP-time	+50% ATSEP-time
ANSP	2	3,1	4,1	5,1	6,1
Overall	**2**	**3,1**	**4.1**	**5,1**	**6,1**
Variation	**-50%**	**-25%**	**-**	**+25%**	**+50%**

Table 13: SESAR Solution PJ.14-W2-84a Impact of the ATSEP effort on undiscounted NPV

9 Recommendations and next steps

The CBA analysis has been concentrated in defining the CBA 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 workload. Indirect benefits related to the integration of non-conventional non-cooperative sensors expected to be more cost effective than conventional Radar or safety improvement of the system are not taken into account at this stage.

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10 References and Applicable Documents

10.1 Applicable Documents

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

[2] Guidelines for Producing Benefit and Impact Mechanisms;

[3] Methods to Assess Costs and Monetise Benefits;

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

[5] Cost Benefit Analyses – Standard Input;

[6] Cost Benefit Analyses – Method to assess costs;

[7] ATM CBA Quality checklist;

[8] Methods to Assess Costs and Benefits for CBAs.

10.2 Reference Documents

[9] SESAR 2020 Common assumptions Ed 00.00 from 20 Dec 19

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

[11] SESAR 2020 Performance Framework Ed 01.00.01 from 20 Dec 19

[12] D11.1.070 PJ14-04-01 T02 TVALR ed00.01.02.docx

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

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

11 Appendix

Mapping between ATM Master Plan Performance Ambition KPAs and SESAR 2020 Performance Framework KPAs, Focus Areas and KPIs, source reference *[11]*

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

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

Table 14: Mapping between ATM Master Plan Performance Ambition KPAs and SESAR 2020 Performance Framework KPAs, Focus Areas and KPIs

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