SESAR SOLUTION PJ.09-W2-44: COST BENEFIT ANALYSIS (CBA) FOR V3/TRL6

Deliverable ID:	D2.1.103
Dissemination Level:	PU
Project Acronym:	PJ.09-W2 DNMs
Grant:	874463
Call:	H2020-SESAR-2019-1
Topic:	SESAR-IR-VLD-WAVE2-07-2019
Consortium coordinator:	EUROCONTROL
Edition date:	Feb 2023
Edition:	00.03.03
Template Edition:	02.00.06

EUROPEAN PARTNERSHIP

Co-funded by the European Union

Authoring & Approval

Authors of the document

Beneficiary	Date
CRIDA	March 2021

Reviewers internal to the project

Beneficiary	Date
DSNA	April 2021
EUROCONTROL	May 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

Rejected By - Representatives of beneficiaries involved in the project

Beneficiary	Date

Document History

Edition	Date	Status	Beneficiary	Justification
00.00.01	26/03/2021	Draft	CRIDA	Document creation
00.02.00	30/11/2021	Intermediate version	CRIDA	Include cost assessment
00.03.00	20/12/2022	Final version	CRIDA	Deliverable pack
00.03.01	10/02/2023	Final version	CRIDA	Completed with PAR inputs

PJ.09-W2 DNMs

PJ.09-W2 DNMS

This document is part of a project that has received funding from the SESAR3 Joint Undertaking under grant agreement No 874463 under European Union's Horizon 2020 research and innovation programme.

Abstract

This document provides the V3 Cost Benefit Analysis (CBA) results for SESAR2020 Project PJ.09–W2 Solution 44 'Dynamic Airspace Configuration'. The Solution involves the deployment of the following Operational Improvement Steps (OIS): CM-0102-B, CM-0103-B, CM-0104-C, DCB-0210, AOM-0805 and AOM-0809-A.

The figures contained in this CBA are based on estimates of the costs and benefits associated with an ECAC-level deployment of the Solution PJ.09-W2-44.

This document contains the description of the CBA for this solution, including the quantitative estimation of costs and benefits. At the end, the results of the CBA model are explained.

Table of Contents

List of Tables

EUROPEAN PARTNERSHIP
Co-funded by the European Union

List of Figures

1 Executive Summary

This document provides the V3 CBA for **SESAR Solution PJ.09-W2-44 – Dynamic Airspace Configuration (DAC),** which is built upon Wave 1 results of Solutions PJ.08-01 – Management of Dynamic Airspace configurations [14] and PJ.09-02 – Integrated Local DCB Processes [13].

The core focus of the Solution PJ.09-W2-44 is the use of DAC concept into the Demand & Capacity Balance (DCB) process including the Integrated Network Management Air Traffic Control (ATC) Planning (INAP) concept, in an integrated way, and not as two different steps.

The expected benefits are an **increase in En-route capacity (CAP)**, with no detrimental impact on safety), an **increase in Air Navigation Service Provider (ANSP) Cost efficiency** (Air Traffic Controller (ATCO) Productivity), a **reduction in fuel burn, CO_2 emissions and flight time,** and **improvements in predictability and punctuality**. The CBA benefit inputs are based on the results obtained in validation exercises and extrapolated to ECAC level in the Performance Assessment Report (PAR). The costs estimations are based on stakeholder's expertise.

The deployment of Solution PJ.09-W2-44 requires the following stakeholders to invest:

- **Civil ANSPs** handling traffic in Very High and High complexity En-route Area Control Centres (ACCs).
- The **Network Manager (NM)** who has an active role in the coordination of DCB measures at ECAC level.

No deployment is required for airspace users (i.e., no airborne enablers) or airport operators.

CBA results show a NPV (discounted) of 2,455 M€ and the payback year is 2028. Benefits are most of the time higher than costs and all KPIs show positive benefit results, except for Predictability (PRD2). In parallel, safety assessment presents positive benefits while Human Performance evaluation is partially ok.

Sensitivity analysis shows a not very significant impact of costs in NPV (discounted), as opposed to benefit, which would halve the NPV if they were also half of what was obtained in the PAR.

2 Introduction

2.1 Purpose of the document

This document provides the V3 CBA based on an ECAC-level view of the deployment of **SESAR Solution PJ.09-W2-44: Dynamic Airspace Configuration (DAC).** The key aim of this document is to provide a view on the costs and benefits of deploying Solution PJ.09-W2-44 at an ECAC-level. There are assumptions included in the production of the CBA results and these assumptions are described in the corresponding sections of the document.

2.2 Scope

The enablers allocated to Solution PJ.09-W2-44 are associated with the OI Steps below:

- CM-0102-B: Dynamic Airspace Management based on complexity
- CM-0103-B: Automated Support for Traffic Complexity Assessment
- CM-0104-C: Automated support to INAP function
- DCB-0210: Full integration of Dynamic Airspace Configurations into DCB
- AOM-0809-A: Initial SD&C Unconstrained by Predetermined Boundaries
- AOM-0805: Collaborative Airspace Configuration

Solution PJ.09-W2-44 will complete the R&D work developed within SESAR2020 Wave 1 trying to take to V3 maturity the DAC and INAP concepts developed within SESAR 2020 W1 in Solutions PJ.08-01 and PJ.09-02.

The focus of Solution PJ.09-W2-44 is the integration of DAC and Integrated Network Management ATC Planning (INAP) concepts, especially on the INAP timeframe where the two overlap, in a seamless way. The scope under this solution also contributes to the ATM Master Plan Essential Operational Change (EOC): “Fully dynamic and optimised airspace”.

The geographical scope of this CBA is the ECAC area, and the stakeholders are ANSPs, Network Manager, Airspace Users and Airport Operators. The CBA focuses on the deployment of the Solution, i.e., it assumes that the validation activities have shown the concepts to be feasible.

2.3 Intended readership

This document is aimed at the following stakeholders:

- Solution PJ.09-W2-44 members
- PJ.19 as the Content Integration Project
- PJ.20 as Master Plan Maintenance Project
- SESAR Programme Management

- SJU Program representatives, as the owner and final approver of the document
- ANSPs with the intention of implementing Solution PJ.09-W2-44

2.4 Structure of the document

The following sections in the document cover:

- Section 2 introduces the document.
- Section 3 describes the objectives and scope of the V3 CBA, including an overview of the concept and detail on the CBA Scenarios.
- Section 4 and 5, respectively, provide the benefits and costs assessment.
- Sections 6, 7 and 8 present, respectively, the CBA model, the CBA results, and sensitivity and risk analysis.
- Section 9 proposes next steps and recommendations.
- Section 10 lists applicable and reference documents
- Appendix shows the mapping of Key Performance Areas (KPA) [11] and details on cost assessment.

2.5 Background

The SESAR Solution PJ.09-W2-44 is built upon Wave 1 results of Solutions PJ.08-01 and PJ.09-02, briefly described below.

- SESAR PJ.09 Solution 02 CBA [13]

Integrated Local DCB Processes see the seamless integration of local network management with extended ATC planning and arrival management activities in short-term and execution phases. It represents the core functionality for the Integrated Network ATM Planning (INAP) process through an enhanced Local DCB tool set. The solution will improve the efficiency of ATM resource management, as well as the effectiveness of complexity resolutions by closing the gap between local network management and extended ATC planning.

- SESAR PJ.08 Solution 01 CBA [14]

Management of Dynamic Airspace Configurations refers to the development of the process, procedures and tools related to Dynamic Airspace Configuration (DAC), supporting Dynamic Mobile Areas of Type 1 and Type 2. It consists of the activation of Airspace configurations through an integrated collaborative decision making process, at national, sub-regional and regional levels; a seamless and coordinated approach to airspace configuration, from planning to execution phases, allowing the Network to continuously adapt to demand pattern changes in a free route environment) and ATC sectors configurations adapted to dynamic TMA boundaries and both fixed and dynamic elements.

Therefore, the CBA documents of mentioned Solutions should be taken into consideration.

2.6 Glossary of terms

Term	Definition	Source of the definition
Cost Benefit Analysis	A Cost Benefit Analysis is a process of quantifying in economic terms the costs and benefits of a project or a programme over a certain period, and those of its alternatives (within the same period), in order to have a single scale of comparison for unbiased evaluation.	*SESAR CoP CBA Champion PJ.19.04*
Full Operational Capability (FOC)	Is reached when the maximum effective number of "instantiations" or deployments of an OI Step (or enabler) have reached Operating Capability. *For the CBA this reflects the time from which full benefits will realised and when investment costs are considered to end*.	*SESAR CoP CBA Champion PJ.19.04*
HotSpot	The HotSpot is a 4D volume (defined in time and space) representing a potential DCB imbalance (not critical as not impairing Safety), identified by ANSP(s) and potentially NM. This imbalance is shared with partners, and ANSPs define solutions, supported by Collaborative Decision-Making process and tools (either in strategical and pre-tactical phases, or in tactical phase with INAP). A hotspot situation represents a nominal, safety noncritical and planned event.	Solution PJ.09-W2-44 SPR-INTEROP/OSED [12]
INAP	Integrated Network Management and Extended ATC Planning function. INAP covers three main time periods, all referred to the time of occurrence of the hotspot: - **From -6H to -2H:** It is assumed that -2H is the cut-off time for CASA application, so this implies that most of the flights are still on ground, - **From -2H to -40':** This period represents the gap that INAP is filling in the DCB process, **From -40' to -15':** In this period small adjustments are possible to optimise capacity without a safety issue.	Solution PJ.09-W2-44 SPR-INTEROP/OSED [12]

Initial Operating Capability (IOC)	Indicates the date from which benefits can be expected. For the CBA this reflects the start of the benefit ramp up period and the start of any operating cost impacts.	*SESAR CoP CBA Champion PJ.19.04*
OptiSpot	The OptiSpot is a 4D volume (defined in time and space) representing a traffic situation where opportunity for optimization has been identified by ANSP (INAP). An ATFCM situation yet to be optimized represents a nominal, safe and planned event.	Solution PJ.09-W2-44 SPR-INTEROP/OSED [12]

Table 1: Glossary of terms

2.7 List of Acronyms

Acronym	Definition
ACC	Area Control Centre
ANS	Air Navigation Service
ANSP	Air Navigation Service Provider
APP	Approach
ASM	Airspace Management
ATC	Air Traffic Control
ATCO	Air Traffic Controller
ATFCM	Air Traffic Flow and Capacity Management
ATM	Air Traffic Management
ATS	Air Traffic Services
AU	Airspace User
BIM	Benefit and Impact Mechanism
CAP	Capacity
CBA	Cost Benefit Analysis
CDM	Collaborative Decision Making
CEF	Cost Efficiency
CO2	Carbon dioxide
DAC	Dynamic Airspace Configurations
DCB	Demand and Capacity Balancing
ECAC	European Civil Aviation Conference
ER	En-route

FEFF	Fuel Efficiency
FOC	Full Operating Capability
HPAR	Human Performance Report
IOC	Initial Operating Capability
kg	Kilogramme
KPA	Key Performance Area
KPI	Key Performance Indicators
MET / METEO	Meteorological
NM	Network Manager
NPV	Net Present Value
OE	Operating Environment
OI	Operational Improvement
OSED	Operational Service and Environment Definition
PAR	Performance Assessment Report
PJ	Project
PRD	Predictability
PUN	Punctuality
RBT	Reference Business Trajectory
RTS	Real Time Simulation
SAF	Safety
SD&C	Sector Design & Configuration
SESAR	Single European Sky ATM Research Programme
SJU	SESAR Joint Undertaking (Agency of the European Commission)
SPR	Safety and Performance Requirements
SWIM	System Wide Information Model
TMA	Terminal Manoeuvring Area
V2	Feasibility stage of the Concept Lifecycle Model (E-OCVM)
V3	Pre-industrial development and integration stage of the Concept Lifecycle Model (E-OCVM)
WOC	Wing Operations Centre

Table 2: List of acronyms

3 Objectives and scope of the CBA

3.1 Problem addressed by the solution

The range of sector configurations available in En-route airspace today is not always optimised for the traffic flows that occur. The lack of flexibility to tailor airspace more closely to the forecast flows can result in inefficiencies and imbalances. So, some sectors may be overloaded due to the number of aircraft and/or the complexity of the situation, which results in regulations and delays. While at the same time, other sectors in the area may be underutilised. DAC is intended to solve these issues.

Current sector configurations are pre-defined and are familiar to supervisors and controllers. The choice to change from a sector configuration to another must be taken considering the number of controllers on-duty, their licenses, and the available infrastructure. In general, the ACC has limited possibilities to optimise the set of sectors that compounds a configuration. DAC aims to provide a more flexible way to handle with air traffic by demand and capacity measures, adapting the configuration to the traffic demand and not the other way around.

3.2 SESAR Solution description

Solution PJ.09-W2-44 is built upon Wave 1 results of solutions PJ.08-01 and PJ.09-02.

The core focus of Solution PJ.09-W2-44 is the use of DAC concept into the DCB process including the Integrated Network Management ATC Planning (INAP) concept, in an integrated way, and not as two different steps. During Wave 1, DAC and DCB concepts were studied separately, as two different steps. But considering that DAC is a part of DCB process corresponding to the optimization of capacity, it was defined for Wave 2 the need to integrate these two concepts. A particular emphasis will be put on the INAP timeframe where these two overlap.

The INAP timeframe could be established between a few hours to a few minutes before a spot occurs, e.g.: from ~-6 hours to ~-15 min, the limits thresholds being to be adjusted according to local specificities. There are two types of spot: hotspot and optispot. A hotspot is a 4D volume (defined in time and space) representing a potential DCB imbalance (not critical as not impairing Safety), identified by ANSP(s) and potentially by NM. An optispot is also a 4D volume (defined in time and space) but representing a traffic situation where opportunity for optimization has been identified by ANSP (INAP).

To manage a seamless integration, the solution will deploy:

- Guidelines for the design of DAC airspace basic structures, i.e., Airspace Building Blocks and Controlling Building Blocks.
- Optimised configurations with the integration of DAC at pre-tactical and tactical phases.
- Integration the use of complexity, ATCO workload and ATCO availability within the sector configuration optimisation process.
- Optimised functions for hotspots resolution based on both capacity and demand measures.
- Adequate automatic support for spots detection, traffic analysis and measures monitoring.
- New features to support the analysis and resolution of hotspots, namely what-if.
- Cross border Dynamic Airspace Configurations.

Alignment of processes, roles, and measures, based on the above-mentioned features, will be necessary to ensure the right level of coordination and shared situation awareness at local, sub-regional and regional network levels.

The schema below presents the scope of Solution PJ.09-W2-44 with the main concepts developed within the solution. It also highlights dependencies with other solutions (in red dotted line) and main stakeholders impacted (all around the Solution PJ.09-W2-44 rectangle).

- Solution PJ.09-W2-49 'Collaborative Network Performance Management' will provide a common framework to assess and share network performance. This Solution was cancelled but part of it is studied by NM.
- Solution PJ.09-W2-45 'Enhanced Network Traffic Prediction and shared complexity representation' will provide What-Else functionality based on AI technology. This development will be done in SESAR 3.
- Solution PJ.07-W2-39 'Collaborative framework managing delay constraints on arrivals' is in charge of the development of a Collaborative Decision-Making (CDM) framework involving AUs, NM, Airports and LTM/EAP roles.
- Solution PJ.07-W2-38 'Enhanced integration of AU trajectory definition and network management processes' is analysing the impact of ATM planning on AUs' costs of operations.
- Solution PJ.10-W2-93 'Delegation of services amongst ATSUs' focus on the cross borders operations to describe the delegation roles and responsibilities.

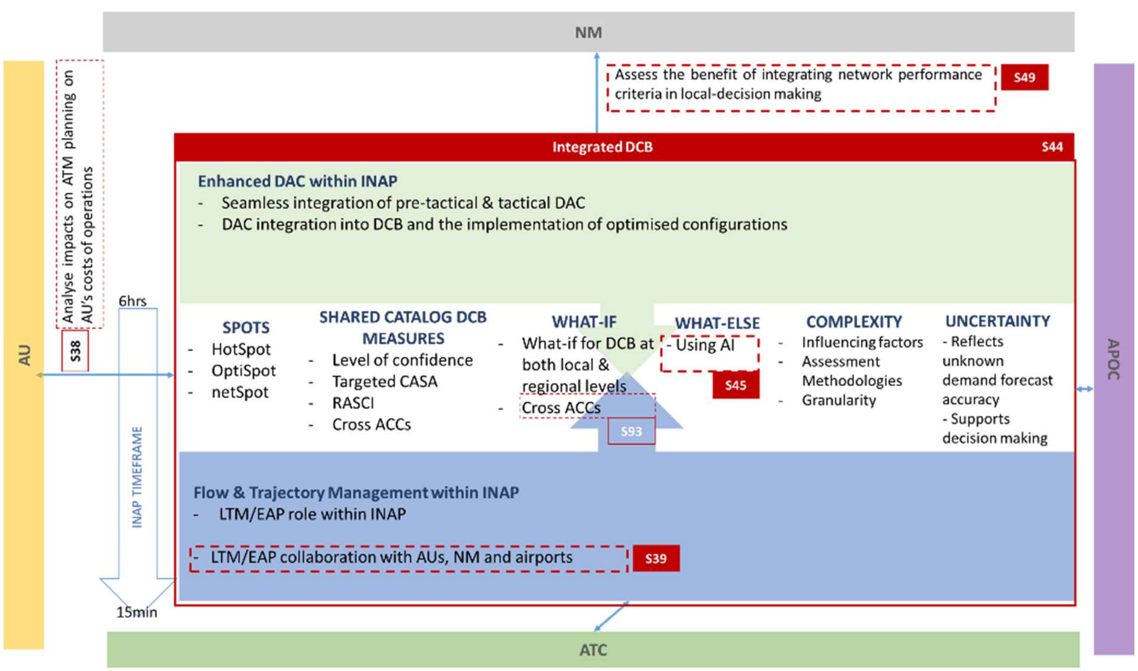

Figure 1. Solution PJ.09-W2-44 Diagram of concepts

The table below presents the OI steps included in this solution.

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.09-W2-44	CM-0102-B	Dynamic Airspace Management based on complexity	Full	eATM Portal
	CM-0103-B	Automated Support for Traffic Complexity Assessment	Full	eATM Portal
	CM-0104-C	Automated support to INAP function	Full	eATM Portal
	DCB-0210	Full integration of Dynamic Airspace Configurations into DCB	Full	eATM Portal
	AOM-0809-A	Initial SD&C Unconstrained by Predetermined Boundaries	Full	eATM Portal
	AOM-0805	Collaborative Airspace Configuration	Full	eATM Portal

Table 3: SESAR Solution PJ.09-W2-44 Scope and related OI steps

In Table 4 are represented the enablers assigned to each OI step in this solution, with their respective applicable stakeholders, according to CRs already accepted for DS22.

OI Steps ref.	Enabler[1] ref.	Enabler definition	Enabler coverage	Applicable stakeholder
CM-0102-B	AAMS-19	Dynamic Airspace Configuration tools for the Integrated local DCB working position	Required	ANSP
CM-0103-B	NIMS 36	Enhanced Complexity assessment tools	Required	ANSP-Civil, NM
CM-0104-C	ER APP ATC 17	Enhance Traffic and Flow Management sub-systems to support dynamic flow management in co-ordination with local, regional, and European levels	Required	ANSP-Civil APP and ER
	NIMS-46	Integrated local DCB working position	Required	ANSP-Civil/Military APP and ER NM Airport Operator (AO)-Civil/Military
	SVC-073	TBD	TBD	TBD
DCB-0210	NIMS-46	Integrated local DCB working position	Required	ANSP-Civil/Military APP and ER NM Airport Operator (AO)-Civil/Military
	SVC-073	TBD	TBD	TBD

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

Co-funded by the European Union

	AAMS-02	Dynamic Airspace Configuration tools for the Integrated Network Working Position	Required	ANSP-Civil, NM
	NIMS-30	ATFCM scenario management equipped with tools for assessing the impact of DAC and capacity changes on trajectory efficiency	Required	NM
AOM-0809-A	NIMS-30	ATFCM scenario management equipped with tools for assessing the impact of DAC and capacity changes on trajectory efficiency	Required	NM
	NIMS-04	ATFCM capacity planning sub-system enhanced to take into account dynamic sector shapes	Required	NM
	PRO-010	Procedures to ensure that all actors involved in the airspace reservations are well aware about the real status of airspace availability and subsequent changes	Optional	ANSP-Civil/Military NM
AOM-0805	NIMS-30	ATFCM scenario management equipped with tools for assessing the impact of DAC and capacity changes on trajectory efficiency	Required	NM
	AAMS-13	Airspace management system equipped with a method to achieve regional airspace coordination capability	Required	NM
	AIMS-04	Network management functions supported with real-time airspace data	Optional	NM
	ER APP ATC 80	Enable ATC System to Use Dynamically Defined Airspace Reservations	Required	ANSP-Civil/Military APP and ER
	PRO-010	Procedures to ensure that all actors involved in the airspace reservations are well aware about the real status of airspace availability and subsequent changes	Optional	ANSP-Civil/Military NM

Table 4: OI steps and related Enablers

EUROPEAN PARTNERSHIP

Co-funded by the European Union

3.3 Objectives of the CBA

The V3 CBA provides information on the costs and benefits of deploying Solution PJ.09-W2-44 at ECAC (European Civil Aviation Conference) level. The objective is to make an assessment that helps to build the 'big picture' of whether the Solution is worth deploying.

3.4 Stakeholders[1] identification

Across the Solution, the following stakeholders are considered from Solution PJ.09-W2-44 CBA point of view, i.e., they need to invest and/or they receive benefits. The impacts described in Table 5 include those from the Benefit and Impact Mechanisms (BIM), which can be found in Appendix A of Solution PJ.09-W2-44 OSED [12]. The following table is at a high-level, more specific cost and benefit information can be found in the relevant CBA sections.

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	En-route ACC (Very high and High complexity)	Costs: Related to new systems development for DCB position and INAP function Benefits: En-Route Capacity, Punctuality, Predictability, ATCO Productivity	Collaboration in cost assessment	Implementation costs: 12M€ Operating costs: 0.6M€/year Benefits: CAP2: +1.78% PUN1: -0.25 min/flight PRD2: +1.88% CEF2: +1.14%
Airport Operators	Civil	Costs: No costs identified Benefits: Punctuality	-	Benefits not monetized
Network Manager	Network	Costs: Systems development for NM functions	-	Implementation costs: 2.7 M€ Benefits not monetized

[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.

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
		Benefits: En-Route Capacity, Punctuality, Predictability		
Scheduled Airlines (Mainline and Regional)	Airspace User	Costs: No costs identified Benefits: Fuel efficiency, Flight Time, Punctuality	Participation in workshop	Benefits: FEFF1: -4.75 kg/flight TEFF1: -0.16 min/flight PUN1: -0.25 min/flight
Business Aviation – Fixed Wing	Airspace User	Costs: No costs identified Benefits: Fuel efficiency, Flight Time, Punctuality	-	Benefits: FEFF1: -4.75 kg/flight TEFF1: -0.16 min/flight PUN1: -0.25 min/flight
General Aviation	Airspace User	Costs: No costs identified Benefits: Fuel efficiency, Flight Time, Punctuality	-	Benefits not monetized
Military – Airborne	Airspace User	Costs: No costs identified Benefits: No benefits identified	-	Benefits not monetized
Military – Ground (WOC)	Airspace User	Costs: No costs identified Benefits: No benefits identified	-	Benefits not monetized

Table 5: SESAR Solution PJ.09-W2-44 CBA Stakeholders and impacts

3.5 CBA Scenarios and Assumptions

This CBA considers the standalone deployment of Solution PJ.09-W2-44. This means that the full costs for the enablers are included in the CBA even if they will enable other Solutions[2] too. In addition, the starting assumption for the CBA is that all the Solution OI Steps are in each deployment location.

The CBA Solution Scenario (green box in Figure 2: CBA Scenario Overview) considers the situation where the Solution OI Steps are already integrated at all deployment locations across ECAC. The CBA Reference Scenario (orange box in Figure 2: CBA Scenario Overview) describes the same future situation, but assuming that Solution PJ.09-W2-44 is not deployed. However, for the CBA Reference Scenario is considered that all deployment locations comply with the necessary pre-requisites to deploy the Solution, including all improvements from SESAR Wave 1. The CBA reflects the delta (difference) between the CBA Reference and Solution Scenarios (i.e., between the orange and green boxes in Figure 2: CBA Scenario Overview).

Defining the CBA Reference Scenario can be challenging because of the assumptions that need to be made regarding the 'ongoing deployments' (blue arrow in Figure 2: CBA Scenario Overview) such as other Solutions and initiatives.

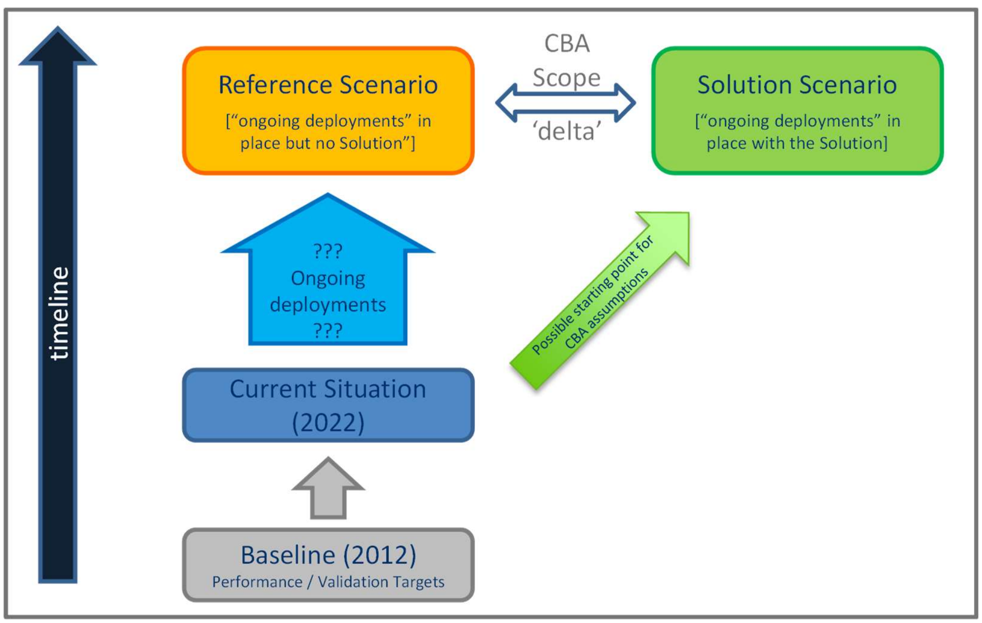

Figure 2: CBA Scenario Overview

3.5.1 CBA Reference Scenario

The CBA Reference Scenario represents the scenario against which the CBA Solution Scenario is compared, obtaining the delta covered by the CBA. It shows the operating method for managing the airspace (En-route airspace encompassing Very High and High traffic Complexity sectors) using NM Tools (CHMI and NOP) by on the date on which the deployment of Solution PJ.09-W2-44 begins. It

[2] Issues of double counting will need to be addressed by PJ19/PJ20 when considering the deployment of multiple solutions.

includes the consideration of a Free Route traffic environment, supposed to be implemented by that date. In fact, there are already some airspaces where free route is already implemented, and it is expected that almost all the ECAC airspace will be a Free Route Environment (FRA) by the end of 2024. This consideration brings the CBA Reference scenario closer to reality on that date, rather than taking the current fixed ATS route traffic.

The CBA Reference scenario is based on the outcomes from SESAR Solutions PJ.09-02 and PJ.08-01 considering that all of them have been implemented at the Start of Deployment (SOD). In this context, Airspace Configuration Management and INAP are almost totally isolated since there is no integration of these two processes. A limited Airspace Configuration Management (called DAC within SESAR work) is considered to be applied during the INAP timeframe for the CBA Reference Scenario, through the consideration of flexible vertical boundaries in the division of elementary sectors.

The schema below shows the respective INAP and Airspace Configuration Management Timeframes.

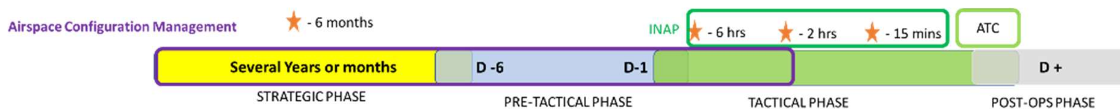

Figure 3: INAP and Airspace Configuration Management Timeframes

Hotspot Management relies on the collection and dissemination by the NM of the forecast demand computed upon the filing repository and updated in real-time using Local Demand refinement performed by the Flow Management Position (FMP) using up-to-date weather information and relevant historic data.

The FMP detects the hotspot and activates the appropriate measure based on his/her expertise, in coordination with the other actors.

The demand measures for the CBA Reference Scenario are limited to the following, as collected in Solution PJ.09-W2-44 Intermediate SPR-INTEROP/OSED:

	Demand Measure	Actors	Timeframe	Spots	Granularity
INAP	Coordinated modification of a flight plan	FMP role (ANSP), AU	Pre-tactical, Tactical Phase - Flight preparation	Hotspot	Flight
	ATFM scenario	NM, FMP role (ANSP)	Strategic, Pre-tactical and tactical phases	Hotspot	Flow
	Regulation	FMP role (ANSP), NM	Pre-tactical & Tactical Phase	Hotspot	Flow
	Regulation Mandatory Cherry Picking	FMP role (ANSP), NM	Tactical Phase	Hotspot	Set of flights
	Short Term ATFM Measures on airborne flights (level-	FMP and ATCO	Tactical Phase	Hotspot	Flight

	Demand Measure	Actors	Timeframe	Spots	Granularity
	capping, horizontal re-routing, speed adjustment, etc.)	roles (ANSP)			

Table 6: INAP catalogue of measures - previous operating method

It does not support:

- other category of spots
- hotspot monitoring (to detect hotspot resolution deviation),

elements that are indeed considered in the CBA Solution Scenario.

3.5.2 CBA Solution Scenario

The CBA Solution Scenario differs from the CBA Reference Scenario in the application of the DAC concept and the integration of it in the DCB process. In the CBA Reference Scenario, sectorisation and resolution of demand and capacity imbalances are performed independently, resulting in system inefficiencies. This integration of DAC within DCB bridges the gap in the DCB process performed by INAP actors and it is possible thanks to an adequate automation support and better situational awareness.

The integration of DAC within DCB has three main objectives:

- first, to respond to local and network performances targets,
- then, to manage airspace configuration by accommodating traffic demand, solving complexity issues and balancing workload and optimizing resources,
- and finally, to serve as a support to DCB Measures implementation, in case the capacity measures issued from DAC process are not enough and requires to be complemented with demand measures.

The integration of DAC into DCB allows to optimally adapt the capacity to the demand and minimize demand adjustments.

The full integration of DAC process within the DCB concept contributes to the Network performance through closer interaction between ATM operating phases, with consolidated and harmonised solutions integrated in the Planning and Execution phases at local, sub-regional and regional levels.

Different DCB phases can be distinguished according to the time horizon:

- Strategic process,
- Pre-tactical process,
- Tactical process,
- Post-Ops process.

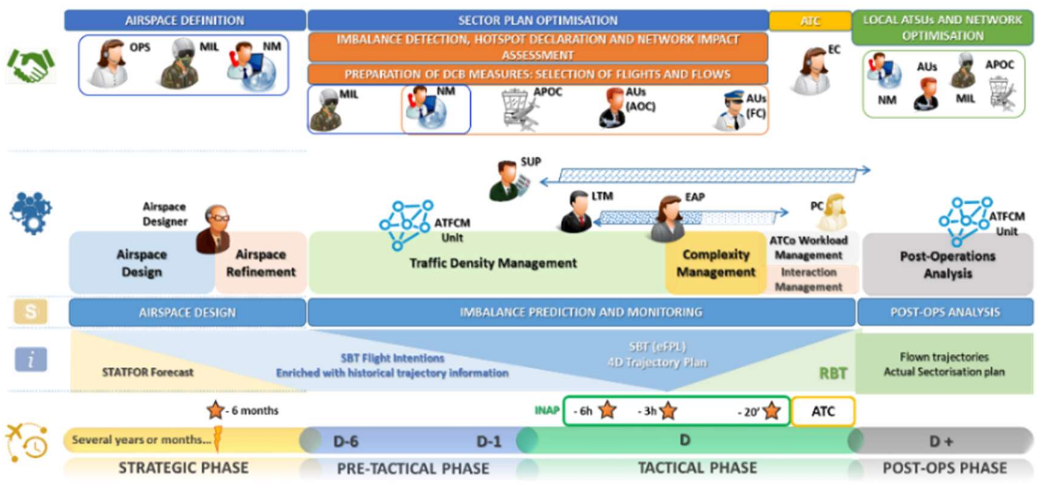

Figure 4: DCB integrated timeframe, schematic view

DAC concept is considered in this solution in the same way as presented in SESAR Solution 08.01, new operating method section [14], enhanced with seamless integration of pre-tactical and tactical DAC and the implementation of optimised configurations.

INAP concept is considered in this solution in the same way as presented in SESAR Solution 09, new operating method section [12], refined regarding INAP roles and extended to Capacity Management at tactical level.

The integrated DCB processes, assisted by decision-support tools, enable to refine optimised combined solutions of the different DCB measures, depending on time horizon, optimisation criteria and performance targets.

In this context, INAP role acts as a collaborative framework where different stakeholders' needs and preferences are taken into consideration when deciding the most suitable solution to fix DCB and complexity issues. In the INAP time horizon, Dynamic Airspace Configuration is a crucial task to assist Demand and Capacity Balancing activities; DAC is part of the toolset available to the DCB actors in INAP timeframe to manage complexity and facilitate users preferred routing, achieving specific performance objectives.

3.5.3 Assumptions

Timeframe considered for the CBA

Within the CBA, the Solution is deployed when the assigned Stakeholders have deployed the required enablers and the system is operational and providing benefits. There are three key dates for the CBA lifecycle:

- Start of Deployment (SOD): is the date on which the deployment of the Solution starts, meaning that the first costs are beginning to be incurred.
- Initial Operational Capability (IOC): is the date on which the benefits ramp-up starts. From this point, there are some remaining costs to be invest, but the benefits of the solution are beginning to be seen.

- Full Operational Capability (FOC): is the date on which deployment ends, so investments also stop. However, the Solution will still be providing benefits until the end date of the CBA W2 timeline.

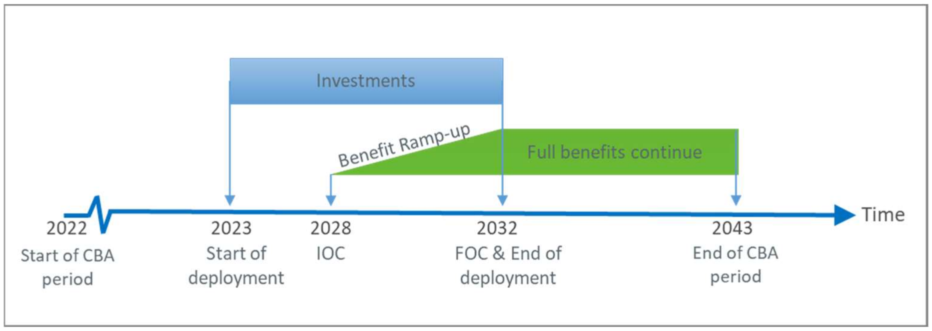

Figure 5: CBA Timeline

There is a first phase of ramp-up of benefits, and then a few stable years during which full benefits are achieved and continuous. In the case of the investments, these are considered to be evenly distributed from SOD to FOC/End of deployment.

Geographical scope considered for the CBA

The operational environment (OE) of the Solution described in the OSED indicates that the geographical scope of the solution is defined for En-Route operating environments of Very High and High Complexity. The ACCs representing these OEs are [16]:

Very High Complexity		High Complexity	
ACC	ANSP	ACC	ANSP
Karlsruhe UAC	DFS	**London Area Swanwick**	NATS
Zurich ACC	Skyguide	**Maastricht UAC**	MUAC
Geneva ACC	Skyguide	**Reims ACC**	DSNA
Brussels ACC	skeyes	**Bordeaux ACC**	DSNA
London Terminal Swanwick	NATS	**Praha ACC**	ANS CR
Langen ACC	DFS	**Padova ACC**	ENAV
Norway ACC (Oslo)	Avinor	**Amsterdam ACC**	LVNL
München ACC	DFS	**Ljubljana ACC**	Slovenia Control
-	-	**Wien ACC**	Austro Control
-	-	**Paris ACC**	DSNA
-	-	**Milano ACC**	ENAV
-	-	**Palma TACC**	ENAIRE

Table 7: En-Route ACCs of Very High and High Complexity in ECAC

Some of the ACCs contained in Table 7 are not classified as En-Route environment but as En-Route/Terminal Airspace environment. The deployment of the Solution is also considered in this “combined” ACCs.

4 Benefits

Solution PJ.09-W2-44 is expected to contribute to the achievement of SESAR performance ambitions evaluating a set of KPIs.

The table below gathers the information extracted from the PAR [17] about the final assessment of the KPIs allocated to Solution PJ.09-W2-44 resulted from the validation activities conducted by different partners through Real Time Simulations of both INAP and ATC timeframes, and the stakeholders expected to receive benefits from each of them:

KPI	Performance Assessment Result	Stakeholder that benefits in the CBA
Operational Efficiency **FEFF1: Fuel Efficiency**	**-4.75 kg/flight**	AU
Operational Efficiency **ENV1: CO_2 Emissions**	**-14.96 kg CO_2/flight**	AU, AO, ANSP
Capacity **CAP2: En-Route Airspace Capacity**	**+3 % (at local level)**	ANSP, NM
Operational Efficiency **PUN1: Punctuality**	**-0.25 min/flight**	AU, ANSP, NM, AO
Operational Efficiency **TEFF1: Flight Time**	**-0.16 %**	AU
Operational Efficiency **PRD2: Predictability**	**+1.88 %**	ANSP, NM
Cost Efficiency **CEF2: ATCO Productivity**	**+1.14 %**	ANSP
Safety	**OK**	AU, ANSP, NM, AO
Human Performance	**POK**	ANSP, NM

Table 8: PAR Results for Solution PJ.09-W2-S44

The mechanism diagrams shown in the following sections are taken from or based on the CBA Reference material [3].

4.1 Operational Efficiency (FEFF1 & ENV1)

Solution PJ.09-W2-44 PAR results show that there is a reduction in fuel consumption and CO_2 emissions of:

EUROPEAN PARTNERSHIP

Co-funded by the European Union

FEFF1: Fuel Efficiency – Fuel burn	**-4.75 kg/flight** (positive impact)
ENV1: CO2 emissions saving – CO_2 emission	**-14.96 kg CO_2/flight** (positive impact)

The figure below shows the monetisation mechanism used in the CBA model for fuel saved, and also for CO_2 saved. The calculation is made in each year, so the values include the evolution of the number of flights and fuel price over the CBA period.

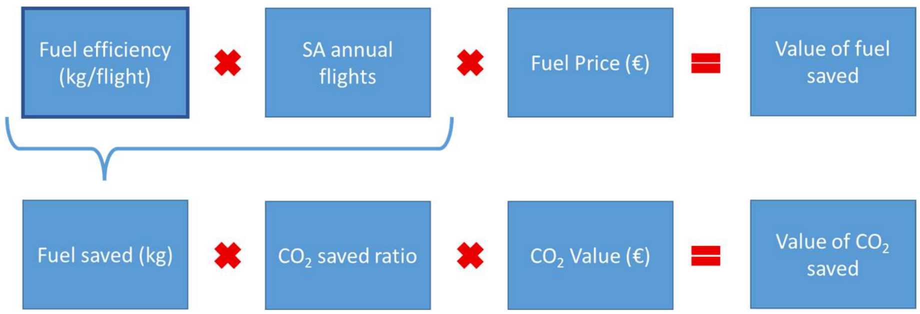

Figure 6: Monetisation mechanism for Fuel efficiency and CO_2

The overall (undiscounted) monetary value of improved fuel burn and CO_2 emissions is **1012 M€.**

4.2 En-Route Airspace Capacity (CAP2)

Solution PJ.09-W2-44 PAR results show that En-Route Airspace Capacity is reduced by:

CAP2: En-Route Airspace Capacity – Tactical and Strategic Delay	**+3%** (positive impact)

CAP2 KPI is not extrapolated at ECAC level in the PAR. But an extrapolation is needed for the introduction in the CBA model.

From the aggregation assumptions for 2035, the contribution to total ENR traffic from the Sub-Operating Environments affected by the operational concept are shown in Table 9.

ID	Sub-OE	Year	Value	Comment
ER-VHC-2035	Very High Complexity ER	2035	31,33%	Contribution to total En-Route traffic from the specific sub-OE
ER-HC-2035	High Complexity ER	2035	27,98%	Contribution to total En-Route traffic from the specific sub-OE

Table 9: Values for extrapolation at ECAC level

The full En-route airspace capacity increase measured obtained in the PAR is ***3%*** (positive impact) in very high and high complexity airspace, which represent 59.31% of the ECAC traffic and therefore, the ***En-route airspace capacity increase*** is:

$$CAP2_{ECAC} = \Delta CAP2_{local} \cdot Traffic_{SubOE} = 3\% \cdot 59.31\% = \mathbf{1.78\%}$$

Therefore, the figure to be used in CBA model for En-Route Airspace Capacity change at ECAC level is **1.78%.**

The figure below shows the monetisation mechanism used in the CBA model for airspace capacity. The calculation is made in each year, so the values include the evolution of the number of flights and cost of delay over the CBA period. The delay calculated is divided in tactical and strategic delay:

- Tactical ATFM Delay is unpredictable delay on the day of operations that exceeds the delay buffer foreseen in the flight plan.
- Strategic Delay is delay that is included in airline schedules (flight plan).

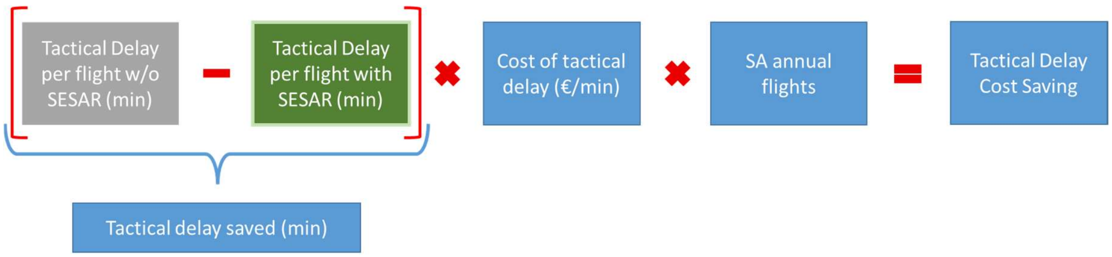

Figure 7: Monetisation mechanism for Tactical Delay Cost Saving

The link between the two types of delay is monetised through the relationship that as tactical delay reduces so does strategic delay. The assumption is that a ratio of 1:0.25 is plausible and can be used.

Figure 8: Monetisation mechanism for Strategic Delay Cost Saving

Figure 9: Monetisation mechanism for Total Delay Cost Saving

The overall (undiscounted) monetary value of avoided delay due to the increase in En-route Airspace Capacity is **2016 M€.**

4.3 Punctuality (PUN1)

Solution PJ.09-W2-44 PAR results show that Punctuality expressed as departure delay is reduced by:

PUN1: Punctuality – Minutes of departure delay	**-0.25 min/flight** (positive impact)

PUN1 is monetised through avoidance of tactical delay which is accumulated during the day of operations due to different circumstances.

The overall (undiscounted) monetary value of improve in Punctuality is **2143 M€.**

4.4 Flight Time (TEFF1)

Solution PJ.09-W2-44 PAR results show a reduction in Flight Time of:

TEFF1: Flight Time – Gate-to-gate flight time (%)	**-0.16%** (positive impact)

The figure below shows the monetisation mechanism used in the CBA model for flight time.

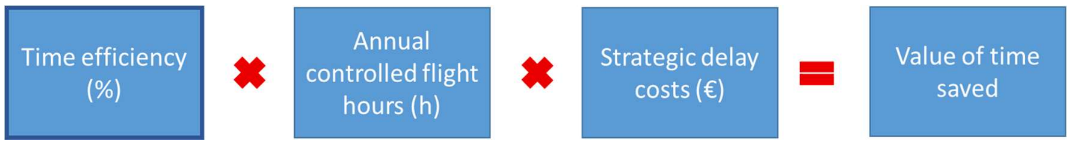

Figure 10: Monetisation mechanism for Flight Time

The overall (undiscounted) monetary value of decrease in Flight Time is **1031 M€.**

4.5 Predictability (PRD2)

Solution PJ.09-W2-44 PAR results show a negative impact in Predictability of:

PRD2: Predictability – Variance of Difference in actual & Flight Plan	**+1.88%** (negative impact)

Predictability is monetised through avoidance of strategic delay which is added into airline schedules to recover from poor predictability. The improvements with SESAR can be calculated via their impact on the duration of the strategic buffer. When the variability in flight time reduces, the estimated buffer in order to achieve a given % flights arriving on time is also reduce, using a normal distribution.

Figure 11: Monetisation mechanism for Strategic Delay Cost Saving (due to variability improvements)

The overall (undiscounted) monetary value of improved predictability is **408 M€.**

4.6 Cost Efficiency: ATCO Productivity (CEF2)

Solution PJ.09-W2-44 PAR results show an improvement in ATCO productivity of:

CEF2: ATCO Productivity – Flights per ATCO-Hour on duty	**+1.14%** (positive impact)

The deployment of Solution PJ.09-W2-44 entails a decrease in ATCO workload, thus leading to an increase in the number of flights that can be managed by the controller per hour on duty. This means additional capacity is created by maintaining the same number of ATCO workforce, all the rest being equal.

ATCO productivity is monetised in the CBA through the number of flights that can be managed by the controller per hour on duty. When a Solution decreases controller workload[3] then additional flights can be managed with the same number of controllers, all else remaining equal. Therefore, the forecast traffic growth can be handled with a smaller increase in controller numbers than if the Solution was not deployed.

The change in ATCO Productivity is used in the CBA model to calculate Operating cost savings (ATCO employment costs, Support staff costs and Non-staff operating costs). The Support staff costs can be calculated based on the ratio of support staff to ATCO hours. The Non-staff operating costs are based on the traffic growth rate.

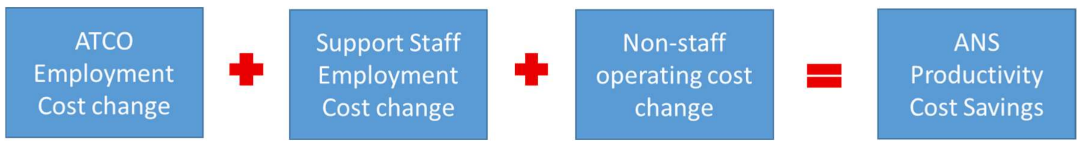

Figure 12: Monetisation mechanism for ATCO Productivity

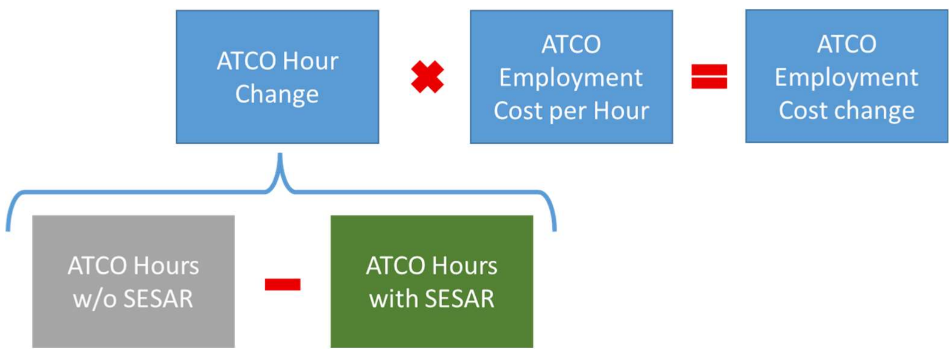

Figure 13: Monetisation mechanism for ATCO Employment Cost change

The ATCO Hours Without and With SESAR are calculated through the flight hours and the ATCO Productivity.

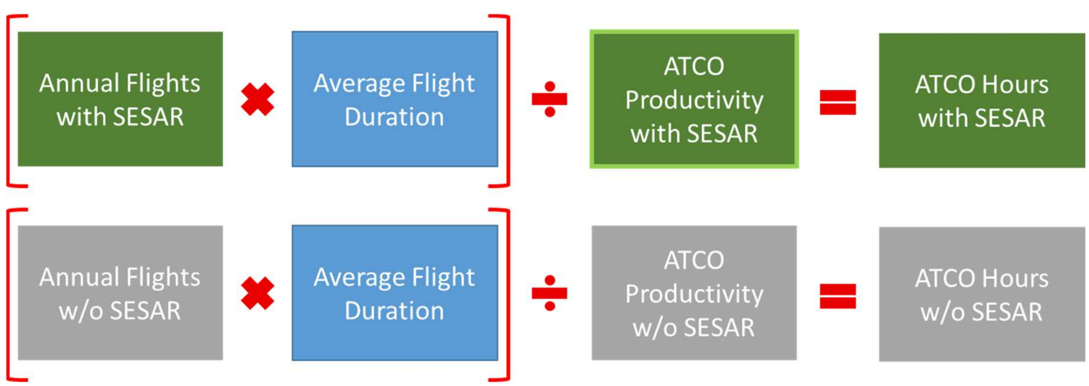

Figure 14: Monetisation mechanism for ATCO hours with and w/o SESAR

[3] During peak-hours reduced controller workload is considered to provide an increase in capacity, while in non-peak-hours it is allocated to ATCO Productivity.

EUROPEAN PARTNERSHIP
Co-funded by the European Union

The (undiscounted) monetary value of ATCO Productivity (i.e., fewer additional controllers are needed to handle the increased traffic) is **1383 M€.**

4.7 Safety

Solution PJ.09-W2-44 does not have direct ATS safety impact but an indirect impact via the potential safety implications of the DAC and DCB services delivered to ATS. Consequently, no Safety Criteria but Safety drivers were defined (see [18]).

The level of safety with the Solution PJ.09-W2-44 has been assessed qualitatively in validation exercises (RTS) via debriefing with participating LTMs (and EAPs where applicable) and/or assessment of LTM & EAP situational awareness.

All safety specification items were evaluated as OK in the PAR [17] from the assessment done in validation exercises.

4.8 Human Performance

As explained in the PAR [17] and the Human Performance Report (HPAR) [19] documents, Human Performance KPIs have been partially covered. Three of the 4 KPIs evaluated have been totally covered:

- HP1: Consistency of human role with respect to human capabilities and limitations.
- HP2: Suitability of technical system in supporting the tasks of human actors.
- HP3: Adequacy of team structure and team communication in supporting the human actor.

However, the last KPI was not totally covered. HP4, Feasibility with regard to HP-related transition factors, is divided in five second level indicators. Three of them were covered:

- HP4.1: User acceptability of the proposed solution.
- HP4.2: Feasibility in relation to changes in competence requirements.
- HP4.5: Feasibility in terms of changes in training needs with regard to its contents, duration and modality.

The other two, HP4.3: Feasibility in relation to changes in staffing levels, shift organization and workforce relocation and HP4.4: Feasibility in relation to changes in recruitment and selection requirements, were not covered. They main reasons why this two HP arguments were not fulfilled are:

- Knowledge, skills and experience requirements for conducting the new operating methods might be underestimated (e.g., highly specialised vs. generic training).
- If the ATCOs are not sufficiently trained for the new sectors, their workload might increase, and the benefit of the concept might not be reached.

Further detail can be consulted in HPAR [19].

Performance Framework KPA[5]	Focus Area	KPI/PI from the Performance Framework	Unit	Metric for the CBA	Unit	Year 2028 (IOC)	Year 2032 (FOC)	Year 2043
Cost Efficiency	ANS Cost efficiency	CEF2 Flights per ATCO-Hour on duty	% and # movements	Strategic delay cost (avoided-; additional +)	M€/year	*15.8*	*88.4*	*111.3*
Capacity	Airspace capacity	**CAP2** En-route throughput, in challenging airspace, per unit time	% and # movements	Tactical delay cost (avoided-; additional +)	M€/year	*13*	*98*	*175*
Predictability and punctuality	Predictability	**PRD2** Variance of Difference in actual & Flight Plan or RBT durations	%	Strategic delay cost (avoided-; additional +)	M€/year	*5.1*	*27.4*	*30.9*
	Punctuality	**PUN1** % Departures < +/- 3 mins vs. schedule due to ATM causes	Minutes per flight	Tactical delay cost (avoided-; additional +)	M€/year	*27*	*144*	*162*
Environment	Fuel Efficiency	**FEFF1** Average fuel burn per flight	Kg fuel per movement	Fuel Costs	M€/year	*11*	*63.6*	*80.8*
Safety	ATM System safety outcome	**SAF1**	%	-	-	-	-	-

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

Performance Framework KPA[5]	Focus Area	KPI/PI from the Performance Framework	Unit	Metric for the CBA	Unit	Year 2028 (IOC)	Year 2032 (FOC)	Year 2043
		Total number of estimated with ATM contribution per year						
Human performance		**HP**		-	-	-	-	-
Operational efficiency	Flight time	**TEFF1** Gate-to-gate flight time	minutes		M€/year	*12.8*	*69.1*	*77.9*

Table 10: Results of the benefits monetisation per KPA

EUROPEAN PARTNERSHIP

Co-funded by the European Union

5 Cost assessment

For the cost assessment, there is a classification of the type of costs that each enabler will imply in the Solution deployment. The categories selected for this classification have been extracted from Methods to monetise and assess costs [8] from SESAR JU. This document contains useful information about the correct methodology to be followed during the CBA document creation. In this case, we consulted the section *Costs per stakeholder* to support the identification of the type of costs for each enabler.

5.1 ANSPs costs

5.1.1 ANSPs cost approach

The analysis for ANSP costs has followed a collaborative strategy. The costs are classified in categories according to [8], and the collaboration from stakeholders has been crucial for the validation of the analysis.
Table 20 in Appendix 11.2 collects the classification by enabler, only including those involving ANSP stakeholders.

After the first round of exchange with stakeholders to identify cost categories, a second round was performed to define the costs estimation. First, feedback from each stakeholder was required and a workshop was held afterwards to define a consensus. From this workshop, Table 21: Implementation & Operating Costs per ACC in Appendix 11.2 containing the cost per category for a standard ACC were obtained. For operating costs, figures are estimated per year. For this reason, an extrapolation to the deployment time horizon of the Solution is needed.

5.1.2 ANSPs cost assumptions

The following costs are not considered to be significant for enablers related to ANSP:

- Transition costs[6]
- Building and facilities related costs
- Raw material costs

Hereafter the justification for all costs estimation is exposed.

IMPLEMENTATION COSTS

One-Off costs

- Initial Training & Staffing: all ATCOs performing LTM role require a training for new DCB tools and/or systems developed in the Solution.
- Project Management: previous expert experience led to an estimation of project management costs equivalent to the 6% of implementation costs.

[6] Costs for maintaining current systems, during transition to a new system.

- Airspace Design & Procedures: new design and procedures modifications are required for airspace impacted by DAC application.
- Administrative costs: bureaucracy aspects and new tools documentation are included in this cost.
- Installation & Commissioning: major installations are required for new tools and systems.
- Validation & Certification: a wide range of validation and certification activities are needed to guarantee safety and good functioning of new systems and tools.

Capital costs

- Equipment & System: software development (internally or outsourced to the ANSPs) and hardware acquisition is required.
- Integration costs: once more, systems and tools need major integration costs in current premises.

OPERATING COSTS

- **Personal & Training**: for certain new elements present in the Solution there is no expected increase in personal or training cost from CBA Reference Scenario. However, there are a few systems that require some extra training not covered in CBA Reference Scenario.
- **Maintenance & Repair:** as well as in the previous cost category, some systems do not incur additional maintenance costs while others require an extra maintenance cost from CBA Reference Scenario basis.
- **Administration costs:** the two previous operating categories demand administrative activities.

5.1.3 Number of investment instances (units)

En-Route/Terminal Airspace				En-route			
VH	H	M	L	VH	H	M	L
4	3	N/A	N/A	4	9	N/A	N/A

Table 11: Number of investment instances – ACCs

As defined in Solution PJ.09-W2-44 OSED and aligned with the Validation Targets assigned to this project, only Very High and High Operational Environments are impacted by the deployment of this Solution. According to SESAR 2020 OEs Classification, there are 8 Very High Complexity ACCs (half of them being a combination of En-Route and Terminal airspaces) and 12 High Complexity ACCs (in this case 3 of them are combined with a TA environment).

5.1.4 Cost per unit

An extrapolation from the ACC-based estimation done is needed to cover all ACCs present in ECAC where the Solution is going to be deployed. The results of such extrapolation are collected in Table 12.

Cost category	En-route and En-Route/Terminal Airspace			
	VH	H	M	L
Pre-Implementation Costs	N/A	N/A	N/A	N/A

Cost category	En-route and En-Route/Terminal Airspace			
	VH	H	M	L
Implementation costs	4.8 M€	7.2 M€	N/A	N/A
Operating costs	0.24 M€	0.36 M€	N/A	N/A

Table 12: Cost per Unit –ACC

5.1.5 Cost Summary

This section provides a summary of how the data in the previous sections is used to feed the CBA model.

Implementation costs

	Cost per-unit		Deployment Locations		Cost
Civil ANSP	0.6 M€ per VH ACC	x	8	=	4.8 M€
	0.6 M€ per H ACC	x	12	=	7.2 M€
	x M€ per M ACC	x	y	=	z M€
	x M€ per L ACC	x	y	=	z M€
			Total Implementation costs		**12 M€**

Table 13: Implementation costs summary

Annual Operating costs changes

	Cost per-unit		Deployment Locations		Cost
Civil ANSP	0.03 M€ per VH ACC	x	8	=	0.24 M€
	0.03 M€ per H ACC	x	12	=	0.36 M€
	x M€ per M ACC	x	y	=	z M€
	x M€ per L ACC	x	y	=	z M€
			Annual Operating cost change		**0.60 M€**

Table 14: : Operating costs summary

The total of 20 ACCs are located in 13 ANSPs across ECAC. Those ACC corresponding to En-Route and Terminal Airspace OE category are considered to need the same investment as the pure En-Route ACCs. If DAC concept is extended to Terminal Airspace environments in the future, it needs to be taken into account that the investment on this “combined” ACCs was already spent for the En-Route deployment.

5.2 Airport operators costs

In the BIMs, as defined in the Solution PJ.09-W2-44 Intermediate SPR-INTEROP/OSED Appendix A.2, Airport Operators have not been identified as required to invest for Solution PJ.09-W2-44, so they do not have associated costs in this CBA.

5.3 Network Manager costs

5.3.1 Network Manager cost approach

The analysis for NM costs has been developed by CBA contributors, especially by EUROCONTROL experts. The costs are classified in categories according to [8]. The NM incurs costs only for the implementation category.

5.3.2 Network Manager cost assumptions

The following costs are not considered to be significant for enablers related to NM:

- Transition costs
- Building and facilities related costs
- Raw material costs
- Personal & Training costs

5.3.3 Network Manager cost figures

The NM costs are not dependant on the number or type of ACCs in which Solution PJ.09-W2-44 will be deployed. For this reason, costs categories contain a general estimation of costs which is not related to VH, H, M or L complexity ACCs ([16]).

The estimated costs are:

- Implementation costs: **2.7 M€**
    - Project management: 300k€
    - Installation & Commissioning: 600k€
    - Validation & Certification costs: 300k€
    - Integration costs: 1.500 k€
- Operating costs: it is not expected that the NM incurs cost changes in this category with respect to CBA Reference Scenario operations.

These costs are part of the NM Release process. The costs are allocated to software development (coded FB/TB/CR/SB blocks) and NM integration to platform (coded E-RB blocks). NM release costs are subject to an external audit once a year and are independent on the number of ACCs of each complexity environment.

5.4 Airspace User costs

In the BIMs, as defined in the Solution PJ.09-W2-44 Intermediate SPR-INTEROP/OSED Appendix A.2, Airspace Users have not been identified as required to invest for Solution PJ.09-W2-44, so they do not have associated costs in this CBA. This statement is reinforced after a workshop organized by the Solution leader with Airspace Users stakeholders.

5.5 Military costs

In the BIMs, as defined in the Solution PJ.09-W2-44 Intermediate SPR-INTEROP/OSED Appendix A.2, Military have not been identified as required to invest for Solution PJ.09-W2-44, so they do not have associated costs in this CBA.

5.6 Other relevant stakeholders

In the BIMs, as defined in the Solution PJ.09-W2-44 Intermediate SPR-INTEROP/OSED Appendix A.2, no other impacted stakeholders are identified. There should be no other costs.

6 CBA Model

SESAR2020 CBA
Model PJ09-S44_v1.0.

Note: The used version of this embedded Model is s7.3.8.

6.1 Data sources

Cost Inputs

The sources for the Solution PJ.09-W2-44 costs have been partners and experts within the Solution.

Benefit Inputs

The source for the monetizable benefit calculation inputs is the Performance Assessment Results from Solution PJ.09-W2-44 Performance Assessment Report [17].

Other Input Parameters

The data sources for the non-Solution specific CBA Model parameters are referenced in the various input's sheets of the CBA Model with details provided in the sheet 'Source of Reference'. These are all part of the Common Assumptions [9]. Additionally, the rest of parameters have been obtained from CBA reference documentation.

7 CBA Results

SESAR Solution PJ.09-W2-44 aims to improve capacity management by the integration of DAC concept into the DCB process including the Integrated Network Management ATC Planning (INAP) concept, in an integrated way. During Wave 1, DAC and DCB concepts were studied separately, but considering that DAC corresponds to the optimization of capacity, it was defined for Wave 2 the need to integrate it into the DCB process.

In summary, the stakeholder most benefiting from the deployment of Solution PJ.09-W2-S44 are Scheduled Airlines, followed by ANSPs. This is consequence of the improvement of certain KPIs, especially Punctuality (PUN1) and En-Route Airspace Capacity (CAP2). On the other hand, the stakeholder who will need to invest the most are ANSPs, followed by the NM, who will not have direct monetizable benefits (based on the performance results).

The return of the investment arrives relatively soon, in 2028, 6 years after the SOD. Besides, negative values in net cumulative benefits are not too high during the first years. After 2028 and until the end of the CBA period (2043) benefits keep gradually growing.

7.1 Discounted values

This section presents the discounted CBA results, resultant from the cost and benefit inputs and assumptions described throughout this document. The values shown below are discounted to account for the time value of money. Undiscounted values are shown in Section 7.2.

This CBA includes costs for ANSPs and the NM, and benefits for ANSPs (En-Route airspace capacity, punctuality, predictability, ATCO productivity), Airport Operators (punctuality), NM (En-Route airspace capacity, punctuality, predictability) and Airspace Users (fuel efficiency, flight time, punctuality).

The Net Present Value (NPV) for Solution PJ.09-W2-44 is **2,455 M€.** This is calculated with an 8% discount rate over the **period 2022 to 2043**.

The payback year is **2028**, as shown in Figure 15, where the discounted cumulative net benefits line crosses back over the x-axis.

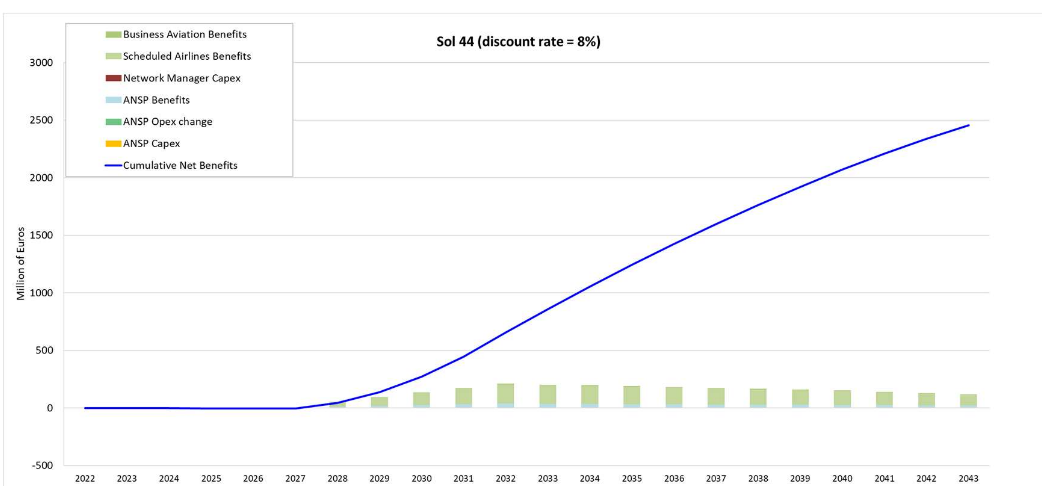

Figure 15: Annual Investment Levels and Benefits (discounted)

Figure 15 shows the discounted values on a year-by-year basis. The Net Benefits are the benefit value per year minus the cost value for that year; these are then shown cumulatively as a line in the figure

Looking at the discounted results of individual stakeholders, see Figure 16, it shows that:

- The results are positive for Scheduled and Business Aviation. Moreover, they have only benefits, with no costs associated.
- ANSPs have capital and operational costs, and directly monetizable benefits (based on the performance results).
- NM has only capital costs but not directly monetizable benefits (based on the performance results).

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

Sol 44 - 2022-2043 (discounted 8%) (M€)				
Discounted	NPV	Capex	Opex	Benefits
ANSP	420.5	-7.5	-2.7	430.6
Airports	0.0	0.0	0.0	0.0
Network Manager	-1.7	-1.7	0.0	0.0
Business Aviation	69.5	0.0	0.0	69.5
Scheduled Aviation	1,966.4	0.0	0.0	1,966.4
RPAS-Civil	0.0	0.0	0.0	0.0
RPAS Military	0.0	0.0	0.0	0.0
Overall	**2,454.7**	**-9.1**	**-2.7**	**2,466.5**

Figure 16: Discounted CBA results (per stakeholder and overall)

Figure 17 shows the cost and benefit data without the cumulative net benefits line to make the scale of the costs and benefits per stakeholder is easier to read. However, in this case, as Scheduled and Business aviation benefits are considerably higher than the rest of the values, all the values in the legend are not so easily distinguishable.

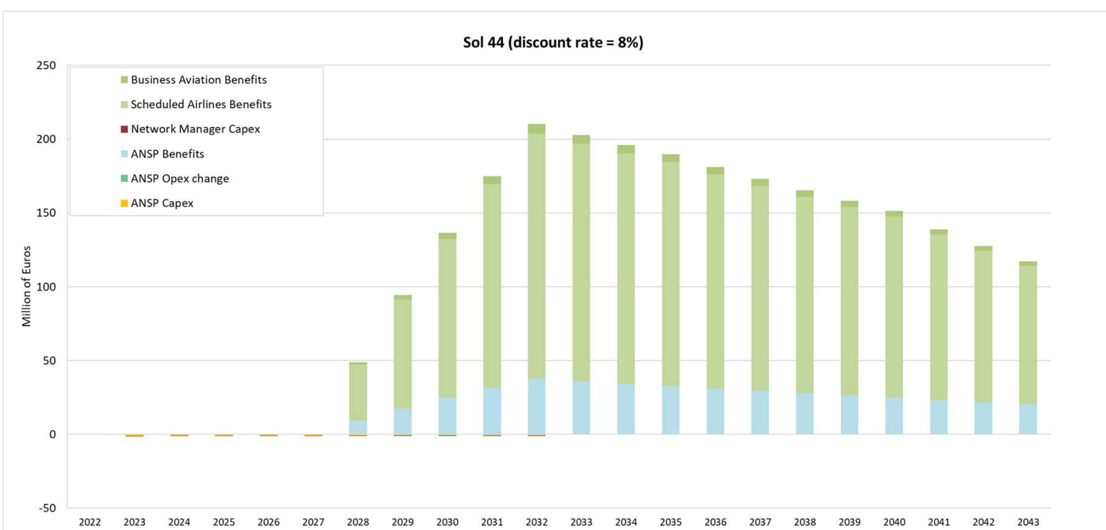

Figure 17: Annual Investment Levels and Benefits (discounted)

7.2 Undiscounted values

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

Figure 18 contains the undiscounted values, which show that, without discounting, the overall net benefits are **7,970 M€.**

Sol 44 - 2022-2043 (undiscounted) (M€)				
	Net Benefits	Capex	Opex	Benefits
ANSP	1,363.0	-12.0	-8.4	1,383.4
Airports	0.0	0.0	0.0	0.0
Network Manager	-2.7	-2.7	0.0	0.0
Business Aviation	220.6	0.0	0.0	220.6
Scheduled Aviation	6,389.2	0.0	0.0	6,389.2
RPAS-Civil	0.0	0.0	0.0	0.0
RPAS Military	0.0	0.0	0.0	0.0
Overall	**7,970.1**	**-14.7**	**-8.4**	**7,993.2**

Undiscounted

Figure 18: Undiscounted CBA results (per stakeholder and overall)

Of course, without considering the 8% discount, all overall results are higher and give the reader an idea of how much it would represent each figure with today's value of the money.

Figure 19 shows the undiscounted costs and benefits over each year.

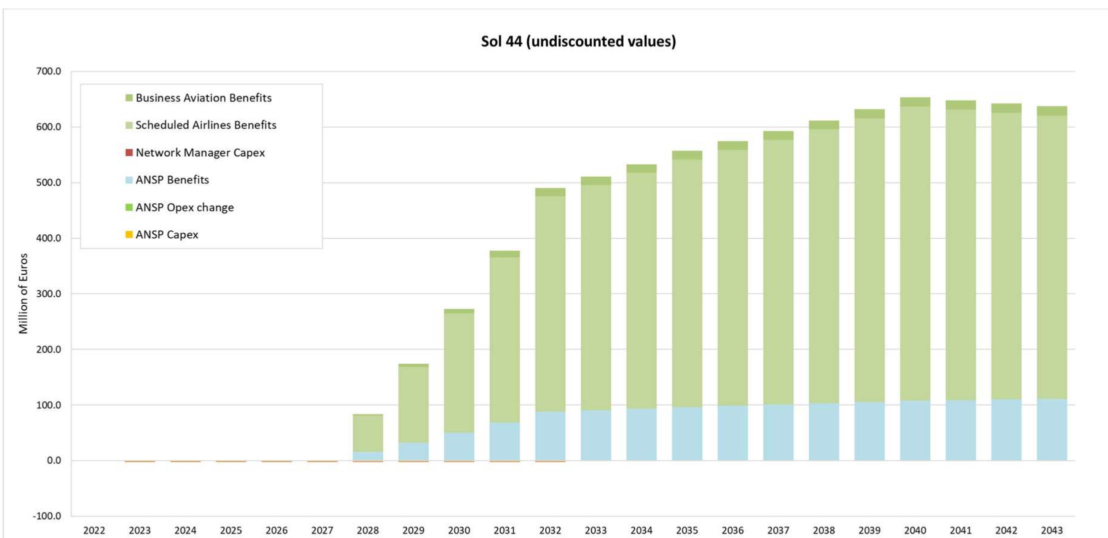

Figure 19: Annual Investment Levels and Benefits (Undiscounted)

8 Sensitivity and risk analysis

This section presents the analysis of the impact of variations in costs, benefits and rate discount on the CBA results. The scenarios to be explored are the following:

- Analysis 1: Sensitivity to Costs
- Analysis 2: Sensitivity to Benefits
- Analysis 3: Sensitivity to discount rate
- Analysis 4: Sensitivity to Punctuality benefit

8.1 Analysis 1: Sensitivity to Costs

This sensitivity analysis seeks to contemplate the situation in which costs are higher than planned (for whatever reason), and then the evaluated scenario changes. In this case, costs are doubled and the impact of this in the results are analysed.

Table 15 represents the impact on the NPV (discounted) of doubling the costs. The **NPV is slightly reduced** and **remains positive**.

Scenario	Costs (M€)	Change compared to reference	NPV (M€)	Change compared to reference
Reference[7]	ANSP Capex: 12 ANSP Opex: 0.6/year NM Capex: 2.7	-	2,455	-
Double costs	ANSP Capex: 24 ANSP Opex: 1.2/year NM Capex: 5.4	+100%	2,443	**-0.5%**

Table 15: Impact of cost change on NPV

8.2 Analysis 2: Sensitivity to Benefits

This section aims to represent a situation in which benefits are not as good as expected after the deployment of the Solution. For this purpose, the results are analysed by modifying the benefits input by half.

[7] Do not mistake this reference scenario with CBA Reference Scenario. The reference scenario defined here correspond to the inputs and CBA results with the original data (data sources explained in 6.1) without any modification for the sensitivity analysis.

Table 16 represents the impact on the NPV (discounted) of diving the benefits by two. The **NPV is significantly reduced**. However, since the margin in the baseline scenario was large, the **NPV remains positive**.

Scenario	Benefits	Change compared to reference	NPV (M€)	Change compared to reference
Reference[8]	CAP2: +1.78% FEFF1: -4.75 kg/flight PUN1: -0.25 min/flight TEFF1: -0.16% PRD2: +1.88% CEF2: +1.14%	-	2,455	-
Half of benefits	CAP2: +0.89% FEFF1: -2.38 kg/flight PUN1: -0.13 min/flight TEFF1: -0.08% PRD2: 3.76%[9] CEF2: +0.57%	-50%	1,425	**-42%**

Table 16: Impact of benefit change on NPV

8.3 Analysis 3: Sensitivity to Discount Rate

The discount rate is used to determine the present value of future cash flows, so reducing the discount rate reduces the difference between the value of money today and its value in the future.

Table 17 shows that **using a lower discount rate increases the NPV.**

Discount Rate	NPV (M€)	Change compared to reference
8%	2,455	0%
6%	3,238	32%
4%	4,320	76%
2%	5,832	138%
0% (undiscounted)	7,970	225%

[8] Do not mistake this reference scenario with CBA Reference Scenario. The reference scenario defined here correspond to the inputs and CBA results with the original data (data sources explained in 6.1) without any modification for the sensitivity analysis.

[9] PRD2 KPI is a negative impact if variance gets higher. So, in this case, instead of dividing the figure by two, it needs to be doubled to represent a "worse" scenario.

Table 17: Impact of discount rate on NPV

8.4 Analysis 4: Sensitivity to Punctuality Benefit

With 2143 M€, Punctuality (PUN1) is the KPI with the highest overall (undiscounted) monetary value of improvement of all evaluated KPIs. It is interesting to evaluate how changes in this metric can impact on the NPV (discounted) result.

PUN1 (min/flight)	Change compared to reference	NPV (M€)	Change compared to reference
-0.23	-10%	2,387	-3%
-0.24	-5%	2,420	-1.4%
-0.25	0%	2,455	0%
-0.26	5%	2,489	+1.4%
-0.28	10%	2,522	+3%

Table 18: Impact of Punctuality (PUN1) on NPV

Even though the Punctuality is the KPI that contributes most to the benefits of CBA, a variation of up to ±10% of this metric does not have a great influence on the NPV.

9 Recommendations and next steps

This document contains the V3 CBA for Solution PJ.09-W2-S44. For further steps of the economic research the following recommendations are defined:

- Review the cost assessment to refine their estimation depending on the Sub-OEs where to deploy the Solution
- Review the estimation of costs, as the benefits far outweigh them, and the analysis might have been *too optimistic*.
- Review the impact of each the results for each KPI in the PAR, as not all Sub-OEs were considered in all validation exercises.

EUROPEAN PARTNERSHIP

Co-funded by the European Union

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

[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] PJ19 – SESAR2020- Common assumptions

10.2 Reference Documents

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

[11] PJ19.04: Performance Framework (2019)

[12] SESAR Solution PJ.09-W2-44 SPR-INTEROP/OSED – Part I

[13] SESAR SOLUTION PJ.09-02: COST BENEFIT ANALYSIS (CBA) FOR V2

[14] SESAR Solution PJ.08-01 Cost Benefit Analysis (CBA) for V2

[15] D19.04.7 Validation Targets W2 & W3 (2020) v00.00.04_2 Quantitative

[16] PJ.19 - En-route & Terminal Airspace Operational Environments (April 2019)

[17] SESAR Solution PJ.09-W2-44 SPR-INTEROP/OSED -Part V - PAR

[18] SESAR Solution PJ.09-W2-44 SPR-INTEROP/OSED -Part II - SAR

[19] SESAR Solution PJ.09-W2-44 SPR-INTEROP/OSED -Part IV - HPAR

11 Appendix

11.1 ATM Master Plan Performance Ambition & SESAR Performance Framework

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

EUROPEAN PARTNERSHIP

Co-funded by the European Union

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	PRD2	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 19: Mapping between ATM Master Plan Performance Ambition KPAs and SESAR Performance Framework KPAs, Focus Areas and KPIs

11.2 Costs estimation

Note: The categories not identified as significant have been removed from the Table.

Sub-category	Cost type	Description	AAMS-19	AAMS-02	NIMS-76	NIMS-46	ER APP ATC 17	ER APP ATC 80	SVC-073	PRO-010
Implementation Costs										
One-Off Costs		Costs incurred during the implementation period and that are paid once								
	Initial Training & Staffing	Initial Staffing								
		Initial Training	x	x		x	x	x		x
		Training simulator	x	x			x	x		
	Project Management	Project Definition, Programme management and support, Planning costs, including design costs, planning authority resources and other planning costs Change management Procurement activities Meeting/ travel costs Processes and documentation costs	x	x	x	x	x	x	x	x
	Airspace design & Procedures	Changes to airspace design	x	x						
		Changes to and design of new ATC and flight procedures	x	x						
		LoAs	x	x						
	Administrative costs	New procedures, regulation, processes to put in place	x	x						x
		Documentation	x	x	x	x	x	x	x	x
		Installation costs,	x	x	x	x	x	x	x	

	Installation & Commissioning	Initial Test and evaluation (*Test plans, procedures, reports; Test equipment/tools, including aircraft; Test staff and training)*	x	x	x	x	x	x	x	
		Functional integration (*standardisation*)	x	x	x	x	x	x	x	
		Human/product interface	x	x	x	x	x	x	x	
	Validation & Certification costs	Validation	x	x	x	x	x	x	x	
		Safety assessments / audits	x	x	x	x	x	x	x	
Capital Costs										
	Equipment & System	Hardware and software acquisition, Software development (*development, engineering, knowledge base: adaptation data, production, reviews and audit*) Initial software licensing	x	x	x	x	x	x	x	
	Integration costs	Physical integration								
		Software development	x	x	x	x	x	x	x	
		System integration	x	x	x	x	x	x	x	
Personal & Training		Change in costs for staff, training due to operational improvements implemented								
	Training	Training (new staff)	x	x		x	x	x		x
Maintenance & Repair										
	Hardware & Software	Hardware and Software maintenance and repair	x	x	x	x	x	x	x	
Administration Costs										
	Expenditures related to changes in procedures, regulation, etc.		x	x	x	x	x	x	x	x
	Documentation		x	x	x	x	x	x	x	x

Table 20: Implementation & Operating costs categories for enablers related to ANSPs (first part)

Sub-category	Cost type	Description	Cost (k€)
Implementation Costs			
One-Off Costs	Costs incurred during the implementation period and that are paid once		
	Initial Training & Staffing	Initial Staffing Initial Training Training simulator	200
	Project Management	Project Definition, Programme management and support, Planning costs, including design costs, planning authority resources and other planning costs Change management Procurement activities Meeting/ travel costs Processes and documentation costs	40
	Airspace design & Procedures	Changes to airspace design Changes to and design of new ATC and flight procedures LoAs	20
	Administrative costs	New procedures, regulation, processes to put in place Documentation	15
		Installation costs,	50

Sub-category	Cost type	Description	Cost (k€)
	Installation & Commissioning	Initial Test and evaluation (*Test plans, procedures, reports; Test equipment/tools, including aircraft; Test staff and training)* Functional integration (*standardisation*) Human/product interface	
	Validation & Certification costs	Validation Safety assessments / audits	21
Capital Costs			
	Equipment & System	Hardware and software acquisition, Software development (*development, engineering, knowledge base: adaptation data, production, reviews and audit*) Initial software licensing	200
	Integration costs	Physical integration Software development System integration	18
Operating costs			
Personal & Training		Change in costs for staff, training due to operational improvements implemented	
	Training	Training (new staff)	8/year
Maintenance & Repair			
	Hardware & Software	Hardware and Software maintenance and repair	18/year
Administration Costs			

Sub-category	Cost type	Description	Cost (k€)
	Expenditures related to changes in procedures, regulation, etc.		7/year
	Documentation		

Table 21: Implementation & Operating Costs per ACC

-END OF DOCUMENT-