[SESAR SOLUTION 10.02a: INITIAL COST BENEFIT ANALYSIS (CBA) FOR V3]

Deliverable ID:	**D4.2.120**
Dissemination Level:	**PU**
Project Acronym:	**PROSA**
Grant:	**743134**
Call:	**[H2020-SESAR-2015-2]**
Topic:	**Separation Management En-Route & TMA**
Consortium coordinator:	**DFS**
Edition date:	**16/10/2019**
Edition:	**00.01.02**
Template Edition:	**02.00.01**

Founding Members

EUROPEAN UNION EUROCONTROL

PROSA

PJ.10.02A IMPROVED PERFORMANCE IN THE PROVISION OF SEPARATION

This document is part of a project that has received funding from the SESAR Joint Undertaking under grant agreement No 734143 under European Union's Horizon 2020 research and innovation programme.

Abstract

This document presents the Cost and Benefit Analysis and Assessment for the solution PJ.10.02a1 (V3) and PJ.10.02a2 (V2). This document is the result of the activities conducted for V2 and V3 solutions regarding the CBA model and scenarios.

It will include the completion of all steps conducted to

- Build the Benefit and Impact Mechanisms diagram for all relevant stakeholders (ANSP, NM and AU)
- Perform the Benefits Assessments analysis for all stakeholders.
- Provide the analysis based on V2 and V3 activities results and NEST simulations *(refer to §4.3.1 for details on NEST tool)*
- Produce the CBA model and cost assessments

This issue is the final draft and covers the full scope.

Table of Contents

List of Tables

List of Figures

1 Executive Summary

This document provides the Cost Benefit Analysis (CBA) for the **SESAR Solution PJ.10.02a – Improved Performance in the Provision of Separation**. We firstly recall the historical background, then we present the key results (among which the KPAs addressed by this CBA and the NPV values)

1.1 Historical background

After the V2 Gate held on 20th December 2018, it has been stated in agreement with SJU to define two sub solutions (relative CRs have been endorsed in August 2019), namely :

- PJ.10.02a1. This solution gathers the V3 part of the solution 10.02a.
- PJ.10.02a2. This solution gathers the V2 part of the solution 10.02a

PJ.10.02a1 aims at improving the separation (tactical layer) in **the En-Route and TMA operational environments** through improved ground trajectory prediction. This is achieved using **existing information on lateral and vertical clearances that are known by the ground system and airborne information such as Mode S** data.

OI steps addressed by PJ.10.02a1: CM-0206, CM-0208-A, CM-0209, CM-0210 and CM-0211

PJ.10.02a2 aims at improving the separation (tactical layer) in the **En-Route operational environment** through improved ground trajectory prediction. This is achieved using existing information on **lateral and vertical clearances that are known by ADS-C/EPP** airborne information.

OI steps addressed by PJ.10.02a2: CM-0209-b and CM-0210-b

This is the direct result of the expected maturity targets defined for the OIs and enablers part of the scope.

Sub-Solution	OI	Target Maturity
PJ.10.02a1	CM-0206	V3 achieved
	CM-0208-A	V3 achieved
	CM-0209	V3 achieved
	CM-0210	V3 achieved
	CM-0211	V3 achieved
PJ.10.02a2	CM-0209-b	V2 achieved
	CM-0210-b	V2 achieved

Figure 1 : List of OIs per maturity target

This version is the final V3 CBA issue and is developed to identify and agree on:

- the stakeholders who will incur costs related to the Solution
  - this is driven by the Enablers linked to the Solution OI Steps
- The scenarios, solution and reference, as defined in the VALP[12]
- which, if any, of the Solution benefits will be monetised
  - this is driven by the content of the Solution's Benefit and Impact Mechanisms, updated and reviewed while working on this issue
  - this will identify any data that needs to be captured from the V3 validation exercises to feed the V3 & V2 CBA model (to be developed in MS Excel)
- The cost approach and methodology applied for each stakeholders, proposed one being the same used for the previous issue of the CBA
  - Where applicable, the V3 & V2 exercise results to feed the V3 & V2 CBA model
  - The results analysis thanks to NEST simulations performed on the exercises results basis

Note : even if the title of the document explicitly stated V3, it is to be understood that it covers both V2 and V3 activities for solutions PJ.10.02a1 and PJ.10.02a2.

A particular attention is provided to clearly separate the V2 scope (PJ.10.02a2) from the V3 scope (PJ.10.02a1).

1.2 Key results

The improvement of ground trajectory prediction will benefit at the operational level for the identification of conflicts, and consequently will allow a reduction of ATC workload at that level. As explained in [10] (see §4.2), there is a direct relationship between the reduction of ATC workload and the resulting increase in the airspace capacity KPA. Therefore, the airspace capacity KPA benefit will be investigated in this CBA, for the ANSPs. A capacity increase will also result in a reduction of the ANS Cost Efficiency (for the ATCO employment), so this KPA will be also estimated.

For the Airspace Users (AU), another KPA likely to be impacted by PJ10.02A would be the fuel efficiency. This would result from an improved descent in TMA form the A U viewpoint, which would be made possible by the airborne Top of Descent being communicated to the ground via the EPP. This improvement is more futurist, and will be expected only in a longer term. Therefore, it has not been investigated in this document. Flight efficiency is addressed in the PAR ([18], §4.10.2), where an estimate of -1.1% for the route length has been estimated, in EXE003. This result is not used in the current document.

In summary, this CBA focuses on the sole Airspace capacity and Cost efficiency KPA. Two different operational environments are considered for these KPA, the Brest ACC and the Bulgarian en-route airspace. These two environments lead to specific NPV values (2024 for Brest ACC, and 2028 for the Bulgarian en-route airspace). In order to extrapolate to the ECAC area, we have considered a mix of these two environments, supposed to be representative of the global ECAC environment. For this mixed environment, only the payback period is estimated, which is the same as the payback period for the Brest ACC, 2024. Finally, NPV are computed locally (see results in §4.1) but not for the aggregated ECAC.

The methodology used for estimating the KPA is based upon the NEST EUROCONTROL tool. When using this tool, we could not estimate the KPA for an extrapolated traffic, because the results would have required a thorough modelling of the extrapolated operational environment (such as opening schemes, and the ability to accept higher traffic than the capacity). The resources for such an analysis was not available, so we had to estimate the KPA based on current traffic (for the year 2018).

The main recommendations are developed in Section 9 and we invite the reader to survey them.

2 Introduction

2.1 Purpose of the document

This document provides the Cost Benefit Analysis (CBA) for the **SESAR Solution PJ.10.02a – Improved Performance in Provision of Separation.** [1]

This version is the final V3 CBA issue and presents the scope of the solution with a particular focus on the split of the solution into two sub-solutions after the V2 Gate.

2.2 Scope

This document develops

- the scope of the V2 CBA for **SESAR Solution PJ.10.02a2 –** ***Improved performance in the provision of separation with use of ADS-C/EPP data***
- The scope of the V3 CBA for **SESAR Solution PJ.10.02a1** – ***Improved performance in the provision of separation without use of ADS-C/EPP data***

2.2.1 Common to both solutions

The CBA will cover the period from start of deployment of the Solution Enablers to 2035 (in line with available S2020 traffic and assumptions, namely the ***"STATFOR 2035 regulated growth" [22]***). The Net Present Value will be calculated back to 2019 (the end of Wave 1).

The stakeholders who need to invest are the ANSPs who provide the provision of separation management.

The benefits are received by ANSPs, Airspace Users and Network.

They mainly reflect the costs related to human performance (e.g. ATCOs assisted in their task) and avoided costs that would have been incurred if the conflict had not been detected and resolved and had resulted either in a costly change of trajectory (incurring additional workload at the flight deck) or in a loss of separation and associated risks, which are numerous and could lead to different event classifications: incident/serious incident/accident.

---

1 The opinions expressed herein reflect the author's view only. Under no circumstances shall the SESAR Joint Undertaking be responsible for any use that may be made of the information contained herein.

* based on DS20.

It is not uncommon for Loss of Separation (LOS) events to result in passengers and/or cabin crew being injured due to pilots' overreaction to TCAS RAs, which automatically classifies these events as 'accidents'.

2.2.2 Specific to PJ.10.02a1

The CBA Scenario will propose deployment of CD aids and MONA in En-Route and TMA ECAC airspace, based on both tactical and planning trajectories.

The improvement with a set of enhanced features, such as what-else, will be considered through this solution, as well as Free Route environment.

These enhanced tools comprise:

- Conflict detection and resolution set, based on improved ground trajectory prediction and enhanced resolution features.
- Conformance monitoring tool, based on improved ground trajectory prediction and enriched with additional alerts, such as rate monitoring.

Outstanding R&D needs to improve trajectory prediction to reduce the number of nuisance alerts and enhance the accuracy of conflict detections, are:

- A deeper focus on the use of improved separation management supporting tools/functionalities in **TMA airspace**
- Enhance **functionalities for CD/R tools** (e.g. : what if / what else probing)
- Enhance **functionalities for conformance tools**
- Use of **Mode S Data**

2.2.3 Specific to PJ.10.02a2

The CBA Scenario will propose deployment of CD aids and MONA in En-Route airspace, based on both tactical and planning trajectories.

The improvement with aircraft derived data (e.g.: ADS-C data) of the trajectory will be considered through this solution.

These enhanced tools comprise:

- Conflict detection and resolution set, based on improved trajectory prediction **through use of aircraft derived data: ADS-C/EPP.**
- Conformance monitoring tool, based on improved trajectory prediction **through use of aircraft derived data: ADS-C/EPP.**

Outstanding R&D needs to improve trajectory prediction to reduce the number of nuisance alerts and enhance the accuracy of conflict detections, are:

- The use of aircraft **ADS-C/EPP data** to enrich trajectory accuracy of ground systems with on-board information
- The use of additional data from ground to enrich trajectory information or tools accuracy

2.3 Intended readership

The intended readership for this document includes:

- PJ.10.02a partners.
- PJ.10 partners.
- PJ19 – who provide inputs such as the assumptions and who will consolidate the CBA results (where required by PJ20).
- PJ20 as Master Plan maintenance project.
- PJ06-01 and PJ18-06 partners, as dependencies exist between the solutions, especially regarding the V2 scope (PJ.10.02a2) for the latter.
- PJ.10.02b partners, as part of the recommendations for next steps could be addressed in the scope of this solution in SESAR 2020 Wave 2.
- SJU.

2.4 Structure of the document

The following sections of this document cover:

- Section 1 presents the Executive Summary for this CBA
- Section 2 provides a general introduction to the CBA document
- Section 3 describes the scope and objectives of the V2 CBA
- Sections 4 & 0 & 5 detail, respectively, the benefits and the costs
- Section 6 provides details of the CBA model
- Sections 7 and 8 provide, respectively, the CBA results and sensitivity analysis
- Section 9 provides recommendations and next steps

2.5 Background

This SESAR solution is in the continuity of SESAR1 projects P04.07.02 and P05.07.02, which each have produced BIMs: [17], [19] & [20]. In addition, the V2 activities, notably the BIM and CBA produced in the frame of this solution PJ.10.02a are used as input material.

SESAR1 V3 validated aspects (i.e.: Solution #27) are considered as the reference scenario in this CBA.

2.6 Glossary of terms

Term	Definition	Source of the definition
Business Case	A Business Case is a tool for decision-makers, it aims to provide them with the information they need to make a fully informed decision on whether funding should be provided and/or whether an investment should proceed. A Business Case is much more than just a financial analysis as it also includes quantitative and qualitative arguments on performance and transversal activities that are key to determining the value of the project.	*SESAR 1*
Controller Backbone	In the frame of this document, this term is equivalent, in NEST language, to the Controller Workload and is usually expressed in minutes	
Cost Benefit Analysis	A Cost Benefit Analysis is a process of quantifying in economic terms the costs and benefits of a project or a program over a certain period, and those of its alternatives (within the same period), in order to have a single scale of comparison for unbiased evaluation.	*SESAR 1*
IOC	Initial Operational Capability (start of benefits and benefit ramp-up period)	*SESAR 1*
NEST	*refer to §4.3.1 for details on NEST tool*	*EUROCONTROL*
Net Present Value	Net Present Value (NPV) is the sum of all discounted cash inflows and outflows during the time horizon period.	*Investopedia*
Opening Scheme	In the frame if this document, this term is equivalent, in NEST language, to the sectors configuration within an ATSU.	

Up to the backbone **Unlimited backbone**	In the frame of this document, these two expressions refer to NEST options for simulating opening schemes: • **Up to the backbone**: simulated opening schemes have to comply with the available staffing (backbone). E.G. : 20 available ATCOs • **Unlimited backbone**: simulated opening schemes are not complied to any staffing resource (so the simulated opening schemes may involve more resources than available)

2.7 List of Acronyms

Acronym	Definition
ACC	Area Control Centre
ADS-C	Automatic Dependent Surveillance-Contract
ANS	Air Navigation Service
ANSP	Air Navigation Service Provider
ATC	Air Traffic Control
ATCO	Air Traffic Controller
ATM	Air Traffic Management
ATN	Air Traffic Network
AU	Airspace User
BIM	Benefit Impact Mechanism
BULATSA	BULgarian Air Traffic Services Authority
CD/ R	Conflict Detection / Resolution
DSNA	Direction des Services de la Navigation Aérienne
EATMA	European ATM Architecture
EPP	Extended Projected Profile
FDP	Flight Data Processing
FOC	Full Operational Capability

IOC	Initial Operational Capability
ISA	Instantaneous Self Assessment
KPI	Key Performance Indicator
LLR	Low Level Requirement
LOS	Loss Of Separation
MET	Meteorology
MONA	Monitoring Aids
MTCD	Medium Term Conflict Detection
NEST	NEtwork STrategic modelling tool
NM	Network Manager
OE	Operational Environment
OI	Operational Improvement
PAR	Performance Assessment Report
PC	Planning Controller
PI	Performance Indicator
R&D	Research & Development
RBT / RMT	Reference Business / Mission Trajectory
(A-)RNP	(Advanced) Required Navigation Performance
SBT / SMT	Shared Business / MissionTrajectory
SESAR	Single European Sky ATM Research Programme
SJU	SESAR Joint Undertaking (Agency of the European Commission)
TC	Tactical Controller
TCAS RA	Traffic alert and Collision Avoidance System “Resolution Advisory”
TMA	Terminal Manoeuvring Area
XFL	eXit Flight Level

3 Objectives and scope of the CBA

3.1 Problem addressed by the solution PJ.10.02a

This CBA deals with benefits and costs related to the SESAR Solution **"Improved Performance in the Provision of Separation"**. This solution aims at assessing new and enhanced tools and services to improve the provision of separation task in En-route and TMA, in Free Route and Fixed Route, in classic organisation and new ones (ATCO team or airspace).

This CBA intends to expose the benefits expected as well as the costs to take into account per stakeholder and allows providing a complete and deeper analysis of the solution true benefits. The CBA will also include results of the exercises performed to enrich and complete this analysis with recommendations.

3.2 SESAR Solution description

The SESAR Solution **"Improved Performance in the Provision of Separation"** aims at improving the provision of separation in TMA and En-Route environments through the use of improved tools and aircraft derived data which allows predicting, with low uncertainty, the present and future aircraft positions.

After the V2 Gate, it has been stated in agreement with SJU to define two sub solutions, namely :

- PJ.10.02a1. This solution gathers the V3 part of the solution 10.02a.
- PJ.10.02a2. This solution gathers the V2 part of the solution 10.02a

PJ.10.02a1 aims at improving the separation in **the En-Route and TMA operational environments** through improved ground trajectory prediction. This is achieved using **existing information on lateral and vertical clearances that are known by the ground system and airborne information such as Mode S** data.

OI steps addressed by PJ.10.02a1: CM-0206, CM-0208-A, CM-0209, CM-0210 and CM-0211

PJ.10.02a2 aims at improving the separation in the **En-Route operational environment** through improved ground trajectory prediction. This is achieved using existing information on **lateral and vertical clearances that are known by ADS-C/EPP** airborne information.

OI steps addressed by PJ.10.02a2: CM-0209-b and CM-0210-b

This is the direct result of the expected maturity targets defined for the OIs and enablers part of the scope.

For details on each sub-solution, refer to §2.2.2 and §2.2.3

The maturity is expected V2 for PJ.10.02a2 and V3 for PJ.10.02a1. See Table 1 for details.

List of addressed OIs and enablers

The following OIs and required enablers, as in EATMA – DS20 draft reference, are listed in Table 1 (O in brackets means optional enabler):

SESAR Solution ID	OI Steps ref. (coming from the Integrated Roadmap)	OI Steps definition (coming from the Integrated Roadmap)	OI step coverage	Comments on the OI step title / definition
PJ.10.02a1	CM-0206	Conflict Detection and Resolution in the TMA using trajectory data	Full coverage	V3 maturity expected at the end of Wave 1.
	CM-0208-A	Automated Ground Based Flight Conformance Monitoring in the TMA in Step 1	Full coverage	
	CM-0209	Conflict Detection and Resolution in En-Route using enhanced ground predicted trajectory in Predefined and User Preferred Routes environments	Full coverage	
	CM-0210	Ground Based Flight Conformance Monitoring in En-Route using enhanced ground predicted trajectory	Full coverage	
	CM-0211	Advanced Support for Conflict Detection and Resolution for ATC planning in En Route	Full coverage	
PJ.10.02a2	CM-0209-b	Conflict Detection and Resolution in En-Route using aircraft data in Predefined and User Preferred Routes environments	Full coverage	V2 maturity expected at the end of Wave 1.
	CM-0210-b	Ground Based Flight Conformance Monitoring in En-Route using aircraft Data	Full coverage	

Table 1: SESAR Solution PJ.10.02a Scope and related OI steps.

A deep analysis of addressed enablers in the solution has been performed. As a result, an updated enablers list will be proposed for DS20 with some additions and removals.

Note: It is expected to finalise OI and EN content for DS20

SESAR Solution ID	SESAR Sub-Solution ID	Contribution to the SESAR Solution short description	OI Steps ref. (from EATMA)	Enablers ref. (from EATMA)
PJ.10-02a	PJ.10.02a1	PJ.10.02a1 aims at improving the provision of separation (tactical layer) in **TMA and En-Route environments with medium to high traffic density and complexity** through the **use** of **improved tools and enhanced trajectory (V3 scope)**. .	**CM-0206** Conflict Detection and Resolution in the TMA using trajectory data	**APP-ATC-155**
				A/C-37a
				ER-APP-ATC-82 (O)
				ER-APP-ATC-104 (O)
				ER-APP-ATC-104b (O)
			CM-0208-A Automated Ground Based Flight Conformance Monitoring in the TMA	**APP-ATC-168**
				ER-APP-ATC-104c (O)
				ER-APP-ATC-104d (O)
			CM-0209 Conflict Detection and Resolution in En-Route using enhanced ground predicted trajectory in Predefined and User Preferred Routes environments	**A/C-48a**
				ER-APP-ATC-104
				ER-APP-ATC-82 (O)
				ER-APP-ATC-160 (O)
			CM-0210 Ground Based Flight Conformance Monitoring in En-Route using enhanced ground predicted trajectory	**A/C-48a**
				CTE-S03b
				ER-APP-ATC-104c
				ER-APP-ATC-160 (O)

			CM-0211 Advanced support for conflict detection and resolution for ATC planning in En Route	**PRO-046b**
				ER-APP-ATC-82 (O)
				ER-ATC-57 (O)
	PJ.10.02a2	PJ.10.02a2 aims at improving the provision of separation (tactical layer) in **En-Route environments with medium to high traffic density and complexity** through the use of **improved tools and aircraft derived data** which allows predicting, with low uncertainty, the present and future aircraft positions .	**CM-0209-b** Conflict Detection and Resolution in En-Route using aircraft data in Predefined and User Preferred Routes environments	**A/C-37a**
				A/C-48a
				ER-APP-ATC-100
				ER-APP-ATC-104b
				ER-APP-ATC-82 (O)
				ER-APP-ATC-160 (O)
				ER-APP-ATC-149a (O)
			CM-0210-b Ground Based Flight Conformance Monitoring in En-Route using aircraft Data	**A/C-37a**
				A/C-48a
				CTE-S03b
				ER-APP-ATC-104d
				ER-APP-ATC-100 (O)
				ER-APP-ATC-160 (O)
				ER-APP-ATC-149a (O)

Table 2: OI steps and related System Enablers

3.3 Objectives of the CBA

The V3 CBA is to provide information on the costs and benefits of deploying Solutions PJ.10-02a1 & PJ.10-02a2 in an ECAC-level CBA Scenario. This assessment will help build the 'big picture' of whether the solutions are worth deploying or should be reviewed. While the views of individual stakeholders involved in the deployment are considered, this CBA task does not provide CBA results for specific local deployments.

This document develops the CBA structure and BIM models in order to identify what are the key areas where benefits and impacts are expected at both V2 and V3 concepts stage, in regards with each sub-solution.

These models have been used as inputs for the validation activities. The validations results have then been used to update consequently the CBA model. BIMs for AU and ANSP have been elaborated and can be found in [14]. Benefits are deemed negligible or indirect for Network, so no BIM is provided for this stakeholder.

PJ.10.02a1 & PJ.10.02a2 solutions focus mainly on safety, human performance, capacity, fuel efficiency, cost efficiency and predictability related benefits.

The main focus of the CBA model is to reflect the cost profile associated with the deployment over time of the solutions across the locations in the CBA Scenario.

Based on the results detailed in chapters 7 & 8, some recommendations have been made for the 2 solutions and detailed in chapter 9. These recommendations are to be considered when launching further activities (e.g.: next related activities in the frame of PJ.10.02b solution within Wave 2).

For reference, 1 contains the text from the Project Handbook [1] on the expectations for a V3 & V2 CBA as well as the relevant Maturity Assessment Criteria [21] against which the CBA will be assessed at the V3 Maturity Gate.

3.4 Stakeholders identification

Sources used to identify the stakeholders were the:

- Enablers – assigned stakeholders in DS20 draft
- Expert Judgement (for Network stakeholder)

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 ANS & TMA ANS Medium to High Complexity	Invest on material and training to take benefit of assistance in operations : separation provision	ANSP have provided inputs, models proposals based on their experience and contributed to cross-reviews	Yes
Network	N/A	Benefit from improved local efficiency of the network use through separation provision, with direct effect on traffic flows (smoother	Network has provided thorough review in En-Route aspect	No quantitative results available, however some qualitative

		management, less delays) and flight trajectory predictability (improved thanks to better accuracy and capability to provide highest adherence)		assessment was possible
All Airspace Users [2], including General Aviation and Military Activities	All AU flying in controlled area.	Take benefit of more efficiency in separation management, allowing them to flight closer to their business trajectory, with lower deltas and delays	AU will be involved at the end of the validation phase, to review all results, including impacts and benefits	No results quantitative nor qualitative results available as this stakeholder was not addressed in the V2 activities. It is expected to address it in V3 activities notably through the use of ADS-C/EPP

Table 3: SESAR Solution PJ 10.02a - CBA Stakeholders and impacts

3.5 CBA Scenarios & Assumptions

This section describes the scenarios that will be compared in the CBA. The minimum is a CBA scenario that reflects the delta (difference) between the Reference scenario (where the Solution is not deployed) and the Solution scenario (reflecting the proposed deployment of the Solution at applicable locations across ECAC). The scenarios are based on the common assumptions and scenarios of the programme as well as those considered in the Validation Plan [12]. Any deviations from those assumptions or scenarios would be explained and justified, where applicable.

3.5.1 Reference Scenario

The Reference Scenario is taken from the work presented in VALP [12].

The Reference Scenario considers the present situation, with a partial development of the solution:

- CD/R aid and MONA tools based on tactical trajectory, are deployed in this category of ANS:

[2] *It has been considered that all Airspace Users could benefit from this solution, as it impacts the separation provision efficiency and management and is therefore likely to impact any aircraft type and category. Military Traffic is assumed to be handled as General Aviation traffic for this solution*

- En-route sector-based airspace

- CD/R aid and MONA tools, based on tactical trajectory are not deployed in this category of ANS
  - In TMA airspace
- CD/R aid and MONA tools, based on planning and coordination trajectory are partially deployed in ANS.
- In the tools currently deployed, there is no special focus on direct route nor free route airspace.
- In addition, there is no use of aircraft derived data in the trajectory used to support the currently deployed tools.

3.5.2 Solution Scenario

In blue are highlighted the part addressed for PJ.10.02a1 solution (V3 scope)

In purple are highlighted the part addressed for PJ.10.02a2 solution (V2 scope)

In blank, the part is addressed for both solutions

What is to be deployed

The next steps to define the deployment locations and timing for PJ.10.02a include:

- Further assessment of the benefit of the CD/R aid services (MTCD and what-if) for the PC based on planning trajectory developed in SESAR 1, including predefined and user preferred route high complexity environments; **[ER-ATC-157b]**
- Increased performance of separation management supporting tools and functionalities by improving the trajectory prediction and monitoring aids through new data (ADS-C/EPP) in order to reduce missed and false alerts; **[ER-APP-ATC-104b, ER-APP-ATC-104d & A/C-37a]**
- Sharing of resolution tasks between PC and TC (thanks to better reliability of the mid-term detection); **[ER-APP-ATC-104]**
- Validating the CD/R aid tools/functionalities to TC based on tactical trajectory in different operational environments (including En-route and TMA). **[APP-ATC-155]**

Inter-dependency with other solutions to be considered in the CBA are

- With PJ18-06 for the 2nd item described above, in regards with the development and use of enablers ER-APP-ATC-100, ER-APP-ATC-104b & ER-APP-ATC-104d.
- With PJ06.01 for the 1st item described above, in regards with related requirements for free route airspace implementation. The two solutions leaders are both from DSNA and are therefore able to share easily their respective work, notably safety and performance requirements described in OSED documents and ensure consistency.

Time-Horizon of the CBA

The solution is expected to be deployed as follows:

- For PJ.10.02a1 (Low to High Complexity) : IOC 31/12/2026 & FOC 31/12/2030
- In link with this solution, the related PJ18-06 enablers ER-APP-ATC-104 & ER-APP-ATC-104c are expected at V3 maturity at 09/12/2019 with IOC on 09/12/2026 (this is in line with this solution time horizon)
- In link with this solution, PJ06.01 dates are : IOC 31/12/2026 & FOC 31/12/2030, also in line with the solution time horizon.

- For PJ.10.02a2 (Low to High Complexity) : IOC 31/12/2029 & FOC 31/12/2033
- In link with this solution, the related PJ18-06 enablers ER-APP-ATC-104b & ER-APP-ATC-104d are expected at V3 maturity at 30/12/2022 with IOC on 30/12/2029 (this is in line with this solution time horizon)

Geographical Scope

The main differences with reference scenario are:

- Enhanced CD/R aids and MONA, based on planning trajectory, in TMA and En-Route environments (Low to High Complexity), on the basis that CD/R aids & MONA are already deployed
- The deployment of CD/R aid and MONA, based on tactical trajectory in TMA environment (Low to Very High Complexity).
- The deployment of CD/R aids and MONA, based on enriched trajectory with aircraft data in En-Route environment (Low to High Complexity)

Discount Rate

Discount Rates for this solution is considered in line with the Common Assumptions in [7], i.e.:

"A discount rate, agreed amongst the stakeholders, of 8% was used for all stakeholders segments in the NPV calculation."

Traffic Evolution

In this CBA we did not consider the traffic evolution. Our rationale for doing so is explained in §4.3.2, in summary this choice results from our use of the NEST tool, and the methodology that we designed, which is based on past traffic.

Scenario feature		Source
ECAC traffic	ECAC traffic considered in this CBA is past traffic.	

Equipage rate	ER-APP-ATC-104 [b, c & d]	All aircraft are equipped with Mode S	From V2 Datapack
	A/C-37a	ATN B2 equipage is included as an assumption with a value of 40% by 2026	From V2 Datapack[12]

Table 4: SESAR Solution PJ.10.02a CBA Solution Scenario

4 Benefits

In this section we firstly present a synthesis of the monetized benefits (in §4.1) and in the sequel (§4.2 to §4.3) we explain in detail how these monetized benefits have been estimated.

4.1 Synthesis of monetized benefits

When estimating the KPA we have not made use of the PAR document ([18]) . We have only performed a local estimation, for each operational environment. The validation targets of the PAR could have been used for assessing the KPA globally, at the ECAC level. This work has not been done, due to a lack of resource, and also to the late delivery of the PAR with regards to the deadline of the CBA.

The KPA where benefits are monetized are Capacity (due to a workload reduction) and Cost Efficiency (for the ANS, due to a reduction of the ATCO resource following the capacity increase). These two KPA have been estimated with the use of NEST for two different operational environments:

- Brest ACC;
- Bulgaria en-route airspace.

As explained later (see 4.3.2), estimating these KPAs for extrapolated traffic would have required a thorough support from operational experts of these two environments in order to properly model the NEST parameters. These resources were not available, so it was decided to rather use rather past traffic.

The values of these KPA are provided below, for these two operational environments.

Performance Framework KPA[3]	Focus Area	KPI/PI from the Performance Framework	Unit	Metric for the CBA
Cost Efficiency	ANS Cost efficiency	ATCO employment Cost change (Brest ACC)	M€/year	-0.33
		ATCO employment Cost change (Bugaria en-route airspace)	M€/year	-0.12
Capacity	En-route Airspace capacity	Strategic delay cost (avoided-; additional +) (Brest ACC)	M€/year	-2.45
		Strategic delay cost (avoided-; additional +) (Bugaria en-route airspace)	M€/year	0

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

Table 5: Results of the benefits monetisation per KPA

In the sequel of this section, we explain in detail how these benefits have been assessed.

4.2 Estimation of the main benefit (capacity increase)

We use the same methodology as the one which was implemented for the V2 CBA (see [6]). The main benefit to be monetized is a capacity increase, which results from a workload reduction. PJ.10.02a is rather extensive, with seven ANSPs having conducted seven different exercises, with dedicated improvement for each of them.

We have focused on exercises for which a capacity increase had been tested, and we have retained the following two :

- **PJ.10.02a1** :
    - EXE001, where DSNA tested a new MTCD algorithm with a net workload decrease due to innovative working methods;
- **PJ.10.02a2** :
    - EXE007, where BULATSA implemented ADS-C/EPP in their ATC tools, with a workload decrease mainly observed in TMA.

** EXE 007 covers both solutions. However, in the frame of this CBA we will only study the ADS-C/EPP related part.*

These two exercises are representative of the workload reductions which were observed during the different exercises.

We recall (see [6]) that the capacity increase is estimated from the workload decrease, using the formula

$$\text{Increase in En Route Airspace capacity (\%)} = \left(\frac{1}{1 - \frac{\text{Workload Reduction (\%)}}{2}} - 1 \right) \times 100$$

4.2.1 PJ.10.02a1 - Estimation of the capacity increase for EXE 001

The DSNA EXE001 tested an innovative MTCD algorithm, where a large amount of MTCD alarms where inhibited. These alarms correspond to incoming aircraft whose Exit Flight Level (XFL) differ from the Entry Flight Level, and are due to a trajectory prediction which adds a vertical evolution till the XFL. These alarms do not correspond to actual conflicts, since the incoming aircraft has not been yet cleared to its XFL. It was felt that these alarms induced an unnecessary workload, so these alarms were inhibited during the exercise. However, Tactical Controllers were instructed to systematically use the "What If" ATC tool before issuing a clearance, so as to double check that the clearance was conflict free.

The Validation Report for PJ.10.02a ([16], §A3.2.2 for the workload and §A3.3.2 for the capacity) gives quantitative assessment of the capacity increase, from the workload reduction. Workload reduction has been assessed using three performance indicators (Bedford, ISA and IAM), leading to the following result on capacity:

SCENARIO	Bedford	ISA *(normalized scores)*	AIM *(normalized scores)*	Overall WL Average	Workload reduction (vs. REF)	Capacity increase

SOL	4,75	4,84	4,06	**4,55**	**1,2%**	**0,6%**
REF	4,88	4,74	4,19	**4,60**		

Other indicators, based on situational awareness (China Lakes, Sasha), lead to the following results:

SCENARIO	China Lakes	SASHA *(normalized scores)*	Overall SA Average	Overall WL *(cf. previous table)*	Efficiency *(= SA/WL)*	Efficiency increase *(vs. REF)*	Capacity increase
SOL	7,63	6,91	7,27	4,55	**1,60**	**14%**	**7,8%**
REF	6,5	6,35	6,35	4,60	**1,40**		

The validation report also provides subjective assessment of a "potential capacity increase", which is the MACE test (however this test is qualitative) and estimates the potential increase at 15.6%.

The 15.6% increase seems overly optimistic if we compare it with the 0.6% and the 7.8% increase provided by the quantitative indicators above, so we chose not to consider it. The two values of 0.6% and 7.8% rely upon two complementary modelling of the controller workload, so we chose to average them, in order to estimate a more reliable capacity increase, **leading to a 4% increase.**

PJ.10.02a1 EXE001 was performed on a limited subset of the Brest ACC, but if the enhanced MTCD was to be implemented it would be on the en-route part of the whole ACC, which is shown on Figure 2.

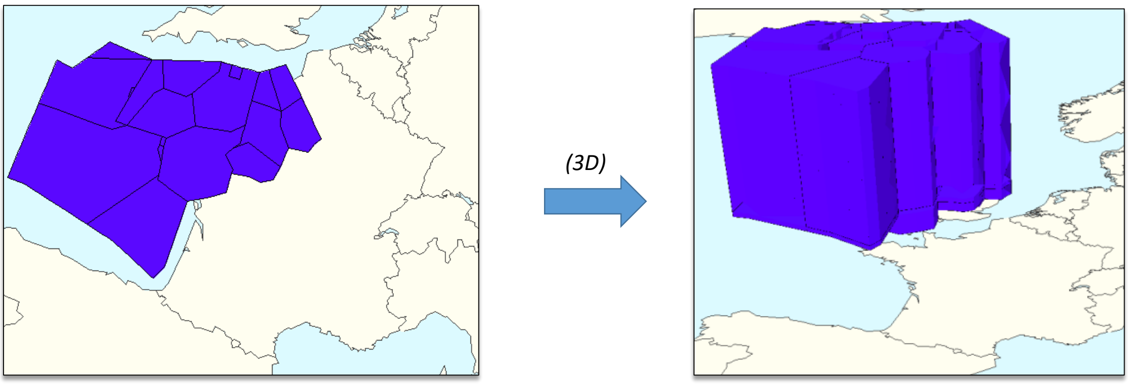


Figure 2: Sectors selected for Brest FIR

4.2.2 PJ.10.02a2 - Estimation of the capacity increase for BULATSA

For the V2 results of EXE007, we see that the workload for TMA controller shows significant reduction, while the workload for en-route controller is not so apparent. It is interesting to note that the same pattern could be observed for V3 results (without ADS-C/EPP).

The detailed percentage change in the workload for TMA controllers is shown in the following table reproduced from the Validation Report ([16]):

	TMA	
Workload	**TC**	**PC**
Bedford questionnaire	-22.22%	-11.76%
Radio Telephony logs	-8.70%	
ISA (Instantaneous Self-Assessment)	-17.65%	-13.24%

** All radio telephony is performed by the TC. That's the reason why there is no data for the PC.*
***All negative values represent reduction of the workload. Positive numbers show increase of the workload*

The detailed percentage change in the workload for en-route controllers is shown in the following table reproduced from the Validation Report:

	ENR	
Workload	**TC**	**PC**
Bedford questionnaire	7.69%	-17.65%
Radio Telephony logs	6.90%	
ISA (Instantaneous Self-Assessment)	15.27%	7.89%

** All radio telephony is performed by the TC. That's the reason why there is no data for the PC.*
***All negative values represent reduction of the workload. Positive numbers show increase of the workload.*

As a consequence, it would be logical to retain a capacity increase only for the TMA. This capacity increase in TMA, results from a workload decrease. Based on the previous Tables, we can fix **a global value of a 12% workload decrease[4], leading to a capacity increase of 6%,** applying the Equation at the end of §4.2.

This capacity increase would only hold for the TMA, and not for the en-route. So the solution scenario is the one where the three TMAs of Bulgaria (Sofia, Varna and Burgas) would have a capacity increase of 6%. These three TMAs are referenced in NEST as LBSFTA (Sofia), LBBGTA (Burgas) and LBWNTA (VARNA), they are shown in Figure 3.

[4] This is an estimation done with Bulatsa team, based on results. The value provided here is a rough average, reviewed by their ops expertise, from their different measures

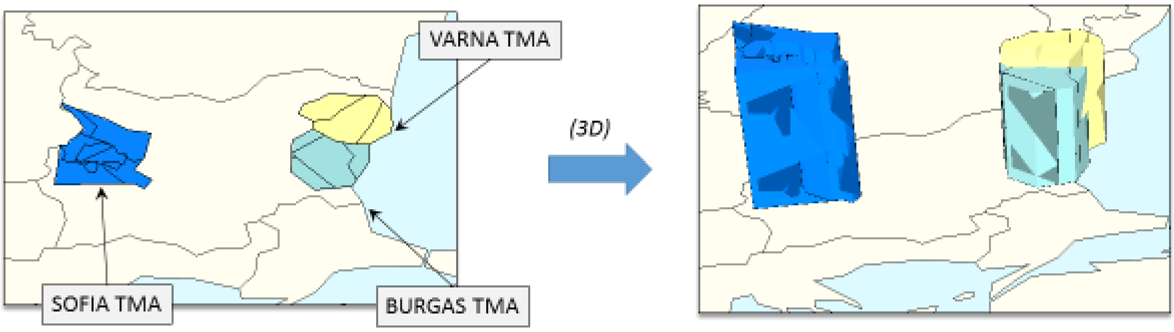


Figure 3 : TMA for BULATSA Exercise

However, we found out that it was not possible to estimate a benefit using NEST, due to the two following factors:

- Bulgaria has zero delay (this will be developed later on);
- The NEST toolkit, that we used, is mostly an en-route simulator, and does not allow to simulate controller workload reduction in TMA.

For these reasons, **we decided to model a compromise with, as a solution scenario, a 6% capacity increase overall the whole en-route airspace of Bulgaria**. This assumption leads to over-estimate the benefits, but this CBA is a V2 (for PJ.10.02a2 scope), and it is reasonable to assume that, in V3, the real implementation would also lead to quantitative benefits in the en-route as well.

In conclusion, we simulated the reference scenario (capacities equal to actual ones) and the solution scenario (capacities increased by 6%) overall the two ACCs of Bulgaria referenced in NEST, which are LBSRCTAS (for Sofia) and LBSTCTAV (for Varna). These two ACCs cover the overall airspace of Bulgaria, as shown in Figure 4.

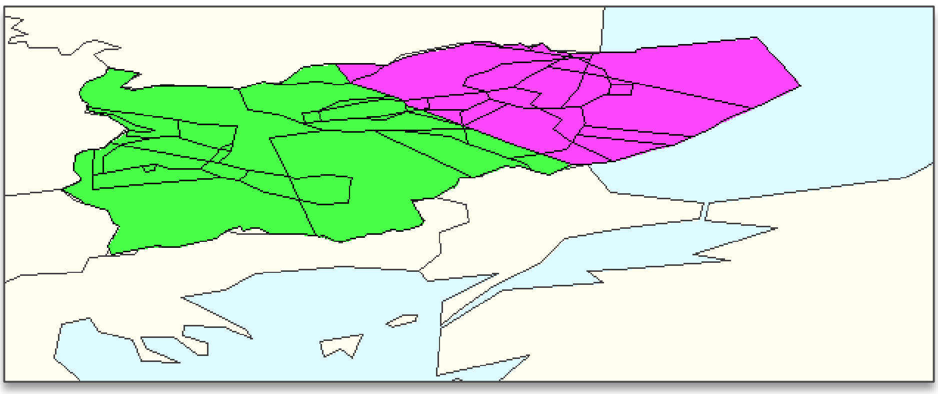


Figure 4 : Bulgaria ACCs

4.3 Use of the EUROCONTROL NEST tool

4.3.1 Introduction to NEST

The estimation of the monetarized benefit from the capacity increase has been done using the EUROCONTROL NEST tool that we briefly introduce.

NEST is a tool designed by EUROCONTROL, which enables to process data from the EUROCONTROL Demand Data Repository (DDR, see https://www.eurocontrol.int/ddr). From these data, it is possible to play and get insight on all traffic for any airspace in Europe, since 2012 till today. The added benefit of NEST is that it allows to simulate a wide range of “modifications” from the past traffic, such as:

- Modifying routes;
- Modifying sectors;
- Modifying capacities;
- And so on.

The general pattern for simulating with NEST is captured through the following sequence of steps that the NEST user may configure. Data are stored as AIRAC cycles, which have a 28 days duration. Once an AIRAC cycle has been selected & loaded by the user, the simulation can include the following steps (see Figure 5):

1. Traffic forecast: It is possible to extrapolate some traffic at a future time, based on an assumed rate of increase of the traffic;
2. Trajectory: it is possible to simulate different scenarios of rerouting (due to military activation, or exclusion area);
3. Opening schemes: different options exist, depending on the use of the controllers (unlimited, etc.);
4. Regulations: Once the opening schemes have been set, regulations are simulated in order to comply with the maximum capacity for the sectors. A percentage of traffic overload can be set, which will inhibit the creation of new regulations when the traffic demand does not exceed the capacity by more than this overload.
5. Delays: once the regulations have been established, the delay is estimated, by applying an algorithm similar to the one used by the NM (CASA).

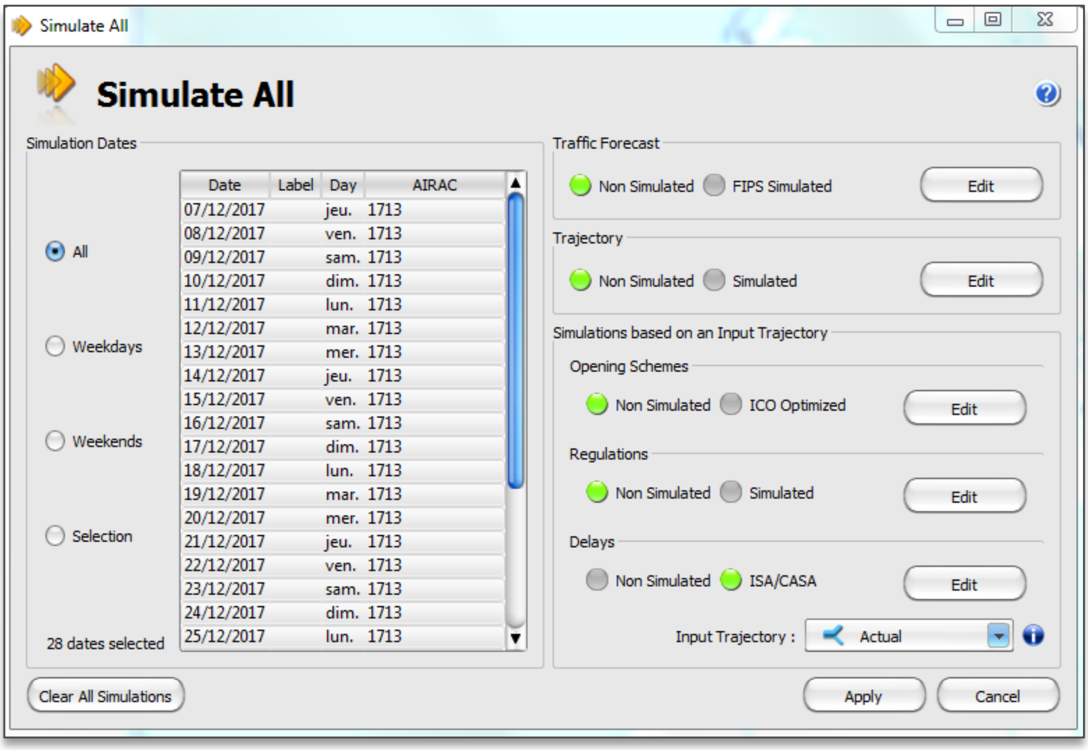


Figure 5 : NEST Options Screen

The NEST tool is fairly complex and requires some time before grasping the underlying logic. For our use, we need to simulate a capacity increase over some part of the European airspace, and to assess the resulting ATFM delays and controller working hours. We have spent some time using NEST, both for the V2 CBA ([6]) and this document, and we eventually found a way to address our need, that we explain in the next subsection.

4.3.2 Determination of a methodology for applying NEST according to our needs

In our case, we are supposed to estimate benefits for the whole duration between the IOC and the FOC, so we should extrapolate the traffic (step 1). We have no need to consider alternative rerouting, so step 2 can be discarded. The remaining steps (3 to 5) are necessary for estimating the delays and the controller working hours.

In our first attempt to use NEST (during the CBA V2, see [6] §5.2.1), when performing the traffic extrapolation (step 1), we found that the sole extrapolation of traffic with traffic increment would also require additional modelling(e.g. re-sectoring, new opening schemes and so on). This use of NEST would have required a detailed analysis with experts form the ACC, which was too complex to do regarding the deadline and the work duration of the CBA. Besides the added value of such a specific study at V3 stage, where our increase estimation of capacity is still based on rough figures, would not be so significant.

We decided then to skip the traffic extrapolation step, and to solely rely on past traffic. So, we would limit ourselves to steps 3 to 5. The traffic data that we have retained for this CBA encompasses five

AIRAC cycles, of 28 days each, from the end of 2017 till the near end of 2018. The magnitude of delays varies significantly with the period of the year, so we have selected five AIRAC cycles so as to represent different yearly events (vacations, feasts, and so on), as shown in Table 6.

AIRAC cycle	Starts	Day at mid Cycle	Ends
A1811	11/10/2018	24/10/2018	07/11/2018
A1808	19/07/2018	01/08/2018	15/08/2018
A1805	26/04/2018	09/05/2018	23/05/2018
A1803	01/03/2018	14/03/2018	28/03/2018
A1713	07/12/2017	20/12/2017	03/01/2018

Table 6 : AIRAC Cycles selected for our NEST Simulations

We received support from a EUROCONTROL NEST expert (Stephanie Vincent, Head of the Ops Performance Plan in EUROCONTROL), which was kind enough to review our computations, and suggest parameter tuning when needed.

The estimation of the benefits is done in terms of **ATFM delay reduction, and controller working hour (denoted in NEST as the Controller Backbone) reduction**. NEST gives access to both actual and simulated data, so we had to decide which kind of data is best suited to our need. We ended up with the following approach:

1. Simulate both a reference and a solution scenario based on initial demand traffic, and estimate a percentage of reduction between the reference and the solution;
2. Apply this percentage to the actual data (delay or controller working hour).

When performing step 2, an additional difficulty was to estimate a yearly result. Here, we benefited from the expertise of the EUROCONTROL expert Stephanie Vincent, which investigated delays statistics on the EUROCONTROL Network Manager Interactive Reporting (NMIR) from EUROCONTROL Web Site (see https://www.eurocontrol.int/dashboard/network-manager-interactive-reporting-dashboard). This helped to retain the AIRAC cycles which were deemed most representative for extrapolating on a yearly basis.

4.4 Estimation of the delay benefits

4.4.1 Estimation of the delay benefits for Bulgaria

We start with Bulgaria, which is the simplest case since no delay was actually reported by Bulgaria not only in 2018 but also since 2014 (see Ref [23], Annex 2 §7). So the delay benefit for Bulgaria is null.

4.4.2 Estimation of the delay benefits for Brest ACC

As for the simulations of the reference and the solution scenarios, we need to account for the specificities of the ACC. Brest ACC is known to accept slight excesses of traffic demand, so the modelling of regulations needs to account for a traffic overload tolerance, which was fixed at 10%. As for the simulation of opening schemes, we made a first attempt without simulating them, but this resulted in an excess of delays, so we eventually decided to simulate them, but with unlimited controller work force. This choice allowed NEST to retain the opening schemes offering the best capacity, when coping with excess traffic demand.

Figure 6 illustrates the result of our simulation for all five AIRAC cycles of Brest ACC, where we estimated:

1. The actual delays for the reference scenario (Reference actual);
2. The simulated delays for the reference scenario (Reference simu);
3. The simulated delays for the solution scenario, with a 4% capacity increase (or 6% increase depending to the solution observed) (Solution Simu).

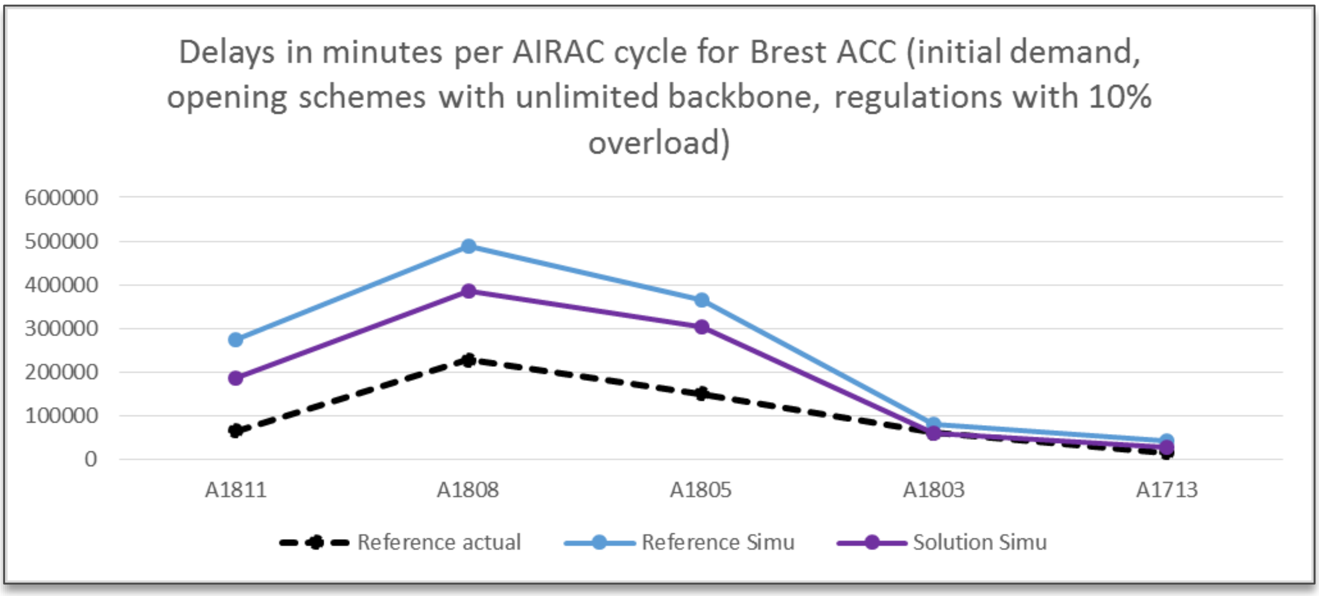


Figure 6 : NEST Simulations results in curves for Delays – Brest ACC

We recall (see Table 6) that AIRAC cycle A1808 corresponds to summer holidays, AIRAC cycle A1713 corresponds to the Christmas period, and the three remaining cycles account for other periods in the year. When investigating delay statistics using the NMIR, it was found that the best AIRAC cycles for extrapolating on a yearly 2018 were AIRAC 1803, 1805 and 1808, with the following weighting:

$$3 \times A1808 + 4 \times A1805 + 5 \times A1803 \quad \textbf{Eq. 2}$$

The final results are shown in Table 7. Equation 2 was used for performing a yearly estimate (bottom array of Table 7). We see that the **percentage of ATFM delay reduction** between the reference and the solution scenario is **-19.6%.**

	Delay (minutes)			
AIRAC Cycle	Reference actual	Reference Simu	Solution Simu	Percentage of reduction
A1811	64464	272200	185401	**31.9%**
A1808	227565	487043	383894	**21.2%**
A1805	149799	364773	303851	**16.7%**
A1803	60092	78580	59631	**24.1%**
A1713	14121	42169	27183	**35.5%**

Yearly Estimate	Reference Simu	Solution Simu	Percentage of reduction
2018	3313121	2665241	**-19.6%**

Table 7 : NEST Simulations Results for Delays - Brest ACC

We now detail how the yearly estimate of actual delays was made. NEST provides such an estimate, but a more refined data source is provided by the NMIR, which also provides the sources of the delays. This part of the work was done by EUROCONTROL. We illustrate in Table 8 the monthly estimates for year 2018, together with the non ATM causes (which are the industrial and the equipment causes). These “non ATM causes” delays were not taken into account in our study. We end up with a final estimate of 880450 minutes. We notice that these delays mostly occur in summer (64% of them take place between June and August).

Finally, the delay reduction corresponds to 19.6% of 880450 minutes, which is 172172 minutes.

Month	Regulation Area	Airspace Stat Au	Airport Delay	ER Delay	I - Industrial Action (ATC)	T - Equipment (ATC)
2018-01	BREST ACC	LFRRACC	1229	6139	0	447
2018-02	BREST ACC	LFRRACC	157	4802	0	0
2018-03	BREST ACC	LFRRACC	36	59887	29911	1144
2018-04	BREST ACC	LFRRACC	140	52825	0	4078
2018-05	BREST ACC	LFRRACC	915	139509	56962	815
2018-06	BREST ACC	LFRRACC	1218	199090	1836	35889
2018-07	BREST ACC	LFRRACC	901	263477	0	2099
2018-08	BREST ACC	LFRRACC	118	140135	0	0
2018-09	BREST ACC	LFRRACC	732	55493	0	0
2018-10	BREST ACC	LFRRACC	644	70555	0	153
2018-11	BREST ACC	LFRRACC	1337	11232	0	139
2018-12	BREST ACC	LFRRACC	4852	25640	14618	243

Delays without Industrial Actions and Equipment		
2018-01	5692	0.65%
2018-02	4802	0.55%
2018-03	28832	3.27%
2018-04	48747	5.54%
2018-05	81732	9.28%
2018-06	161365	18.33%
2018-07	261378	29.69%
2018-08	140135	15.92%
2018-09	55493	6.30%
2018-10	70402	8.00%
2018-11	11093	1.26%
2018-12	10779	1.22%
Total	**880450**	**100.00%**

Table 8 : Monthly estimates year 2018 for ATFM Delays – Brest ACC

4.5 Estimation of the controller backbone benefits

4.5.1 Estimation of the controller backbone benefit for Brest ACC

The estimation is made according to the two steps introduced in §4.3.2: firstly we determine a percentage of deduction between the simulated solution and reference scenario, and secondly we apply this percentage to the actual controller backbone. These two steps are illustrated in Table 9 below. The estimation of yearly data is made using Equation 2.

	Controller backbone (hours)			
AIRAC Cycle	Reference actual	Reference Simu	Solution Simu	Percentage of reduction
A1811	13440.00	17616.00	17070.00	**3.1%**
A1808	14629.00	19350.00	18744.00	**3.1%**
A1805	13028.00	17365.00	16918.00	**2.6%**
A1803	11673.00	15297.00	14688.00	**4.0%**
A1713	11749.00	14253.00	13731.00	**3.7%**

Yearly Estimate	Yearly Controller backbone (hours)	Reference Simu	Solution Simu	Percentage of reduction
2018	154364	203995	197344	**-3.3%**

Yearly Controller backbone benefit (hours)	**-5033**

Table 9 : NEST Simulations Results for ATCO Backbone – Brest ACC

4.5.2 Estimation of the controller backbone benefit for Bulgaria

When using NEST, we limited ourselves to the simulation of opening schemes, since we are not interested in simulating delays but only the controller working hours. Since there is no delay, we found out that it was necessary to check the option “full capacity” in the options for the opening scheme simulation, together with the option “Allow up to backbone”.

In order to estimate yearly values from the AIRAC cycles, we applied the following weighting for the AIRAC cycles (we recall that AIRAC cycle A1808 corresponds to summer holidays, AIRAC cycle A1713 corresponds to the Christmas period, and the three remaining cycles account for other periods in the year):

$$A1713 + 2 \times A1808 + 3 \times (A1803 + A1805 + A1811) \quad \textbf{Eq. 1}$$

We still proceed in two steps (percentage of reduction in the first step, and actual controller backbone estimate in the second step). Table 10 illustrates our results.

	Controller backbone (hours)			
AIRAC Cycle	Reference actual	Reference Simu	Solution Simu	Percentage of reduction
A1811	5696.00	4836.00	4664.00	**3.6%**
A1808	7162.00	6478.00	6226.00	**3.9%**
A1805	5301.00	4804.00	4654.00	**3.1%**
A1803	4481.00	3918.00	3795.00	**3.1%**
A1713	4513.00	3827.00	3678.00	**3.9%**

Yearly Estimate	Yearly Controller backbone (hours)	Reference Simu	Solution Simu	Percentage of reduction
2018	**65271**	**57457**	**55469**	**3.4%**

benefit (hours)	**2237**

Table 10 : NEST Simulations results in figures for ATCO Backbone – Bulgaria ACC

The associated diagram is shown in Figure 7.

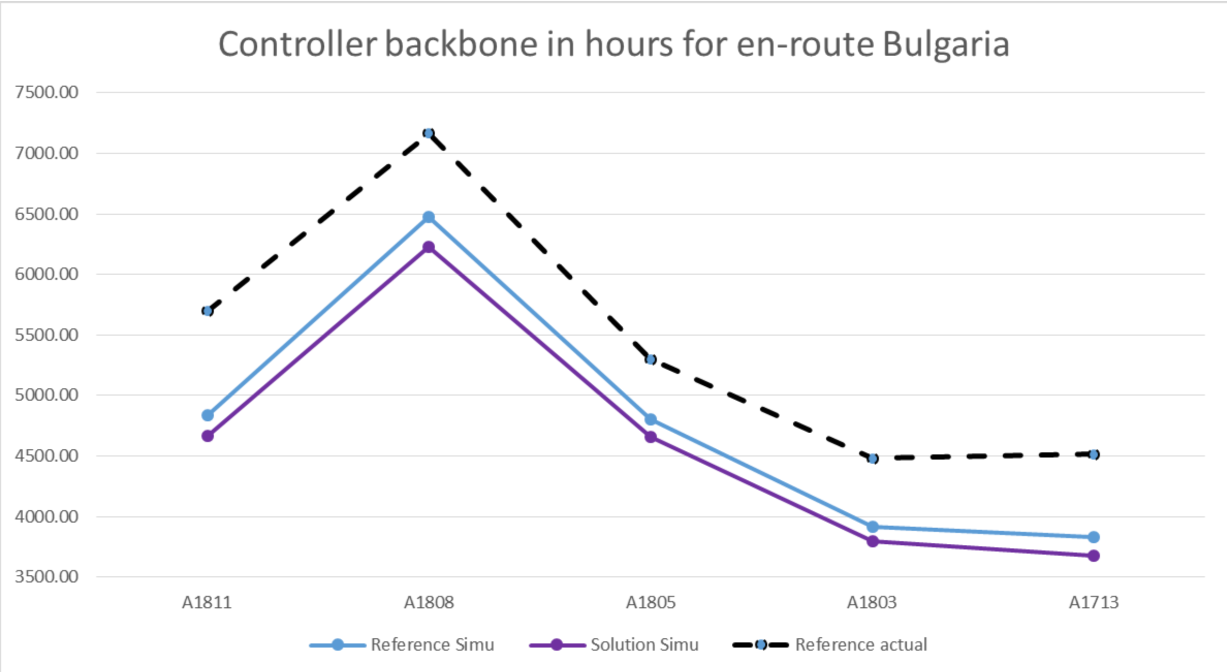


Figure 7 : NEST Simulations results in curves for ATCO Backbone – Bulgaria ACC

5 Cost assessment

We propose to re-use same approach and methodology developed at V2 stage.

The same approach will be used for the two sub-solutions

Methodology is detailed hereafter.

This section details the costs identified, the assumptions and the proposed approach used for the cost analysis, **per identified stakeholder.**

The methodology applied to write this section is in line with the proposed approach provided in the Guideline [3].

As a reminder: it is important to keep in mind that we evaluate ONLY the deltas induced by this solution. The Reference scenario (see §3.5.1) is assumed to be deployed. Therefore, CD/R tools and services are already deployed and partially FASTI compliant depending on local implementations. This cost assessment will take this in consideration and provides a cost evaluation depending on the initial status of the tool / service (i.e. : not deployed / deployed).

5.1 Cost Assessment methodology

5.1.1 Cost decomposition

The main difficulty for performing the cost analysis is that, in the V2 or V3 phases, the Solutions have not been implemented, so we have to somehow “imagine” the costs of products which do not yet exist. In order to do so, we have considered the software development process from the V2 baseline, and we have assessed costs for all the development steps.

Note : we could have considered from V3 baseline for PJ.10.02a2, however as R&D costs up to V3 are not to be considered, this was not relevant, hence the choice to consider from V2 baseline, so an identical baseline for the two sub-solutions to ease our cost assessment.

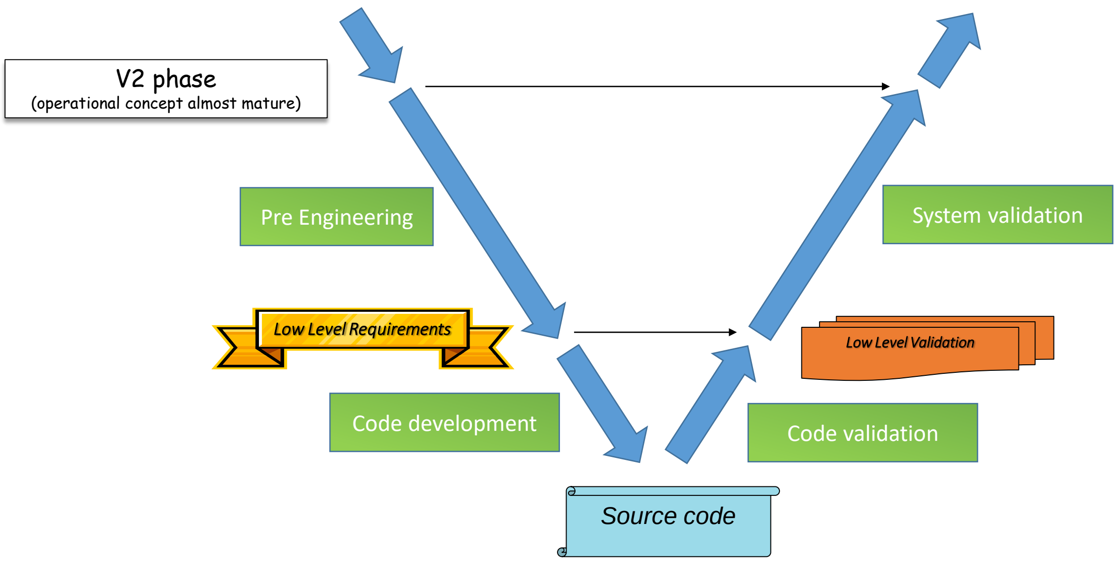


Figure 8 – V-cycle for tool development with main phases

The process that we have considered is illustrated in Figure 8, it relies upon the following assumptions:

- The code development for PJ.10.02a can be assumed to be limited to an individual software component, rather than a whole software architecture;
- Therefore the software development activity is composed of Low Level Requirements (LLR), which will be directly developed into source Code;
- The requirements are expressed at a sufficiently low level for allowing a code development duration expressed in terms of man day per requirement (typically, between 5 and 8 days per requirement);
- Before deriving the low level requirements, it is necessary that the operational experts and the software developers meet, in order to make sure that the operational need is properly captured. This preliminary activity is denoted in Figure 8 as ***Pre Engineering***, it aims at finalizing the validation of the operational concept.
- The code validation activity is made exclusively by the provider.
- The system validation will require to identify scenarios of test, and to check the validity of the software on these scenarios. The system validation also includes the integration and deployment phases to check the compliant integration of the updated or new tool in the existing system and that is operational and correctly deployed on-site.

The activities to be performed are the green boxes in Figure 8. The cost assessment will be performed firstly in terms of work duration per activity and per worker, and secondly converted into financial cost. These costs are ANSP costs, even if some activities are performed by a provider. We now provide additional insight on each activity.

The Pre Engineering is typically made of brainstorming sessions, where operational experts and code developers exchange their views on possible software implementation. Depending on the complexity of the task, this activity may take one of the two following forms:

- If the software implementation is not too complex, paperwork may be sufficient;
- In the other case (if the V2 prototype was not mature enough), additional prototyping may be necessary, for instance for clarifying dataset issues (definition of dataset parameters, dataset tuning, and so on).

This activity involves both ANSP operational experts and code developers supplied by the provider.

The definition of Low Level Requirements, the code development and code validation are mainly performed by the provider, the costs (expressed in terms of work duration) linearly depend on the number of LLR (each LLR has a fixed work duration, and a fixed Code development/validation duration work).

For simple cases, the System validation may be limited to defining and testing scenarios of test. For more complex ATC tools, it may also comprise the definition and tuning of datasets.

In addition to these activities, we need to add:

- An Overall Management Task which comprises all transverse activities (such as progress meetings, peer reviews, and reviews at several levels: set up, design and conformity);
- The safety activities;
- The training activities.

5.1.2 Implicit assumption

In addition to the assumptions presented above, our methodology relies upon on an additional assumption: **the supplier and the ANSP are assumed to negotiate the cost of the tool at the level of the development process.**

So the cost of the additional required tools has been evaluated in a similar way that we would do our best cost estimate before launching a call for tender. Those best estimated costs would be used to judge the offers. Costs resulting from the tender may be lower (if the supplier may find other customers for the product) or higher (we may have underestimated the work to be done to reach a robust industrial product).

5.2 ANSPs costs

The ANSPs costs presented below are detailed in the Excel spreadsheets of subsections 6.2 and 6.3 (sheet “COSTS ESTIMATION”).

Following the guidance, the costs can be refined into three categories.

1. **Pre-Implementation Costs**: all costs that need to be used up to define the needs, to develop solutions (R&D), to decide which solution best serves the needs.

An important note in that respect is that the SESAR R&D costs (up to V3) should not be included as costs in any SESAR CBA. The CBA should be focussed on deployment, i.e. what the stakeholders will pay to put the solution in place.

2. **Implementation costs**: all costs related to the acquisition and implementation of the solutions.
3. **Operating costs**: all costs related to the change in daily operations that is brought about by the solution.

At this stage, the following costs have been identified, at ANSP level

Cost category	Sub-categories
Pre-Implementation Costs	Concept definition review, with a panel of experts to identify the potential lacks and specificities needed for a given system Concept definition completion, where applicable *(this item will not be evaluated as considered optional)*
Implementation costs	**One-Off costs**: installation costs, including coding, testing until Deployment, Validation & Certification costs, Initial Training costs, Project Management costs, Administrative costs **Capital Costs** (evaluated for one ACC): equipment, hardware, licence, physical integration costs **Transition Costs** Optional: Airspace design & Procedures *(this item will not be evaluated as considered optional)*
Operating costs	**Personal & Training,** **Maintenance & Repair** **Facility Costs** **Administration Costs**

Table 11 : Cost categories

5.2.1 ANSPs cost approach

The costs have been deduced from past and similar experiences on ATM tools and systems' evolutions and provided in this document per sub-solution.

One major issue when evaluating costs is the difficulty to remain sufficiently general to englobe most of the situations (e.g.: each ANSP has its own way of managing costs) and sufficiently detailed to provide accurate data and give a rough but good idea of the implementing costs.

To avoid as much as possible this bias, all ANSPs partner of the solutions PJ.10.02a1 & PJ.10.02.a2 have been involved to perform the cost evaluation.

5.2.2 ANSPs cost assumptions

Assumptions on metrics used

In order to evaluate costs ranges, one metric could be defined as the number of requirements, so as to evaluate the size of the evolution and ease the comparison with a similar one performed on existing tools.

However, from DSNA expertise, the granularity of the requirements used to evaluate the cost of an evolution might differ significantly from one project to another. It could then be higher or lower than the one known to date and used in this analysis (i.e.: from OSED and TS). It has then been assumed that **a requirement in this document** "costs" is between 1 to 5 man.days for implementation (installation costs only).

Assumptions on scope

It has been assumed that the same costs applied for each ANSP for easier computation. However, values have been evaluated between a minimum and a maximum and only the maximum value has been used for NPV

5.2.3 Number of investment instances (units)

PJ.10.02a1 is applicable to any TMA or ACC environment in Europe, whatever its category is. **Although it is assumed more useful in H and M environments (based on exercises results – see also VALR [16])**.

PJ.10.02a2 is applicable to any En-route ACC environment in Europe, whatever its category is. Although it is assumed more useful in H and M environments, as for PJ.10.02a1 (same reference for exercises results details)

5.2.4 Cost per unit

In the frame of this solution, the costs per ECAC unit are deemed identical. A service will be implemented in its full scope or will not be. Therefore, whatever the ECAC category, the costs should not vary significantly.

On the contrary, one key factor has a significant influence on costs: the initial status of the tool / service, in extenso, if the tool or service is already deployed and operational or not.

In the first case, the impact induced by this solution would be similar as a major evolution, while in the second case, the impact is much more significant to consider.

Refer to CBA models (chapter 6 for details on costs)

5.3 Network costs

The main investments have to be expected at local ANSP level, to upgrade existing systems and tools and deploy brand new one.

There should be low or negligible cost effort at Network level.

Therefore, the Network costs are not considered.

5.3.1 Network Manager cost approach

To reach the conclusion written above, expert judgement has been used from ECTL members (namely Stephen Morton).

To evaluate the effort, new ATM systems (such as 4-Flight, SYSAT) set in place by DSNA have been used as examples. Those systems have not induced specific costs at NM level. Given their nature and importance, it is likely that evolutions induced by this solution should remain local and not impact NM systems and costs.

5.4 Airspace User costs

The main investments have to be expected at local ANSP level, to upgrade existing systems and tools and deploy brand new one.

At AU level, the aircraft should be equipped with ADS-C/EPP enabler systems but it is deemed included in the aircraft price, with no direct impact on the cost.

Therefore, the AU costs are not considered.

5.4.1 Airspace User cost approach

To reach the conclusion written above, expert judgement has been used from industrial partners, including aircraft manufacturers (Airbus).

To evaluate the effort, new on-board systems including a connection to the ground have been used as examples. Those systems have not impacted the overall price of an aircraft, usually counter-balanced by other improvements. Therefore, the AU should not been impacted significantly by this solution per se.

6 CBA Model

The following excel files include the cost estimation, the benefit estimation and the balance between benefit and costs.

6.1 Data sources

As explained in previous chapter, costs considered for this solution are ANSP's costs. Therefore, the main source used to fill the CBA model comes from the ANSPs involved in this solution, based on their past experiences on similar tools or services deployment.

However, all partners of the solution have been reviewer and able to provide additional inputs whenever applicable.

6.2 CBA Model for PJ.10.02a1 Solution

This CBA Model has been elaborated based on data from EXE 001

CBA PJ10_01A.xlsx

6.3 CBA Model for PJ.10.02a2 Solution

This CBA Model has been elaborated based on data from EXE 007

CBA Model
D1.2.120 - Final CBA

6.4 Mixed Model for PJ.10.02a level

This CBA Model is mixed, computed based on the two previous models to provide a wider view of both costs and benefits and limit bias of collecting data from a unique source. This mixed model is the ne which will be used for the aggregated ECAC, when estimating the payback period.

CBA Model
D1.2.120 - Final CBA

7 CBA Results

See the CBA models embedded in previous chapter for details on results computation.

7.1 PJ.10.02a1 Solution

Below are the main results.

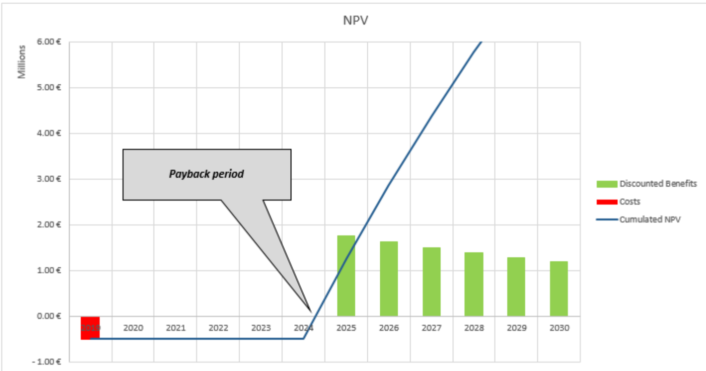
When looking at the Table above, we see that the yearly benefits (27801882,82€) are more than five times higher than the overall cost (500182,82€). The rationale for this can be found in the "Cost and Benefits" sheet, where we notice that the ATFM delay reduction represents most of this massive benefit. As stated earlier, the ATFM delay reduction is estimated at almost 20% per year which leads to a very high benefit.

As a conclusion, the payback period is reached very soon, at the first trimester of 2025, as shown in the chart.

It is likely that the benefits estimation is overestimated, though it clearly shows a very high added-value for this solution.

As in V2 CBA, we decided to take the max value for the cost and the min value for the benefit, due to:
The supplier cost being potentially under estimated
The gain of ATFM delay is very important and even if endorsed by NEST Team, we prefer to remain in the pessimistic scenario

Year	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Year index	0	1	2	3	4	5	6	7	8	9	10	11
Discount rate	100.00%	92.59%	85.73%	79.38%	73.50%	68.06%	63.02%	58.35%	54.03%	50.02%	46.32%	42.89%
Costs	-500 181.82 €	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €
Benefits	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	2 780 188.82 €	2 780 188.82 €	2 780 188.82 €	2 780 188.82 €	2 780 188.82 €	2 780 188.82 €
Discounted Benefits	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	1 751 990.55 €	1 622 213.47 €	1 502 049.51 €	1 390 786.58 €	1 287 765.36 €	1 192 375.33 €
Cumulated discounted benefits	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	1 751 990.55 €	3 374 204.02 €	4 876 253.53 €	6 267 040.12 €	7 554 805.48 €	8 747 180.80 €
Cumulated NPV	-500 181.82 €	-500 181.82 €	-500 181.82 €	-500 181.82 €	-500 181.82 €	-500 181.82 €	1 251 808.73 €	2 874 022.20 €	4 376 071.72 €	5 766 858.30 €	7 054 623.66 €	8 246 998.99 €
Payback period	2024											



7.2 PJ.10.02a2 Solution

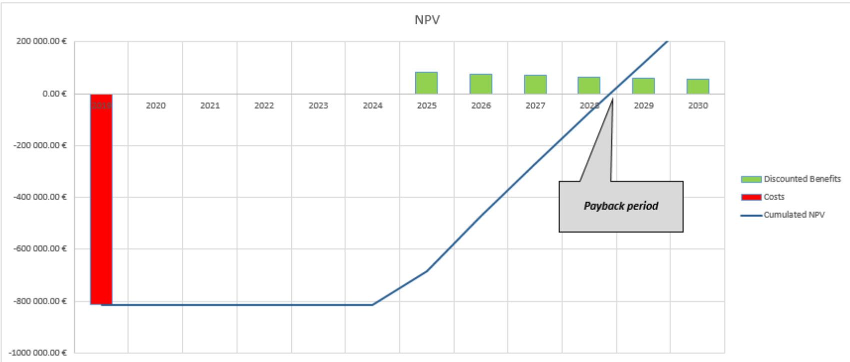
Below are the main results.

We can see here that benefits compensate the investments (made in our NPV in 2019) 4 years after the entry into service (set beginning of 2025).

This is especially due to the fact that the considered investment is expected higher than for PJ.10.02a1 solution with benefits significantly low due to the fact that on the tested area, there were no registered ATFM delays, so no potential gain.

Given that the costs estimation seems overestimated and the benefit on this area are only linked to ATCO backbone, for extrapolation' sake, we deem it more representative to keep in this case max values for benefits and min value for costs

Year	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Year index	0	1	2	3	4	5	6	7	8	9	10	11
Discount rate	100.00%	92.59%	85.73%	79.38%	73.50%	68.06%	63.02%	58.35%	54.03%	50.02%	46.32%	42.89%
Costs	-814 545.45 €	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €
Benefits	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	128 919.84 €	128 919.84 €	128 919.84 €	128 919.84 €	128 919.84 €	128 919.84 €
Discounted Benefits	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	81 241.36 €	75 223.49 €	69 651.38 €	64 492.01 €	59 714.83 €	55 291.51 €
Cumulated discounted benefits	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	0.00 €	128 919.84 €	210 161.20 €	204 143.32 €	198 571.21 €	193 411.85 €	188 634.66 €
Cumulated NPV	-814 545.45 €	-814 545.45 €	-814 545.45 €	-814 545.45 €	-814 545.45 €	-814 545.45 €	-685 625.62 €	-475 464.42 €	-271 321.10 €	-72 749.89 €	120 661.96 €	309 296.63 €
Payback period	2028											



7.3 Mixed model

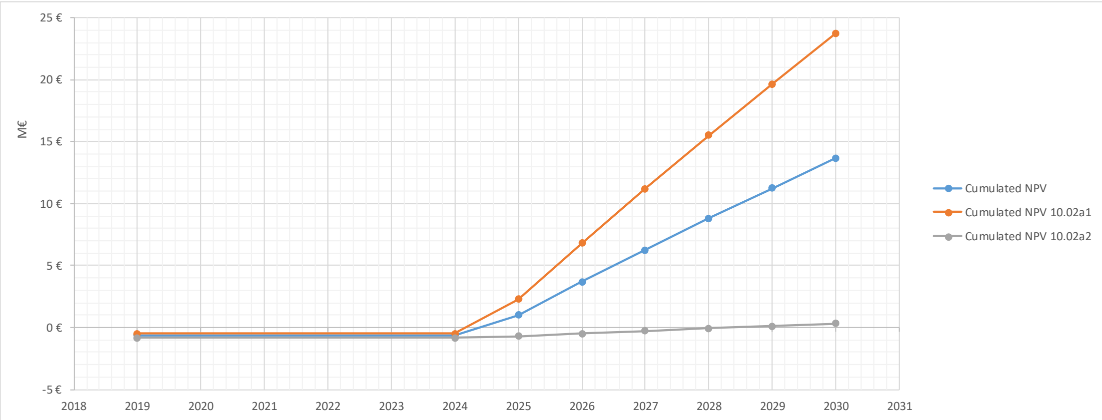
Below are the main results, computed based on average of previous models.

This is interesting to allow a wider view of the costs and the benefits and avoid a bias by observing a given area or taking into account ACC cost inputs of one area.

The NPV is provided with NPV for PJ.10.02a1 and PJ.10.02a2 to ease comparison.

This is a mixed model. We used average value from Bulatsa exercise and average value from DSNA exercise to determine the min and max values. From these, we computed an average costs and benefits, retained for the NPV computation.

Year	2019	2024	2025	2026	2027	2028	2029	2030
Year index	0	5	6	7	8	9	10	11
Discount rate	1	68,06%	63,02%	58,35%	54,03%	50,02%	46,32%	42,89%
Costs	638 181,82 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €
Benefits	0,00 €	0,00 €	1 640 192,50 €	1 640 192,50 €	1 640 192,50 €	1 640 192,50 €	1 640 192,50 €	1 640 192,50 €
Discounted Benefits	0,00 €	0,00 €	1 033 599,50 €	957 036,57 €	886 144,97 €	820 504,60 €	759 726,49 €	703 450,45 €
Cumulated discounted benefits	0,00 €	0,00 €	1 640 192,50 €	2 673 792,00 €	2 597 229,07 €	2 526 337,47 €	2 460 697,10 €	2 399 918,99 €
Cumulated NPV	-638 181,82 €	-638 181,82 €	1 002 010,68 €	3 675 802,68 €	6 273 031,75 €	8 799 369,22 €	11 260 066,32 €	13 659 985,31 €
Cumulated NPV 10.02a1	-500 181,82 €	-500 181,82 €	2 280 007,00 €	6 812 186,37 €	11 214 588,66 €	15 496 826,99 €	19 667 802,39 €	23 735 756,57 €
Cumulated NPV 10.02a2	-814 545,45 €	-814 545,45 €	-685 625,62 €	-475 464,42 €	-271 321,10 €	-72 749,89 €	120 661,96 €	309 296,63 €



On first approach, the NPV for PJ.10.02a2 seems underestimated as the delta from the average is important, and this will probably need to be refined through V3 activities and additional development and evaluations. It is very likely that the results are biased by the lack of ATFM delay gain, as this is probably where the solution can provide the more important benefits.

The payback period is roughly similar to the one for Brest ACC. This “mixed” payback period is the one which estimates the payback period for the aggregate ECAC.

8 Sensitivity and risk analysis

8.1 Level of confidence

The results of the exercises seemed sufficiently reliable to be quite confident on the analysis conducted in this CBA regarding gain in capacity and monetisation. Moreover, the gain (+4%) for solution PJ.10.02a1 is really consistent with the gain estimated in V2 CBA in 2018.

From the results and the maximum costs to perform the NPV, we can consider it as a good and realistic basis.

It is however interesting to keep in mind that **an increase of the benefit, notably taking into account the ATFM delay reduction,** could quickly lead to very high discrepancies in a few years, as shown in previous chapters.

The results presented in this document have been transferred to NEST expert and reprocessed after counter-analysis and refinement. Given that we have been close to NEST staff to perform this CBA and especially the second trials of simulations presented here, we can be quite confident with the results and we can confirm the solutions could be expected to be highly efficient.

9 Recommendations and next steps

9.1 Common

The current analysis showed **clear benefits to ANSPs** based on the capacity increase and ANSP (ATCO backbone) levels, with however **an expected initial investment quite important for ANSP**.

With these results, it appears that both **solutions provide concrete benefits for ANSP in an environment with part of the tools deployed, as detailed in our reference scenarios**.

At AU & Network levels, the solutions are considered most profitable given that no major cost are foreseen and that both should benefit from the capacity increase.

9.2 Specific PJ.10.02a1

The expected investment is very low compared to the expected benefit especially linked to ATFM delay reduction.

Indeed, expected benefit is estimated more than 100% of the initial investment which permits to reach a positive NPV Value within a year.

9.3 Specific PJ.10.02a2

The expected investment is considered more important here, given the costs to refine features to handle the ADS-C/EPP aspect.

However, the benefits are expected very significant, actually more important than the PJ.10.02a1 solution if we compare rough data (4% vs 6% of capacity increase).

In our results, benefits appear clearly less important than for PJ.10.02a1 but, given that we rely on the sole ATCO backbone in the case of PJ.10.02a2, it is probably a biased result. However, even with this only benefit, the solution is profitable after only 4 years in service.

In addition, this solution is at V2 maturity, meaning that we may overestimate the costs given that there are still some development needs at R&D Level.

It will also be interesting to perform tests within area for which ATFM delay are observed and estimate the potential for reduction which would then increase the benefits.

In summary, the potential to reach a positive NPV within a year is likely, bringing thus this solution to more added value than presented in this document, and potentially higher than the PJ.10.02a1.

A last point to keep in mind is that the cost estimation did not consider the costs associated to the transmission of EPP data through ADS-C. We have limited ourselves to the sole development costs.

9.4 Recommendations for next steps

9.4.1 Specific PJ.10.02a1

Based on the analysis through the quantitative data that were missing from previous CBA and that have been provided for this new thread of exercises, it is possible to conclude that this solution brings important benefits for a reasonable investment costs and has reach V3 maturity.

The conclusion from the VALR goes in the same direction regarding the maturity level. Extract from VALR [16] :

> *"Based on the obtained results, it can be concluded that the improved separation management tools/functionalities can work coherently together and are capable of delivering the required benefits. Nevertheless, in order to reach their full potential and to integrate them successfully into the target ATM, detailed analysis of the existing operational settings and accordingly tools' parameters adjustment is required"*

9.4.2 Specific PJ.10.02a2

Based on the analysis provided, it is reasonable to conduct V3 activities for this solution, which seems already promising in terms of benefits vs costs.

The conclusion from the VALR goes in the same direction regarding the maturity level. Extract from VALR [16]:

> *"The concept was operationally validated in TMA and in en-route environment. The conclusions on the performance, operability, technical feasibility and acceptability of the concept were drawn out based on the results obtained through real-time simulations and indicated readiness of the MTCD enhanced with ADS-C/EPP data to move to V3 maturity phase."*

In order to provide and complete the CBA analysis, the few following elements are to keep in mind for V3 activities:

- Cost estimation should be refined after more research and knowledge, especially on the needs to handle ADS-C/EPP data
- PJ18-06 CBA would be needed to complete the overview for this solution and estimates real costs. It is indeed possible that in our analysis, some costs have been counted twice or some R&D costs have been introduced unwillingly
- Activities should be set for environment with ATFM delays to estimate the reduction even if NEST tool has a tendency to overestimate the gain in money.

9.4.3 Common

A set of recommendations has been provided regarding the integration of the tools in the ATM system. They are available in the VALR [16], §5.2.1. They concern especially the validation activities and technical fields and are less relevant at CBA level. That is why we have not listed them in this document, though they are very important at solution level.

The following suggested enhancements, however, valid for both solutions, could enable a higher degree of realism in future validation activities and in the CBA analysis, increasing the level of confidence of the overall study.

They have been extracted from VALR [16] and summarized hereafter:

- a **greater number of runs** (and traffic sample) would preserve the validity and confidence level of human performance and **KPA measures**, as the participants would not be over-exposed to the same conditions and callsigns.

- **More realistic traffic runs**, with more variability and covering a wider range of situations would help consolidating the resulting KPAs and provide relevant measures. This could be achieve through, e.g. :

  - more variability in scenarios and more variability (e.g. not only one traffic peak) during run. In addition, scenarios should include sufficient conflict situations to be able to validate separation management supporting tools adequately.

  - better aircraft performance would improve the realism of validation

  - more non-nominal situations in the traffic scenarios including adverse MET conditions, runway changes or TSA activation, and partial tool failure

- **Reduced bias in the simulation** results would also contribute to consolidate the overall CBA analysis. This could be achieved through, e.g. :

  - appropriate training and exposure of the controllers to the new system functionalities leading to better understanding, which influences greatly the trust in the new functionalities and has an effective impact on the workload controller and capacity, main KPA used in our analysis.

  - a greater number of controllers with a wider range of experience levels would be preferable and would generate more reliable data.

- **Involvement of Airspace Users** in future validation and deployment activities would provide an increase awareness of the improved separation management supporting tools from the cockpit side, completing the benefits for all stakeholders. This is even more true for the PJ.10.02a2 solution.

9.5 Recommendations for updating ATM Master Plan Level 2

Extract from VALR [16]

As already, explained in previous sections, the solution addresses improved separation management supporting tools/functionalities both with (V2 maturity level) and without (V3 maturity level) use of ADS-C/EPP. Therefore, two change requests (CR3390 and 3391) are under review on Mega to officialise this split.

Two solutions resulting from this split are:

- Solution PJ.10-02a1 – Improved performance in the provision of separation without use of ADS-C/EPP data, addressing CM-0206, CM-0208-A, CM-0209, CM-0210 and CM-0211 at V3 maturity level; and
- Solution PJ.10-02a2 – Improved performance in the provision of separation with use of ADS-C/EPP data, addressing CM-0209-b and CM-0210-b at V2 maturity level.

10 References and Applicable Documents

10.1 Applicable Documents

[1] SESAR 2020 Project Handbook

[2] SESAR 16.06.06-D26_04, Guidelines for Producing Benefit and Impact Mechanisms, Edition 03.00.01

[3] SESAR 16.06.06-D26_03, Methods to Assess Costs and Monetise Benefits for CBAs, Edition 00.02.02

[4] Challenges of Growth 2018, Task4: European Air Traffic in 2035, EUROCONTROL Network Manager

[5] Standard Inputs for EUROCONTROL Cost-Benefit Analyses, Edition 8.0, January 2018

[6] SESAR Solution PJ.10.02a: Cost Benefit Analysis (CBA) for V2, July 2018

10.2 Reference Documents

[7] Common assumptions for CBAs as maintained by Pj19 (provisionally the ones included in the 16.06.06- D68_Part 1, New CBA Model and Methods 2015, Edition 00.01.01 can be used)

[8] SESAR C.02-D110, Updated D02 after MP Campaign, Edition 00.01.00

[9] SESAR 2020 D108, Transition Performance Framework, Edition 00.06.00

[10] SESAR 2020 D86, Guidance on KPIs and Data Collection – Support to SESAR2020 transition

[11] https://www.eurocontrol.int/sites/default/files/publication/files/standard-input-for-eurocontrol-cost-benefit-analyses-2015.pdf or later version applicable for SESAR 2020

[12]SESAR Solution 10-02a: Initial Validation Plan (VALP) for V3 - Part I - Edition 00.01.00, 29th March 2019

[13]SESAR Solution 10-02a: Initial Validation Plan (VALP) for V3 - Part IV - Human Performance Assessment Plan, Edition 00.01.00, 29th March 2019

[14]SESAR Solution 10-02a SPR INTEROP OSED for V3, *Edition : Draft – February 2019*

[15]SESAR Solution 10-02a : Validation Report (VALR) for V2, Edition : v00.01.02, 26th November 2018

[16]SESAR Solution 10-02a : Validation Report (VALR) for V3, Edition : v00.00.05, 2nd August 2019 *Draft Edition – Handover expected 16th August 2019*

[17]P04.07.02 – Validation Report_4 / Appendix 1, Edition 00.02.00

[18]SESAR Solution 10-02A Performance Assessment Report (PAR) for V3, Edition: 00.01.02, 16th September 2019

[19]P05.07.02 - HD HC Multi Airport TMA-V2b Validation Report VP740-VP743 / Appendix D, Edition 00.01.01

[20] P05.07.02 - MD MC Multi Airport TMA-V2b Validation Report VP738-VP741 / Chapter 2, Edition 00.01.01

[21] SESAR 2020, Maturity Assessment Tool 2020, Edition 1.2

[22] European ATM Master Plan – Edition 2015

[23] Network Operations Report 2018, available at (https://www.eurocontrol.int/publication/annual-network-operations-report-2018)

11 Appendix

A. Mapping between ATM Master Plan Performance Ambition KPAs and SESAR 2020 Performance Framework KPAs, Focus Areas and KPIs, source reference [9]

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

ATM Master Plan SESAR Performance Ambition KPA	**ATM Master Plan SESAR Performance Ambition KPI**	**Performance Framework KPA**	**Focus Area**	**#KPI / (#PI) / <Design goal>**	**KPI definition**
Operational Efficiency	PA5 - Arrival predictability: 2 minute time window for 70% of flights actually arriving at gate		Variance of actual and reference business trajectories	PRD1	Variance of differences between actual and flight plan or Reference Business Trajectory (RBT) durations
	PA2 - 3-6% reduction in flight time	Environment	Fuel efficiency	(FEFF3)	Reduction in average flight duration
	PA3 - 5-10% reduction in fuel burn			FEFF1	Average fuel burn per flight
Environment	PA8 - 5-10% reduction in CO_2 emissions			(FEFF2)	CO_2 Emissions
Safety	PA9 - Safety improvement by a factor 3-4	Safety	Accidents/incidents with ATM contribution	<SAF1> see section 3.4	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

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
				(SEC4)	Military mission effectiveness risk after mitigation

Table 12: Mapping between ATM Master Plan Performance Ambition KPAs and SESAR 2020 Performance Framework KPAs, Focus Areas and KPIs

B.

The SESAR 2020 Handbook [1], section 5.2 (CBA methods and practices overview), page 84, states that:

In **V2**, the feasibility phase, the CBA assesses the economic feasibility of the solution(s) and can help to compare different alternatives e.g. a system implemented with a centralised or local backups or whether a solution is deployed everywhere or only in most complex environments. In this phase there is a quantitative assessment of both costs and benefits (i.e. the performance assessment) of SESAR Solutions. In areas such as safety, security, environment and human performance the benefits are assessed only qualitatively but the costs (e.g. to implement associated requirements) need to be monetised. Critical variables to the economic value of the solution(s) are identified and recommendations for further research to reduce critical uncertainties and improve quality of inputs are made for V3. In V2, the output should already include a first order of magnitude of benefits and net present value (NPV) of the different options being compared.
The final R&D CBA is developed in **V3** and should include all the evidence gathered in terms of impacts, benefits and costs of a solution. By V3, the CBA should provide the NPV overall and per stakeholder group, a sensitivity analysis identifying most critical variables to the value of the project, a risk analysis, the CBA model, report and recommendations

The Maturity Assessment Criteria [21] against which the CBA will be assessed at the Maturity Gate is PER V2.7 at V2 stage & PER.V3.7:

PER V2.7 Has a V2 CBA been developed and documented following PJ19 Reference Material? It shall include: (1) CBA scenarios and impact on different stakeholders (2) monetisation of deployment costs to the different stakeholders possibly in Low-High ranges (3) monetisation of benefits using the validation results for the different KPAs possibly in Low-High ranges (4) sensitivity analysis identifying the most critical variables and uncertainties for further analysis (5) recommendations on whether it's economically worthwhile for this solution to move to V3 including options and scenarios to include in the validation, uncertainties, benefit and cost variables on which to focus future validation activities. If CBAs have already been developed for this solution (or parts of this solution) traceability to these CBAs (including the outline CBA in V1) should also be part of this Preliminary CBA. (Validation exercises provide the evidence needed for a building a credible CBA)
PER V3.7 Has a Final R&D Cost Benefit Analysis CBA) been produced following PJ19 Reference Material? *Validation exercises provide the evidence needed for a building a credible CBA*

Sub-criterias *Has a Cost Benefit Analysis, refining previous CBAs (Outline CBA, Preliminary CBA of that solution or other relevant CBAs) with recommendations for deployment been produced?* *Does the CBA include more robust benefit estimates relying on validation results, detailed deployment scenarios, more robust deployment costs and identifying financial risks such as for example long pay back periods, uneven distribution of costs and benefits between different stakeholders ? (These may lead to financial recommendations on incentives and regulation)* *Does the CBA cover the different operating environments proposed for the solution? If the solution is proposed for the whole network, is the CBA applicable to the whole network?*

-END OF DOCUMENT-