INDUSTRIAL RESEARCH

SESAR SOLUTION PJ07-W2-40: COST BENEFIT ANALYSIS (CBA) FOR V3

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OPTIMISED AIRSPACE USER OPERATIONS

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Abstract

This document provides the V3 Cost Benefit Analysis (CBA) for SESAR Solution PJ.07-W2-40: **Initial 4D Mission Trajectory development with integrated DMA types 1 and 2 supported by automation and dynamic civil-military CDM**. The Solution involves the deployment of the following Operational Improvement Steps: AOM-0208-B, AOM-0304-B, AUO-0210 and AUO-0216. This V3 CBA estimates costs and benefits of a potential deployment of Solution PJ.07-W2-40 in en-route airspace across ECAC.

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1 Executive Summary

This report provides the V3 Cost Benefit Analysis (CBA) for SESAR Solution **PJ.07-W2-40: Initial 4D Mission Trajectory development with integrated DMA types 1 and 2 supported by automation and dynamic civil-military CDM (Collaborative Decision Making)**.

This V3 CBA estimates costs and benefits of a potential deployment of Solution PJ.07-W2-40 at relevant locations across ECAC[1]. This involves the Operational Improvement Steps: AOM-0208-B, AOM-0304-B, AUO-0210 and AUO-0216.

The PJ.07-W2-40 Solution has developed processes, procedures and tools to enable CDM between the Military and Civil stakeholders to negotiate DMA type 1 and type 2 airspace reservation (ARES) requests so that they meet the Military mission needs while minimising the impact on civil traffic. The Solution is applied in the planning phase and includes relevant local level actors.

The benefits expected from executing the negotiated plan are an **increase in en-route airspace capacity** (with no detrimental impact on safety), a **reduction in fuel burn and CO_2 emissions** and **improvements in time efficiency and predictability**[2]. In addition, Military operations will not be negatively impacted.

The CBA benefit inputs are based on the validation results consolidated in the Final Wave 2 Performance Assessment Report [14].

The deployment of PJ.07-W2-40 will require the following stakeholders to invest:

- **Civil and Military ANSPs** handling traffic in Very High, High and Medium complexity En-route Area Control Centres (ACCs).
- **Military Airspace Users (Ground)** who need to equip their Wing Operation Centres (WOC) to allow them to coordinate their airspace reservations (ARES) through the CDM process.
- The **Network Manager (NM)** so that mission trajectory data including ARES is available and shared between actors.

No deployment is required for civil or military airspace users (i.e. no airborne enablers) or for civil airspace users at their Flight Operation Centres.

These V3 results are based on the assumptions that WOC systems with the functions necessary to manage dynamic airspace configurations are already deployed and that only the additional PJ.07-W2-40 functionalities are included in this CBA. In addition, the initial Operational Air Traffic Flight Plan (iOAT FPL) is also assumed to be deployed as it is needed to share Mission Trajectory (MT) data with the NM and ANSPs.

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[1] European Civil Aviation Conference

[2] the V3 Performance Assessment provides limited results for predictability and so, to take a conservative approach, it is not monetised in the CBA.

The CBA results are discounted at 8% between 2022 and 2043, with PJ.07-W2-40 being deployed between 2028 and 2033 and with benefits starting to be realised in 2030[3].

The **Net Present Value is 546 M€** and the **payback year is 2033.** The undiscounted Net Benefits over the CBA period are 2125 M€.

By stakeholder, the key points are that:

- Civil airspace users will receive the monetised benefits and have no associated costs
- ANSPs, NM and Military Airspace Users (WOC) have investment costs and no monetised benefits

Recommendations and next steps

A key recommendation for expanding the concept developed in PJ.07-W2-40 CBA is to involve the sub-regional/local Air Traffic Flow and Capacity Management (ATFCM) and sub-regional/national Airspace Management (ASM) actors in the associated dynamic civil-military CDM.

This V3 CBA is a combined effort from, AIRBUS D&S, PANSA, ANS CR (B4) and EUROCONTROL.

[3] It is noted that following updates to some enabler V3 end dates, the Solution Start of Deployment (SOD) and Initial Operating Capability (IOC) dates in DS23 draft have been adjusted to 2024 and 2027 respectively (from 2028 and 2030). However, the WOC deployments for PJ.07-W2-40 involve adding additional functionalities to a WOC system, which itself is not expected to be fully deployed by 2027. Therefore the solution has opted to maintain the dates of 2028 for SOD and 2030 for IOC as they better reflect the expected deployment potential.

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2 Introduction

2.1 Purpose of the document

This document provides the Cost Benefit Analysis (CBA) for SESAR Solution **PJ.07-W2-40: Initial 4D Mission Trajectory development with integrated DMA types 1 and 2 supported by automation and dynamic civil-military CDM** (Collaborative Decision Making) that has been validated to V3 level. The CBA looks at the affordability of deploying the solution with respect to its expected benefits.

This V3 CBA considers the impacts, benefits and costs of deploying the solution at ECAC-level. It includes the Net Present Value (NPV) for the Solution and per impacted stakeholder group, as well as a sensitivity analysis to identify the most critical variables to the value of the project.

2.2 Scope

Deploying PJ.07-W2-40 will allow Military Airspace Users to reserve airspace to meet their needs while reducing the impact on civil airspace users. The tools and CDM processes will make it possible to negotiate the location of reserved airspace volumes (in time and location) to minimise their impact on civil traffic flows. This will provide benefits to civil Airspace Users in terms of:

- Improvements in **Fuel Efficiency**, **Time Efficiency** and **Predictability**
- Increases in **En-route Airspace Capacity** that can reduce en-route ATFM delays during peak periods

This PJ.07-W2-40 V3 CBA provides the costs and benefits of the Solution Operational Improvement Steps:

- AOM-0208-B: Dynamic Mobile Areas (DMA) of types 1 and 2
- AOM-0304-B: Integrated management of Mission Trajectory in trajectory based operations environment
- AUO-0210: Participation in CDM through iSMT and Target Time (TTO) negotiation
- AUO-0216: Shared Mission Trajectory Data

See section 3.2 for their associated enablers.

The CBA considers the standalone deployment of the Solution, i.e. independently from any other SESAR Solution(s). This means that the costs of any enablers that also enabler other solutions are fully included here.

The CBA covers the period from 2022 to 2043. The Solution is assumed to be available to deploy from 2028, with initial benefits starting in 2030 and full benefits from 2033. The CBA includes Very High, High and Medium complexity en-route control centres (ACCs) [10].

2.3 Intended readership

The intended readership for this document includes:

- PJ.07-W2 Solutions

- PJ.09-W2-44, which has strong links regarding the integration of DMAs into Dynamic Airspace Configurations (DAC)
- PJ.19.04 who provides inputs such as the assumptions and guidance on CBAs and who will consolidate the CBA results (where required by PJ.20).
- PJ.20 in its role of Master Plan Maintenance project
- Key stakeholders who will benefit from the deployment of the Solution:
    - Military and Civil Airspace Users
    - Air Navigation Service Providers (ANSPs), particularly Airspace Managers (AMCs) and Air Traffic Flow and Capacity Managers (FMPs)
    - Network Manager, indirectly from improved sub-regional/local processes

2.4 Structure of the document

- Section 1 contains the executive summary;
- Section 2 provides the scope, intended readership, document structure, background, glossary of terms and acronyms;
- Section 3 presents the objectives and scope of this CBA, including a description of the Solution, information on the main stakeholders and descriptions of the CBA scenarios;
- Section 4 describes the benefits and how they are monetised as well as a view on the overall contribution to Key Performance Indicators (KPIs)
- Section 5 details the costs along with the cost approach per stakeholder group and the associated assumptions;
- Section 6 includes the CBA model and information on the sources of data used to feed it;
- Section 7 provides the CBA results;
- Section 8 includes the sensitivity analysis;
- Section 9 includes recommendations and next steps;
- Section 10 includes the references and applicable documents.
- The appendices provide a more detailed overview of the concept, the stakeholder codes linking the enablers to the CBA stakeholders, an overview on the WOC assumptions and some information on Key Performance Areas.

2.5 Background

In SESAR 2020 Wave 1 two solutions covered aspects that are considered pre-requisites for PJ.07-W2-40, these were:

- PJ.08-01: 'Management of Dynamic Airspace configurations' described in EATMA as:

  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.

- PJ.07-03: 'Mission Trajectory Driven Processes' described in EATMA as:

  Mission Trajectory Driven Processes refer, through a full integration of the wing operations centre (WOC) within the ATM system, to the updating WOC processes for the management of the shared and reference mission trajectory (SMT/RMT). These processes respond to the need to accommodate individual military airspace user needs and priorities without compromising optimum ATM system outcome and the performances of all stakeholders.

The OI Step AUO-0210: 'Participation in CDM through iSMT and Target Time (TTO) negotiation' was included in the PJ.07-03 CBA [11] and AOM-0208-B: 'Dynamic Mobile Areas (DMA) of types 1 and 2' was included in the PJ.08-01 CBA [12].

2.6 Glossary of terms

Term	Definition	Source of the definition
Benefit	A Benefit is the positive value of the return on investment to (some or all) stakeholders.	*SESAR 16.06.06 - Methods to Assess Costs and Monetise Benefits for CBAs [4]*
Benefit and Impact Mechanism	A Benefit and Impact Mechanisms a cause-effect description of the positive and negative impacts of the Solution proposed by the project	*SESAR 16.06.06 – Guidelines for Producing benefit and Impact Mechanisms (D26_04, Edition 03.00.00)*
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 16.06.06, SESAR Business Case Example – Remote Tower, D48, Edition 00.01.02, 06/05/14*
Cash Flow	Cash flow is the difference between the cash inflows and outflows related to the project during the time horizon in which they occur.	*SESAR 16.06.06 - ATM CBA for Beginners, D26-01, October 2014*
Cost	A Cost is the monetary value of an investment used up to produce or acquire the benefit.	*SESAR 16.06.06 - Methods to Assess Costs and Monetise Benefits for CBAs (D26, Edition 00.02.02, July 2016)*
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 16.06.06, SESAR Business Case Example – Remote Tower, D48, Edition 00.01.02, 06/05/141*

Term	Definition	Source of the definition
	A CBA is a neutral financial tool that helps decision makers to compare an investment with other possible investments and/or to make a choice between different options / scenarios and to select the one that offers the best value for money while considering all the key criteria for the decision.	
Discount Rate	Discount Rate is a way to capture the time value of money. This is a percentage that represents the increase in the amount of money needed or estimated to keep the same value as one year ago.	*SESAR 16.06.06, ATM CBA for Beginners, D26-01, October 2014*
Initial Operational Capability	Initial Operational Capability is the state when a capability is available in its minimum usefully deployable form. In other words, it identifies the start of benefits and the benefit ramp-up period.	*16.06.06-D68-New CBA Model and Method 2015- Part1 of 2*
Net Present Value	Net Present Value (NPV) is the sum of all discounted cash inflows and outflows during the time horizon period.	*SESAR 16.06.06, ATM CBA for Beginners, D26-01, October 2014*
Sensitivity Analysis	Sensitivity refers to the impact one given input to the model has on the overall NPV.	*SESAR 16.06.06, ATM CBA for Beginners, D26-01, October 2014*
Stakeholder	Stakeholders are organizations and entities who will have to pay for or will be impacted by the project directly or indirectly.	*SESAR 16.06.06, ATM CBA for Beginners, D26-01, October 2014*
Time Value of Money	Time Value of Money means that the same (nominal) amount of money received at different points in time has different value	*SESAR 16.06.06, ATM CBA for Beginners, D26-01, October 2014*

Table 1: Glossary of terms

2.7 List of Acronyms

Acronym	Definition
2D	2 dimensions
3D	3 dimensions
4D	4 dimensions
ACC	Area Control Centre
AERO	Aerodrome
AIS	Aeronautical Information Services
AMC	Airspace Management Cell
ANSP	Air Navigation Service Provider

Acronym	Definition
ANS	Air Navigation Service
AOC	Airline Operation Centre
APP	Approach
APT	Airport
ARES	Airspace Reservation
ASM	Airspace Management
ATC	Air Traffic Control
ATCO	Air Traffic Control Officer
ATFCM	Air Traffic Flow and Capacity Management
ATFM	Air Traffic Flow Management
ATM	Air Traffic Management
ATS	Air Traffic Services
AU	Airspace User
AUC	Airspace User Cost Efficiency (KPA)
B2B	Business to Business
BA	Business Aviation
BIM	Benefit and Impact Mechanisms
CAP	Capacity (KPA)
CAPEX	Capital Expenditure
CAT	Common Airspace Tool
CBA	Cost Benefit Analysis
CDM	Collaborative Decision Making
CEF	Cost Efficiency (KPA)
CIV	Civil
CMC	Civil Military Coordination
CNS	Communication, Navigation, Surveillance
CO_2	Carbon Dioxide
DAC	Dynamic Airspace Configuration
DCB	Demand and Capacity Balancing
DMA	Dynamic Mobile Area
DS	Dataset

Acronym	Definition
EATM	European ATM (Portal, database, dataset)
EATMA	European ATM Architecture
EC	European Commission
ECAC	European Civil Aviation Conference
eFPL	Extended Flight Plan
ENV	Environment (KPA)
EUR	euro
FEFF	Fuel Efficiency (KPA)
FF-ICE	Flight and Flow Information for a Collaborative Environment
FMP	Flow Management Position
FO	Flight Object
FOC	Full Operational Capability or Flight Operation Centre
FPL	Flight Plans
G2G	Gate to Gate
GAT	General Air Traffic
H	High Complexity ACC (sub-OE category)
IFR	Instrument Flight Rules
iMT	Initial Mission Trajectory
iOAT	Improved Operational Air Traffic Flight Plan
IOC	Initial Operational Capability
iSMT	Initial Shared Business Trajectory
IT	Information Technology
Kg	kilogram
KPA	Key Performance Area
KPI	Key Performance Indicator
L	Low Complexity ACC (sub-OE category)
LTM	Local Traffic Management
LSSIP	Local Single Sky Implementation
M	Medium Complexity ACC (sub-OE category)
MET	Meteorological
MIL	Military

Acronym	Definition
MT	Mission Trajectory
NM	Network Manager or Nautical Mile
NPV	Net Present Value
OAT	Operational Air Traffic
OAUO	Optimised Airspace User Operations
OE	Operating Environment
OPEX	Operating Expenditure
OSED	Operational Service and Environment Description
PAR	Performance Assessment Report
PIRM	Programme Information Reference Model
PJ	Project
PAR	Performance Assessment Report
PRD	Predictability (KPA)
PUN	Punctuality (KPA)
R	Required (enabler)
R&D	Research and Development
RBT	Reference Business Trajectory
RES	Resilience (KPA)
RMT	Reference Mission Trajectory
S3JU	SESAR3 Joint Undertaking
SA	Scheduled Airlines
SEC	Security (KPA)
SESAR	Single European Sky ATM Research Programme
SMT	Shared Mission Trajectory
SWIM	System Wide Information Management
TBO	Trajectory Based Operations
TEFF	Time Efficiency (KPA)
TMA	Terminal Manoeuvring Area
TTO	Target Time Over
V3	Pre-industrial development and integration stage of the Concept Lifecycle Model (E-OCVM)

Acronym	Definition
VFR	Vertical Flight Rules
VH	Very High Complexity ACC (sub-OE category)
VPA	Variable Profile Area
W1	Wave 1
W2	Wave 2
WOC	Wing Operation Centre

Table 2: List of acronyms

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3 Objectives and scope of the CBA

3.1 Problem addressed by the solution

When airspace is reserved for military use, civil airspace users must avoid that airspace. This often results in longer routes with sub-optimal flight levels that negatively impact fuel burn and flight time. Airspace reservations are defined to meet the mission needs, however, there are currently no tools or processes available to identify and negotiate alternative airspace reservations (time shift or different location), in a timely fashion, that would meet the military needs with lower impacts on civil traffic.

3.2 SESAR Solution description

Solution PJ.07-W2-40: 'Initial 4D Mission Trajectory development with integrated DMA types 1 and 2 supported by automation and dynamic civil-military CDM' is described in EATMA (DS23 draft) as:

This solution develops new operating methods that enable more flexibility and dynamicity to the planning of airspace structures configuration and the development of mission trajectory to be considered by all users performing activities in temporary restricted/reserved airspace and by the concept of dynamic airspace configuration DAC (Dynamic Airspace Configurations). The solution provides a detailed description of the integrated military Air Traffic Management (ATM) demand that evolves through trajectory lifecycle undertaking modification through local level CDM (Collaborative Decision-Making).

The integration of DMAs (Dynamic Mobile Areas) of Type 1 and Type 2 design principles for Airspace Reservation (ARES) into both the mission trajectory development and dynamic airspace configuration processes will enable an optimised and coordinated organisation and management of airspace and traffic flows in the medium to short-term ATM planning phase and improved collaboration between civil and military ATM actors.

A dynamic coordination between Wing Operation Centre (WOC) and local DAC actors, specifically national Airspace Management (ASM) and local Air Traffic Flow & Capacity Management (ATFCM), throughout CDM on a single 4D Mission Trajectory data set supported by automation of impact assessments is a key element for this solution.

The solution PJ.07-W2-40 builds upon the results of SESAR 2020 Wave 1 solutions PJ.07.03 and PJ08.01 and refines, integrates and further validates to a V3 maturity level operational concept elements of Mission Trajectory and Advanced Flexible Use of Airspace – Dynamic Mobile Areas DMA of types 1 and 2. It addresses local actors and the processes for the development of an initial 4D mission trajectory by integrating airspace reservations designed and managed in accordance with the DMA of types 1 and 2 principles with enhanced automation support and civil-military collaborative decision-making.

The following description is based on the Solution description from the OSED [13], section 3.1.

For the Military AUs a new generation of manned and unmanned aircraft/platforms, with innovative technologies and new tactical capabilities, requires the ATM network to be more flexible and adaptive in order to integrate military mission-specific requirements. Effectively, trajectory management becomes more dynamic and complex with enriched data content to be managed in real time, while providing opportunities for a better balance of the Military AU demand leading to the optimisation of the entire ATM network operations.

The Optimised Airspace Users Operation project (PJ.07) offers a platform to express military needs and to project specific aspects regarding the integration of military ATM demand into the future Trajectory based operations (TBO) environment through the realisation of the operational improvement steps and corresponding technical enablers.

These improvements are enabled through the use of the 4D trajectory - specifically the Mission Trajectory (MT) concept and new ARES DMA type 1 and 2. Importantly, the MT concept does not challenge those military operations that constitute national defence and security and which are aimed at protecting national airspace – those are out of scope of SESAR R&D.

The solution contributes to the increasing transparency, flexibility, predictability, efficiency and effectiveness, enabling unrestricted flexible access to airspace by improving the MT concept. The MT concept facilitates integration of military IFR flights and military mission-specific requirements into the ATM network operations, but this should not restrict other airspace users exploiting the concept in circumstances where their operational requirements cannot be fulfilled by applying the concept of business trajectory.

For military aircraft operators, the utilisation of the MT concept as a way to integrate flight intent with flight profile containing Airspace Reservation (ARES), allocated via ASM processes, represents a significant operational improvement. It reflects how complex processes managed by different actors and composed of several activities in the planning phase can be integrated into the 4D trajectory dataset hence sharing respective IMT data with all ATM actors concerned.

Offering new opportunities in the context of the Advanced Airspace Management concept, ARES types based on VPA (Variable Profile Area) and DMA design principles are agreed upon in a CDM process, and form part of the holistic trajectory description.

The trajectory data, shared via iOAT FPL (initial Operational Air Traffic Flight Plan) in the ATM network systems for DCB (Demand and Capacity Balancing) and DAC processes, aims at fulfilling the military mission requirements whilst minimising the potential impact on the wider ATM network performance. The complexity of the task involving dynamic management and dynamic updates, together with the interaction between processes, makes automation and new modelling capability for decision-making a necessity while keeping in mind that the human role remains key in the decision making chain. The concept envisages full integration of ASM/ATFM/ATS processes, in combination with a dynamic and collaborative decision-making layered process supported by automated tools.

Military AU operations are strongly supported by the WOC function with the system support performed at different levels and based on the architecture of the military national ATM systems. This is a key capability for the military operational stakeholders that facilitates the trajectory development, planning, execution, and management and provides an interface with the ATM network.

The Solution PJ.07-W2-40 aggregates effort from two solutions that were well-developed and validated in SESAR 2020 Wave 1 and which bring together concept elements of the entire MT concept. The Solution is focusing on further improvement of operating methods and operational activities related to the definition of DMA, their integration into the iMT description and collaborative layered planning process with a focus on CDM and management of the ATM constraints.

The MT concept context as such is wider than the Solution PJ.07-W2-40 and dependencies between concept elements is reflected in the figure below, including the elements that were out-of-scope of the validation activities.

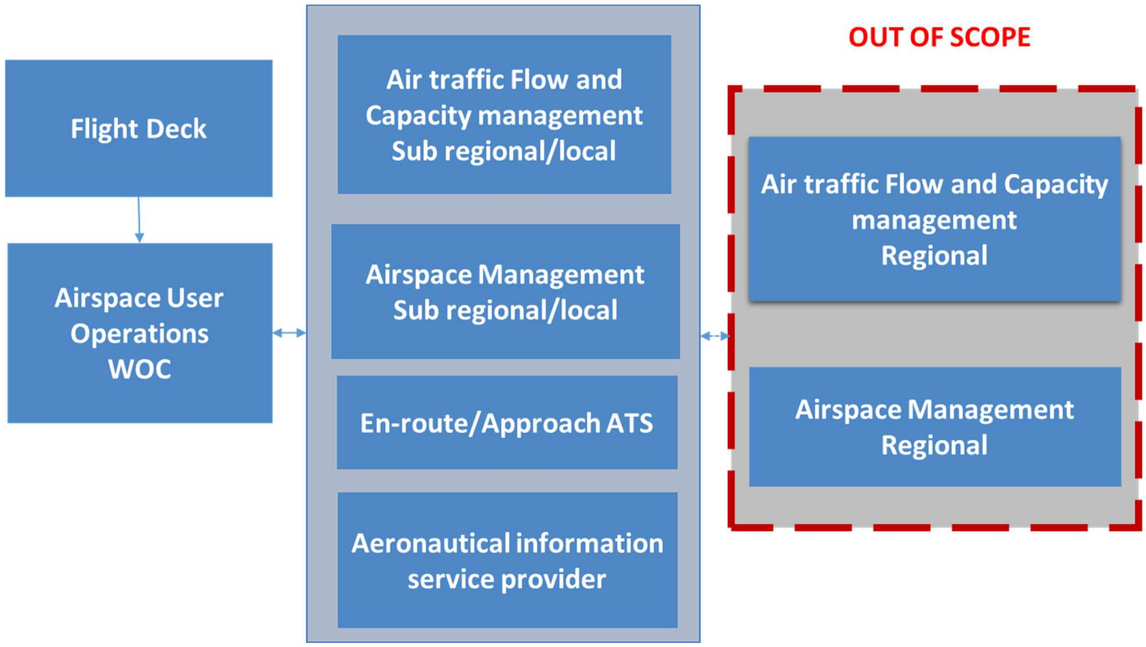

Figure 1: Scope of the Mission Trajectory concept in PJ.07-W2-40

In more detail, the processes that were tested in the validation exercises involved the Military Wing Operation Centres defining and submitting the mission trajectory requests including DMA types 1 and 2 using two new functionalities, one for mission trajectory management and one for airspace management. The WOC provided flexibility criteria for the DMA to indicate the range of changes to the DMA that would be acceptable (from no flexibility to change to full flexibility).

According to a well-defined CDM process, the WOC submitted their ARES (DMA) request(s) to Civil users (ASM/ATFM functions) where:

- the sub-regional/local Airspace Management actor assessed the various WOC requests and the civil traffic demand to get a full local picture.
- the sub-regional/local Air Traffic Flow and Capacity Management actor assessed the impact of the WOC requests on the traffic flows and sector loads.
- changes to the DMAs were proposed to the WOC where the changes reduced the impact of the DMA on the civil traffic and met the DMA flexibility criteria

Figure 2 shows some screenshots from the tools used by the various actors with the visualisations of the DMA locations.

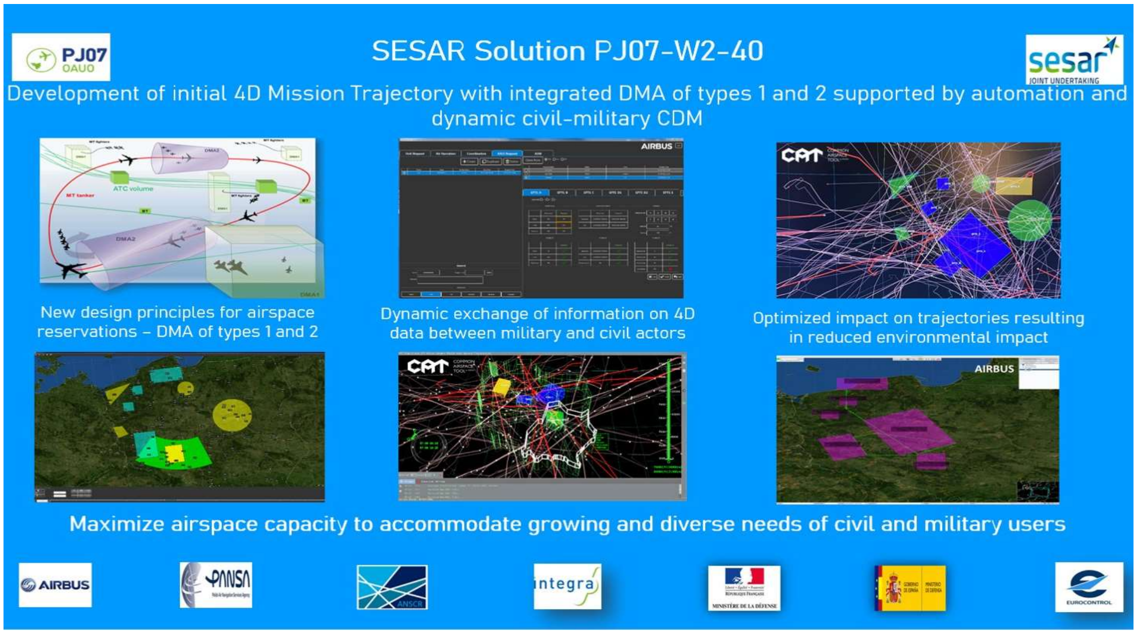

Figure 2: Examples of the displays of the various tool prototypes

PJ.07-W2-40 is designed with consideration of data transfers with PJ.09-W2-44: 'Dynamic Airspace Configurations (DAC)' and PJ.07-W2-38: 'Enhanced integration of AU trajectory definition and network management processes'. However, neither of these solutions is required to be deployed for PJ.07-W2-40 to become operational and no additional benefits are expected when they are deployed together.

Table 3 lists the Solution OI Steps and Table 4 lists the Solution Enablers.

SESAR Solution ID	OI Steps ref.	OI Steps definition	Source reference
Initial 4D Mission Trajectory development with integrated DMA types 1 and 2 supported by automation and dynamic civil-military CDM	AOM-0208-B	Dynamic Mobile Areas (DMA) of types 1 and 2	EATMA – DS23 draft
	AOM-0304-B	Integrated management of Mission Trajectory in trajectory based operations environment	
	AUO-0210	Participation in CDM through iSMT and Target Time (TTO) negotiation	
	AUO-0216	Shared Mission Trajectory Data	

Table 3: SESAR Solution PJ.07-W2-40 OI steps

Enabler[4] ref	Enabler definition	Applicable stakeholders
AAMS-16a (R)	Airspace management functions equipped with tools able to deal with free-routing	Air Navigation Service Provider - Civil ATS En-route Service Provider Network Manager
AAMS-16b (R)	Airspace management system equipped with tools able to deal with flexible use of airspace	Network Manager
AOC-ATM-14 (R)	Upgrade of WOC system to handle improved OAT flight plans	Airspace User - Military Wing Operations Centre
AOC-ATM-20 (R)	Sharing of trajectory data between AOC/WOC and the ATM world using B2B web services	Airspace User - Civil Flight Operations Centre - Military Wing Operations Centre
MIL-0105 (R)	CDM data integrated into the Wing Operations Centre Mission Support System	Airspace User - Military Wing Operations Centre
MIL-0106 (R)	Wing Operations Centre Mission Support System enhanced to support the CDM process	Airspace User - Military Wing Operations Centre
MIL-0108 (R)	Exchange of specific MT data (ARES description) in standard format	Air Navigation Service Provider - Civil-Military Airspace Management Cell (civil side) Civil-Military Airspace Management Cell (military side) Airspace User - Military Wing Operations Centre
MIL-AOC-ATM-0108a (R)	Integration of DMA type 1 and 2 into the development of MT	Airspace User - Military Wing Operations Centre
MIL-AOC-ATM-0108b (R)	WOC mission support system enhanced to enable converting DMA type 1 and 2 data into the standard format	Airspace User - Military Wing Operations Centre
PRO-076 (R)	Procedures for the iSMT in the CDM process	Air Navigation Service Provider - Civil ATS En-Route Service Provider Airspace User - Military Wing Operations Centre Network Manager

Table 4: SESAR Solution PJ.07-W2-40 Enablers and Stakeholders

[4] This includes System, Procedural and Human Enablers

Table 5 shows the links between the OI Steps and Enablers and highlights which Enablers are linked to multiple OI Steps.

Enabler code	AUO-0210	AUO-0216	AOM-0208-B	AOM-0304-B
AAMS-16a			R	R
AAMS-16b				R
AOC-ATM-14	R			
AOC-ATM-20	R			
MIL-0105	R			
MIL-0106	R			
MIL-0108				R
MIL-AOC-ATM-0108a			R	
MIL-AOC-ATM-0108b		R		
PRO-076	R			

Table 5: Links between OI Steps and Enablers (R = required)

3.3 Objectives of the CBA

This V3 Cost Benefit Analysis helps to build an assessment of whether PJ.07-W2-40 is worth deploying from an economic perspective for the involved stakeholders.

The objective is to provide an assessment of the costs and benefits of deploying 'Initial 4D Mission Trajectory development with integrated DMA types 1 and 2 supported by automation and dynamic civil-military CDM' across the Very High, High and Medium complexity ACCs included in the ECAC-level CBA Solution Scenario.

This CBA assesses whether the benefits of the deployed Solution are expected to exceed the costs over the CBA time horizon (up to 2043). It does this using discounted cash flow analysis, which provides the Net Present Value (NPV) for the Solution and per stakeholder group. As there is a positive NPV, the break-even year is provided, which is the year when the benefits will cover the costs incurred.

The CBA results are also explored through a sensitivity analysis to assess the impact on the NPV of changes to the input values. There is also a scenario analysis looking at setting the costs to their high values and halving the benefits to see how that impacts the NPV.

As the CBA provides results at ECAC-level it does not provide sufficient detail to support individual deployment decisions that must take into account the local environment/situation (e.g. current operational systems, their lifespan(s), replacement timing, etc.). However, interested parties can take the mechanisms and inputs used here and refine them for their local CBAs, if appropriate.

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3.4 Stakeholders identification

Table 6 provides information on the stakeholders that are impacted by this solution and their involvement in the CBA activity. It provides an overview of the types of costs and benefits they have and whether they are quantified in the CBA results in section 7.

Stakeholder	Type of stakeholder and/or applicable sub-OE	Type of Impact	Involvement in the CBA analysis	Quantitative results available in the current CBA version
ANSP	En-route ACCs with Very High, High and Medium Complexity	Costs: implementation of tools to support the CDM negotiation of airspace reservation locations. Training for FMPs on the system and CDM processes Benefits: En-route capacity planning is improved so fewer regulations are needed to handle capacity issues as ARES have less impact on civil traffic flows because the MT is shared and used to analyse upcoming traffic complexity	Provided cost data, reviewed inputs, assumptions, CBA Scenarios and CBA Results.	Costs included No monetised benefits
Airport Operators	Civil / Military	Out of scope for this Solution.	N/A	N/A
Network Manager	Network	Costs: NM systems need to handle the MT data where it includes ARES information and NM should be involved in the CDM process Benefits: effective cooperation between all stakeholders in moving towards an optimised airspace configuration. Improved efficiency of sub-regional/local ASM-ATFCM and military requirements based CDM	None	Costs included No monetised benefits
Military – Airborne	Military Airspace User (Trainer, Fighter, Transport)	Costs: no costs associated with this Solution Benefits: Mission needs and constraints continue to be met	None	No costs No monetised benefits
Military – Ground	Wing Operation Centre (WOC)	Costs: upgrade of WOC mission support systems to process properly the initial MT information integrated with DMAs of types 1 and 2 including tools to support the CDM negotiation of airspace reservations. Training for operators on the system and CDM processes	None	Costs included No monetised benefits

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Stakeholder	Type of stakeholder and/or applicable sub-OE	Type of Impact	Involvement in the CBA analysis	Quantitative results available in the current CBA version
		Benefits: Continued access to the required airspace and flight profiles to meet mission needs. Improved flexibility of the ATM system to accommodate civil and military ATM planning constraints and preferences/priorities including short notice requests/changes.		
Scheduled Airlines (Mainline and Regional) Business Aviation	Airspace Users operating in Very High, High and Medium complexity ACCs	Costs: no costs associated with this Solution Benefits: Reduced impact of ARES on flight trajectories so fewer ATFM regulations (avoided delays, route extensions, sub-optimal flight levels, etc.) Leads to improvements in fuel efficiency, CO_2 emissions, time efficiency and predictability.	None	No costs Benefits are monetised
Rotorcraft General Aviation IFR and VFR	Airspace User	Considered out of scope of this solution as they have limited, if any, operations in Very High, High and Medium complexity ACCs	None	None

Table 6: SESAR Solution PJ.07-W2-40 CBA Stakeholders and impacts

Some of the benefits mentioned in Table 6 and the solution description, section 3.2, are only described qualitatively because there is currently either no clear, agreed mechanism to quantify them or no data available to populate a mechanism. Examples include benefits for NM, WOCs and Military Airspace Users. However, these topics have been discussed with the relevant stakeholders during the development of the PJ19.04 CBA model who agreed with this qualitative approach.

3.5 CBA Scenarios and Assumptions

This section describes the scenarios that are compared in the CBA. The comparison is between the CBA Reference scenario (where the Solution is not deployed - the orange box in Figure 3) and the CBA Solution scenario (reflecting the proposed deployment of the Solution at applicable locations across ECAC - the green box in Figure 3). The CBA uses a delta approach where the focus is on the costs and benefits associated with the ECAC-level deployment of the solution, i.e. with the changes from the CBA Reference Scenario.

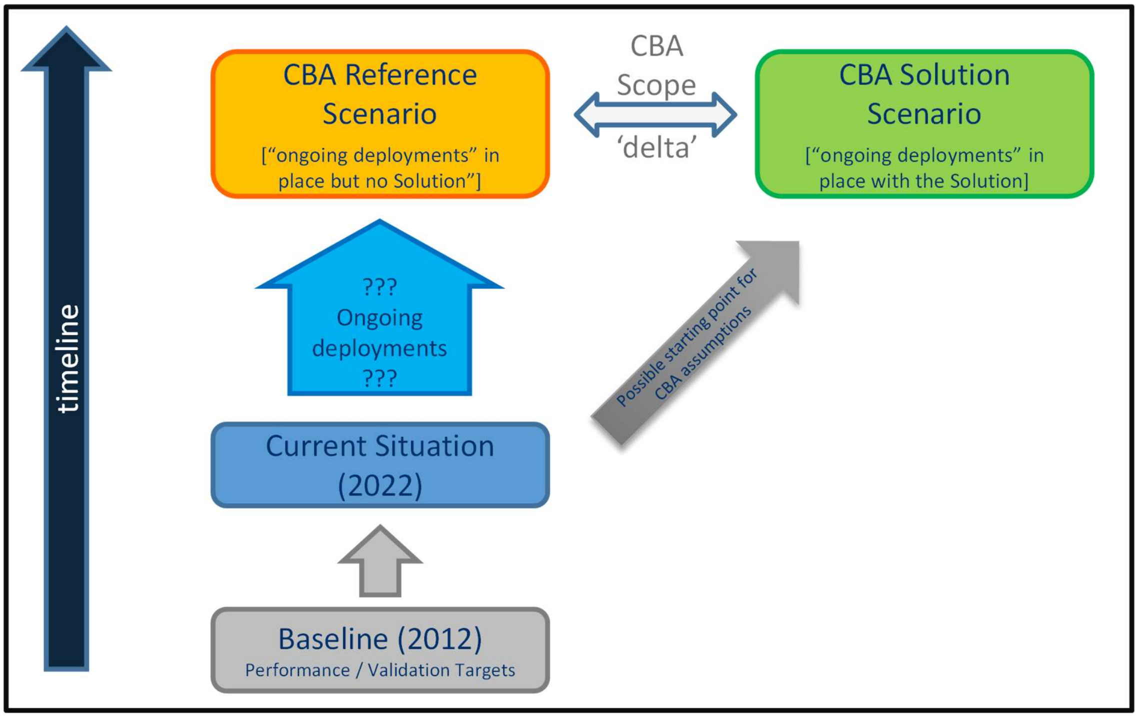

Figure 3: Scenario Overview

3.5.1 CBA Reference Scenario

The CBA Reference Scenario reflects the future situation where PJ.07-W2-40 is not deployed. Relevant elements that are assumed to already be deployed are:

- the WOC system with the functions necessary to manage dynamic airspace configurations,
- the iOAT FP (initial operational air traffic flight plan) that enables the sharing of MT data with NM and ANSPs.
- NM enablers AAMS-16a and AAMS-16b, see section 3.2.

In addition, existing concepts using static ARES are available to Military airspace users requiring temporary reservation/restriction of airspace for their activities.

3.5.2 CBA Solution Scenario

In the CBA Solution Scenario, PJ.07-W2-40 is deployed and Military Airspace Users can choose to use DMA type 1 and type 2 ARES to meet their mission requirements.

DMA may contain flexible parameters, which are integrated into the MT dataset and are shared with all pertinent ATM and non-ATM actors. Flexible DMA parameters are used to optimize DMA configuration/geographical location in the scope of dynamic configuration of ATC sectors and traffic volumes in order to satisfy local performance targets. CDM processes between ASM, ATFCM and WOC actors facilitates agreement on the optimal conflict-free airspace configuration within predefined geographic limits, while preserving the requirements of the military activity.

The deployment of the Solution involves the implementation of the enablers listed in section 3.2, which will provide:

- Additional functionalities in the WOC systems:
    - WOC Mission Trajectory functions to allow the integrated definition and development of mission trajectories (iMT) that include DMA Type 1 and 2 in the sub-regional/local ATM planning phase. The DMA data, including flexible parameters, is provided in the iOAT FP.
    - WOC Airspace Management which will enable ARES, including DMA Type 1 and 2, to be managed and negotiated through the civil-military CDM process
- A support tool to enable ANSPs to:
    - participate in ARES/DMA allocation and CDM processes between WOC and local DAC (Airspace Management – Airspace Management Cell (ASM-AMC) and Air Traffic Flow and Capacity Management – Local Traffic Management (ATFCM-LTM)) regarding DMA allocation
    - collect, via B2B, and de-conflict users' requests for ARES/DMAs based on historical GAT (general air traffic) flows, planned ATC sectorisations and the requested locations for DMA with the aim to minimise their impact on civil traffic and en-route capacity
    - measure performance improvements
- involved actors with the means to integrate iSMT in local traffic management and manage it with planning ATM constraints (TTO)
- means to implement the CDM process and ensure relevant data is shared between the involved parties

CBA timeline

The CBA covers the period from 2022 to 2043 as defined by PJ19.04; this means that the Net Present Value is calculated by discounting the cash-flows back to 2022 (the end of Wave 2).

The table below lists the key dates used in the CBA and Figure 4 shows them over a timeline. It is noted that following updates to some enabler V3 end dates, the Solution Start of Deployment and Initial Operating Capability dates in DS23 draft have been adjusted to 2024 and 2027 respectively. However, the WOC deployments for PJ.07-W2-40 involve adding additional functionalities to a WOC system, which itself is not expected to be fully deployed by 2027. Therefore the solution has opted to maintain the dates in Table 7 as they better reflect the expected deployment potential.

Dates	PJ.07-W2-40
Start of deployment date: the start of investments for the first deployment location	**2028**
End of deployment date: the end of the investments for the final deployment location, same as FOC	**2033**
Initial Operating Capability (IOC): the time when the first benefits occur following the *minimum deployment* necessary to provide them. Costs continue after this date as further deployment occurs at other locations.	**2030**
Final Operating Capability (FOC): Maximum benefits from the *full deployment*[5] of the Solution at applicable locations. Investment costs are considered to end[6] here although any operating cost impacts would continue.	**2033**

Table 7: CBA Investment and Benefit Dates

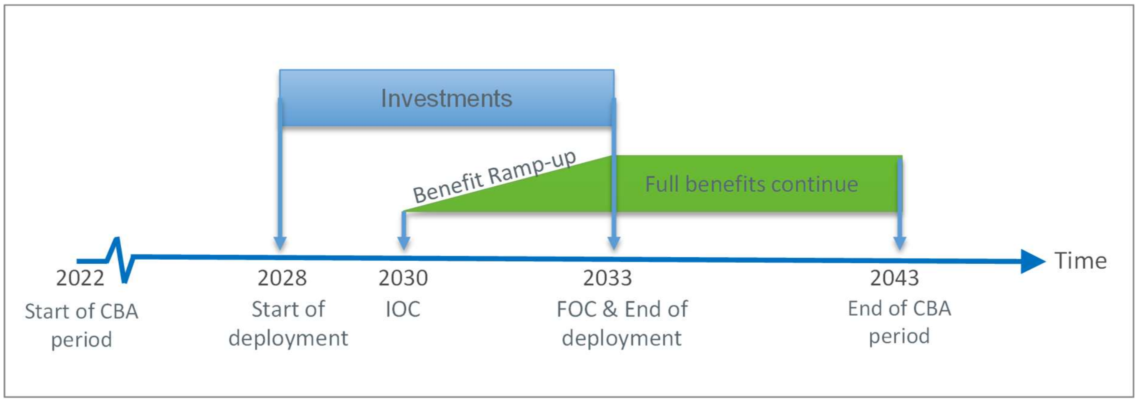

Figure 4: Overview of CBA Dates

Figure 2 shows that:

- Investment costs are spread linearly between the Start and End of Deployment dates.
- Benefits ramp-up linearly between IOC and FOC and then continue up to the end of the CBA period.
- Operating cost impacts (increases or decreases) would also start at IOC and ramp-up linearly to FOC before continuing for the rest of the CBA duration.

3.5.3 Assumptions

For the extrapolation of the local validation results to ECAC level, the following assumptions and resulting scale factor are used:

- The recurrent military training activities are performed during working days; considering 52 weeks a year, the maximum training days is 260, which represents 71% of the total number

[5] Where ***full deployment*** means deploying the Solution in the all the locations where it makes sense to deploy it (i.e. it does not mean it has to be deployed everywhere)

[6] The basic assumption is that infrastructure does not need to be replaced during the CBA period

of days; the assumption is that the airspace reservation configuration in the validation solution scenario is representative of the average level of training on a working day in ECAC States;

- Taking into account additional holidays, the application of a 0.65 scale factor is considered as an acceptable assumption for the magnitude of solution impacts at ECAC level and is used in the calculation of the benefits in section 4.

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4 Benefits

The deployment of PJ.07-W2-40 is expected to bring benefits by reducing the impact of static airspace reservations on planned trajectories and improving the capability to adjust and balance the distribution of traffic across ATC sectors. The CBA assumes that the planned trajectories are flown as planned because the benefits will only be realised during execution.

PJ.07-W2-40 has used the Single Solution CBA model developed by PJ.19-04 and therefore the benefits are calculated using the benefit monetisation mechanisms that it includes. The mechanism diagrams shown in the following sections are taken from or based on the SESAR CBA Reference material, see section 10.1.

The benefit input values included in the CBA are the Performance Assessment Results shown in Table 8. For details of the calculations, see the Performance Assessment Report [14]. The Validation Targets [16] are also included in the table for reference[7].

KPA	Validation Targets	ECAC-level value (used in CBA)	Stakeholder that benefits in the CBA
Capacity			
CAP2: Airspace Capacity – En-route throughput, in challenging airspace, per unit time	**Impact level 2**	**0.6%** (2.07% local value in PAR)	Airspace User (avoided route extensions and ATFM tactical delay)
Operational Efficiency			
FEFF1: Fuel Efficiency – Fuel burn reduction per flight (kg)	No validation target assigned	**6.5kg/flight**	Airspace User (reduced fuel burn and avoided CO_2 emissions)
ENV1: CO_2 Emissions – CO_2 reduction per flight (kg)	No validation target assigned	Calculated from FEFF1 value	Airspace User (avoided CO_2 emissions)
TEFF1: Time Efficiency – Average of the distribution of actual gate-to-gate flight durations	**Impact level 1**	**0.14%**	Airspace User (reduced flight duration)
PRD1: Average of difference of actual & Flight Plan or RBT durations – Average of the distribution of the differences between flown trajectories & Flight Plans or RBT durations	**Impact level 1**	Not monetised to align with PAR comment that cross-border scenarios are needed for more relevant figures	Airspace User (reduced delay)
Cost Efficiency **CEF2: ATCO Productivity -** Flights per ATCO-Hour on duty	**Impact level 2**	Not monetised as the ATCO role was not included in the validation activities	ANSP (increased ATCO productivity from handling more flight

[7] See section 2.2 of the Validation Targets Wave 2 [16] for a description of the qualitative scale used for the validation targets. Impact level 3 is the highest impact, then level 2 and level 1 or no impact.

KPA	Validation Targets	ECAC-level value (used in CBA)	Stakeholder that benefits in the CBA
			hours with the same ATCO-hours)

Table 8: PJ.07-W2-40 Performance Assessment Results

The confidence in the ECAC-level values is low because the cross-border aspect was not addressed in the validation activities

4.1 Airspace Capacity - En-Route (CAP2)

PJ.07-W2-40 is expected to improve En-route Airspace Capacity through the optimization of DMAs. A dynamic civil-military CDM will enable the reduction of the impacts of airspace segregation on deviations to planned Free Route trajectories. This is expected to improve the capability to adjust and balance the distribution of traffic amongst ATC sectors.

Furthermore, the application of planning time constraints, TTO, to mission trajectories supports integrated ASM-ATFCM measures to improve ATC sectors capability to accommodate the predicted demand. The ANSP tool will enable flow managers to identify a TTO over the DMA entry/exit point of relevant mission trajectory(ies), which will lead to a reduction of the impacts of the airspace reservation/restrictions on ATC sector configurations and business trajectories. The expectation is an improvement to ATC sector traffic throughput.

Airspace capacity is monetised in the CBA as a reduction in tactical and strategic delay where:

- 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).

The overall (undiscounted) monetary value of avoided delay due to the increased in En-route Airspace Capacity is 669 M€.

The link between capacity and delay is estimated using the elasticity approach developed in the SESAR Integrated CBA model.

Figure 5 and Figure 6 show the monetisation mechanisms used in the CBA model.

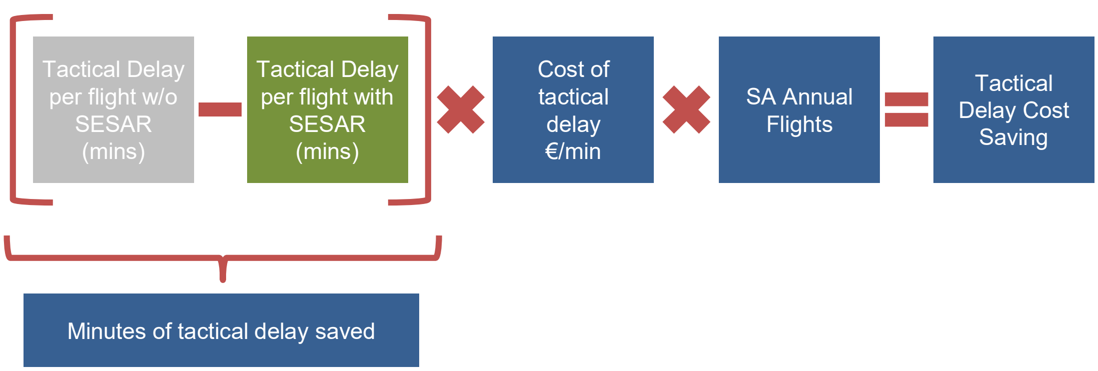

Figure 5: Tactical Delay Monetisation Mechanism

Figure 6: Strategic Delay Monetisation Mechanism

The Performance Assessment provides an expected percentage increase of 2.07% in capacity-constrained airspace during the hours when it is actually constrained (peak-hours), i.e. at a local-level. However, the CBA is at ECAC-level and so the 2.07% value has been scaled so that it only applies to Very High / High / Medium Complexity En-Route ACCs during peak-hours[8] on days with active airspace reservations.

Calculation elements	values
Local airspace capacity benefit	2.07%
Share of flights that benefit (flights in very high, high and medium complexity en-route airspace in peak-hours [9])	44.5%
ECAC Scaling factor (reflect days with active ARES)	0.65
Scaled En-Route Capacity	**0.6 %**

Table 9: Airspace Capacity Scaling Factor Calculation

The scaled En-Route Capacity increase (0.6%) is used to calculate the 'Tactical (ATFM) Delay per flight with SESAR (mins)' (green box in Figure 5) as well as the part of the Strategic delay savings[9] linked to Tactical delay (Figure 6).

4.2 Fuel Efficiency (FEFF1) and CO_2 Emissions (ENV1)

PJ.07-W2-40 is expected to improve fuel efficiency by reducing the impact of static airspace segregation on planned trajectories and profiles.

Although all OI steps in the solution contribute to improved fuel efficiency and CO_2 emissions, their impact differs significantly. The major contribution is brought by the new operating method associated with the new design principles of ARES, the DMA types 1 and 2 (AOM-0208 B) and the application of TTO (AUO-0210) that enable in practice a significant reduction of the airspace reservation impact on trajectory rerouting (up to 60% fewer impacted flights).

The shared mission trajectory (AUO-0216) is important from two perspectives: (1) the integration into the local traffic demand of mature and stable information on the military ATM demand and (2) the ASM-ATFM impact analysis triggering the identification and negotiation of TTO.

[8] Ideally, the local capacity gains are fed into a network-wide fast time simulation to assess the impact on delays. However, this is a significant task that is not feasible at Solution level; hence, the use of the scaling approach.

[9] The other part of the Strategic delay savings are calculated using the Flight Time Variability (Predictability) performance assessment results.

Finally, although not directly quantifiable, the sharing of mission trajectory profiles described by a 4D dataset (AOM-0304 B), which contains 4D target ATM constraints is a key requisite to the optimization of military ATM demand within the local ASM-ATFM processes of DAC.

FEFF1: Fuel Efficiency – Fuel burn reduction per flight (kg)	**6.5 kg/flight**
ENV1: CO_2 Emissions – CO_2 reduction per flight (kg)	**6.5 x 3.15= 20.5 kg/flight**

Table 10: Fuel Efficiency and CO_2 Emission Results

Fuel Efficiency is monetised in the CBA as the value of fuel saved which also links to the value of CO_2 saved. The overall (undiscounted) monetary value of fuel saved and CO_2 saved is 1263 M€.

Figure 7 shows the monetisation mechanisms used in the CBA model. The calculation is made in each year so the values include the evolution of the number of flights and fuel price, coming from the long term STATFOR forecast, over the CBA period. The same calculation is applied for the Business Aviation (BA) benefits but using the BA annual traffic.

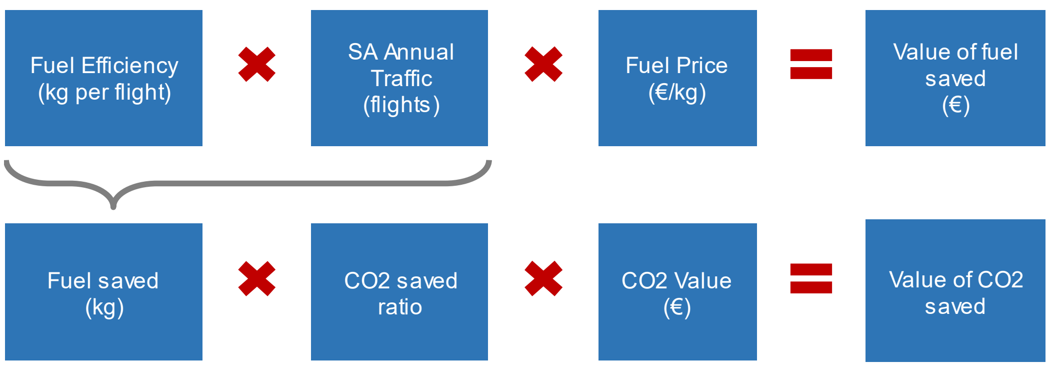

Figure 7: Fuel Efficiency and CO2 Monetisation Mechanisms

4.3 Time Efficiency (TEFF1)

PJ.07-W2-40 is expected to improve time efficiency through the sharing of early flight intent with DMA type 1 and 2 and the civil-military CDM on DMA allocation enabling fewer modifications to AU preferences for trajectories.

In addition, the flexible allocation of DMA 1 and 2, as well as the application of target times over mission trajectory profiles, will enable less ARES overbooking and consequently more opportunities for GAT flights to be able to directly cross the ARES airspace.

Time savings are calculated as the average flight time saved in En-route Airspace (minutes/flight) for each aircraft.

The overall (undiscounted) monetary value of the improvement in Time Efficiency is 815 M€.

TEFF1: Average of the distribution of actual gate-to-gate flight durations	-0.14%

Table 11: Time Efficiency Result for SA

Figure 8 shows the monetisation mechanism included in the CBA model.

Figure 8: Time Efficiency Monetisation Mechanism

4.4 Predictability (PRD1)

PJ.07-W2-40 is expected to improve predictability through the sharing of early flight intent with DMA type 1 and 2 and the civil-military CDM on DMA allocation enabling fewer modifications to AU preferences for trajectories. In addition, the implementation of DMA 1 and 2 leads to less ARES overbooking and supports better awareness on the actual status of airspace, thus improving predictability for the planning of free route operations.

However, the values obtained from the validation results for the PRD 1 KPI did not provide sufficient evidence to draw a conclusion on the contribution of the solution to predictability so to take a conservative approach predictability is not monetised in the CBA.

4.5 ATCO Productivity (CEF2)

ATCO Productivity reflects the relationship between flight-hours and ATCO-hours. For example, handling additional flight-hours with the same number of ATCO-hours is an improvement in ATCO productivity. For PJ.07-W2-40 there is no data available from the validation to assess potential changes in ATCO Productivity so this is not monetised in the CBA.

4.6 Civil-Military Cooperation and Coordination (CMC)

While Civil-Military Cooperation and Coordination (CMC) is not monetised in the CBA, to avoid double counting with Fuel Efficiency [14], it is expected to be supported by the integration of DMA types 1 and 2 into the management of mission trajectories. There are two ways these DMAs are expected to impact on the effectiveness of military missions, on one hand, the flexibility of DMAs will provide more options to military planners to cope with dynamic changes to mission requirements inside reserved airspaces while, on the other hand DMA types 1 and 2 could have an impact on the entire mission profile, specifically in cases where multiple airspace reservations are associated to a trajectory profile.

The overall expectation is that the solution will ensure the provision of optimized ATM support to achieving mission objectives by maintaining the parameters of trajectory profiles and associated airspace reservations/restrictions within the appropriate limits in accordance with the flexibility parameters pre-defined by the mission trajectory user.

A summary of benefits for the Military stakeholders from having effective integration of military airspace requirements into the future ATM environment include:

- A CDM process that fully consider military priorities and requirements
- The flexibility to reserve/restrict the airspace in accordance with actual needs and the airspace situation, including for very short-notice requests
- Enhanced efficiency of military decision making for optimal reservation of airspace thanks to automated support

- Improved military-military ATM interoperability thanks to harmonised ASM procedures from local to network levels
- The possibility to assess cross-border opportunities for airspace reservation enabled by the access to network-wide information on airspace status

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4.7 Benefit Monetisation of the Performance Framework KPI/PI

Performance Framework KPA	Focus Area	KPI/PI from the Performance Framework	Unit	Metric for the CBA	Unit	Total benefits from IOC to 2043
Cost Efficiency	ANS Cost efficiency	**CEF2** Flights per ATCO-Hour on duty	Nb	ATCO employment Cost change	€/year	Not monetised in the CBA
				Support Staff Employment Cost Change	€/year	
				Non-staff Operating Costs Change	€/year	
		CEF3 Technology cost per flight	EUR / flight	G2G ANS cost changes related to technology and equipment	€/year	
	Airspace User Cost efficiency	**AUC3** Direct operating costs for an airspace user	EUR / flight	Impact on direct costs related to the aeroplane and passengers. Examples: fuel, staff expenses, passenger service costs, maintenance and repairs, navigation charges, strategic delay, landing fees, catering	€/year	
		AUC4 Indirect operating costs for an airspace user	EUR / flight	Impact on operating costs that do not relate to a specific flight. Examples: parking charges, crew and cabin salary, handling prices at Base Stations	€/year	
		AUC5 Overhead costs for an airspace user	EUR / flight	Impact on overhead costs. Examples: dispatchers, training, IT infrastructure, sales.	€/year	

Performance Framework KPA	Focus Area	KPI/PI from the Performance Framework	Unit	Metric for the CBA	Unit	Total benefits from IOC to 2043
Capacity	Airspace capacity	**CAP1** TMA throughput, in challenging airspace, per unit time	% and # movements	Tactical delay cost (avoided-; additional +)	€/year	
			% and # movements	Strategic delay cost (avoided-; additional +)	€/year	
		CAP2 En-route throughput, in challenging airspace, per unit time	% and # movements	Tactical delay cost (avoided-; additional +)	€/year	568 M€
			% and # movements	Strategic delay cost (avoided-; additional +)	€/year	101 M€
	Airport capacity	**CAP3** Peak Runway Throughput (Mixed mode)	% and # movements	Value of additional flights	€/year	
	Resilience	**RES4a** Minutes of delays	Minutes	Tactical delay cost (avoided-; additional +)	€/year	
		RES4b Cancellations	% and # movements	Cost of cancellations	€/year	
		Diversions	% and # movements	Cost of diversions	€/year	
Predictability and punctuality	Predictability	**PRD1** Variance of Difference in actual & Flight Plan or RBT durations	Minutes^2	Strategic delay cost (avoided-; additional +)	€/year	Not monetised in the CBA
	Punctuality	**PUN1**	% (and # movements)	Tactical delay cost (avoided-; additional +)	€/year	

Performance Framework KPA	Focus Area	KPI/PI from the Performance Framework	Unit	Metric for the CBA	Unit	Total benefits from IOC to 2043
		% Departures < +/- 3 mins vs. schedule due to ATM causes				
Flexibility	ATM System & Airport ability to respond to changes in planned flights and mission	**FLX1** Average delay for scheduled civil/military flights with change request and non-scheduled / late flight plan request	Minutes	Tactical delay cost (avoided-; additional +)	€/year	
Environment	Time Efficiency	**TEFF1** Reduction in average flight duration	% and minutes	Strategic delay: airborne: direct cost to an airline excl. Fuel (avoided-; additional +)	€/year	815 M€
	Fuel Efficiency	**FEFF1** Average fuel burn per flight	Kg fuel per movement	Fuel Costs	€/year	1178 M€
	Fuel Efficiency	**FEFF2** CO_2 Emissions	Kg CO_2 per movement	CO_2 Costs	€/year	84 M€
Civil-Military Cooperation & Coordination	Civil-Military Cooperation & Coordination	**CMC2.1a** Fuel saving (for GAT operations)	Kg fuel per movement	Fuel Costs	€/year	Not monetised in the CBA
		CMC2.1b Distance saving (for GAT operations)	NM per movement	Time Costs	€/year	Not monetised in the CBA

Table 12: Results of the benefits monetisation per KPA

5 Cost assessment

The CBA considers the costs associated with deploying PJ.07-W2-40 at ECAC level.

The costs include the investment costs of acquiring the systems including specific adaptations and functionalities, integration costs, training costs, regulatory costs as well as the costs associated with the project management and the development and documentation of procedures. An assessment has also been made of changes in annual operating costs following the deployment, for example, changes in maintenance costs or ongoing training costs.

The cost values were estimated by the Solution partners using a bottom-up approach to estimate the stakeholders' implementation costs and any changes in operating costs. The scope of each enabler was analysed by the relevant experts.

5.1 ANSP costs

5.1.1 ANSP cost approach

The ANSP stakeholder covers several different service provision aspects, for PJ.07-W2-40, the focus is on the civil-military airspace management cell (AMC) and civil En-Route provision.

The CBA takes a conservative approach and includes costs for each ACC separately. If relevant data becomes available then this could be refined to consider that some ANSPs could equip multiple centres via a centralised deployment.

The PJ.07-W2-40 ANSP partners reviewed the Enablers allocated to the ANSP stakeholder, Table 13, and provided cost values. AAMS-16a and PRO-076 are only allocated to civil ANSPs while MIL-0108 covers both civil and military ANSPs. There are no Optional Enablers allocated to the ANSP stakeholder.

OI Steps				ANSP		
AUO-0210	AOM-0208-B	AOM-0304-B	Enabler Code	ANSP-CIV-AMC	ANSP-CIV-ER	ANSP-MIL-AMC
	R	R	AAMS-16a		x	
		R	MIL-0108	x	x	x
R			PRO-076		x	

Table 13: ANSP Required (R) Enablers

Table 14 provides the Enabler Titles.

Enabler Code	Enabler Title
AAMS-16a	Airspace management functions equipped with tools able to deal with free-routing
MIL-0108	Exchange of specific MT data (ARES description) in standard format

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PRO-076	Procedures for the iSMT in the CDM process

Table 14: ANSP Enabler Titles

For the CBA, and based on the assumptions taken in the Wave 1 Solutions PJ.07-03 and PJ.08-01, the Civil / Military ATS provision is considered to be either separated, co-located or integrated; as shown in Table 15. Note that OAT traffic refers to transit flights only and excludes training flights or air defence missions as they are always under the control of a military controller (air defence control units).

	#	Military ATS System is:	OAT traffic controlled by:	Costs allocated to:
Separated	1	Same as Civil ANSP System	Military controller	Civil ANSP
	2	Separate Military ATS System	Military controller	Military ANSP
Co-located	3	Same as Civil ANSP System	Military controller	Civil ANSP
	4	Separate Military ATS System	Military controller	Civil ANSP (*)
Integrated	5	Same as Civil ANSP System	Civil controller	Civil ANSP

Table 15: Main Civil-Military ANSP Organisations

The deployment costs at Co-located (# 3 and 4) and Integrated (#5) locations are considered to be covered by the civil ANSP costs. The assumption for #4 locations (*) is that the upgrade of the systems will result in the move towards an Integrated deployment hence the allocation of costs to the civil ANSP.

The deployment costs at Separated locations are assigned to the Military ANSP in the CBA; see Table 17. However, only half the number of such locations are considered for deployment as there is expected to be an increase in co-located and integrated ATS provision.

5.1.2 ANSP cost assumptions

The ANSP unit cost is based on the following assumptions:

- The unit cost does not vary in function of the traffic complexity level managed by the ACC or the controlled airspace (En-Route, Terminal Airspace or both En-Route and Terminal Airspace).
- Where Civil and Military ANSPs operate the same ATS system, the costs are allocated to the civil ANSP.

The ANSP costs have been calculated for a single ACC by consolidating the provided per-Enabler costs. Confidence in the per-ACC cost is estimated to be 'moderate'. The per-ACC values have then been multiplied by the number of ACCs in the ECAC area to get the overall cost envelope. Costs for the AMC related deployments are considered as included within this envelope and so no additional per-AMC costs are included.

The concept is considered applicable in Very High, High and Medium complexity en-route ACCs.

5.1.3 Number of investment instances (units)

Table 16 shows the number of Very High, High and Medium civil ACCs [10] that are included in the CBA.

	Airport	Terminal Airspace				En-Route				En-Route + Terminal Airspace			
	All Sub-OE	VH	H	M	L	VH	H	M	L	VH	H	M	L
Civil	Not Applicable	Not Applicable				4	9	19	-	4	3	14	-
						32				21			
		Deployment locations: 53											

Table 16: Number of investment instances - ANSPs

By 2035, it is expected that there will be a move towards integrated civil/military ATM, however, to assume that integration will have occurred in each ECAC Member State, in that timeframe, is considered unrealistic. For this reason, the CBA considers that half of the ECAC states will still have separate civil and military ATM systems. The CBA takes the value of 41 from a previous assessment of the LSSIP data and assumes that only half those locations will deploy the solution. The other half are assumed to do so through moving to co-located/integrated deployments.

	Separated
Military	41 / 2 = 20

Table 17: Number of ANSP (military) Deployment Locations

5.1.4 Cost per unit

The costs shown in Table 18 include the enablers listed in section 5.1.1.

Cost category	Airport	TMA	En-route ACC Enroute and Terminal Airspace ACC			
	All Sub-OE	All Sub-OE	VH	H	M	L
Implementation costs	Not Applicable	Not Applicable	2.3 – 6.3 M€ per civil or military ACC 4.3 M€ per ACC (mid-point)			
Operating costs			0 – 0.6 M€ per civil or military ACC Up to 10% of the investment costs annually 0.3 M€ per ACC (mid-point)			

Table 18: Cost per Unit – ANSP

The cost ranges reflect that some ACCs already have the enabler AAMS-16a deployed or planned for deployment. While this enabler is not allocated to the military ANSPs, there are differences in the current systems that can impact their deployment costs.

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5.2 Airport operators costs

Airport Operators are not required to invest for this solution.

5.3 Network Manager costs

The Network Manager was not represented in the PJ.07-W2-40 Solution team, therefore some assumptions have been taken regarding the deployment of enablers assigned to them in DS23 draft; these assumptions are detailed below.

5.3.1 Network Manager cost approach

Network Manager costs were assessed during Wave 1 in an exercise that considered all the SESAR2020 Enablers assigned to NM. This Wave 1 assessment forms the basis for the current cost assumptions.

Table 17 lists the Solution Enablers that are assigned to the Network Manager. There are no Optional Enablers allocated to the Network Manager.

OI Steps				Network Manager	
AUO-0210	AOM-0208-B	AOM-0304-B	Enabler Code	NET-MAN	Comment
	R	R	AAMS-16a	x	DS23 draft – deployment ongoing IOC:2017 FOC: 2025
		R	AAMS-16b	x	DS23 draft – already deployed FOC: 2015
R			PRO-076	x	

Table 19: Network Manager Required (R) Enablers

Table 20 provides the Enabler Titles.

Enabler Code	Enabler Title
AAMS-16a	Airspace management functions equipped with tools able to deal with free-routing
AAMS-16b	Airspace management system equipped with tools able to deal with flexible use of airspace
PRO-076	Procedures for the iSMT in the CDM process

Table 20: Network Manager Enabler Titles

5.3.2 Network Manager cost assumptions

Table 19 includes two enablers that are not included in the CBA because the DS23 draft shows:

- AAMS-16a has an IOC of 2017 and an FOC of 2025 so can be considered to be deployed before PJ.07-W2-40
- AAMS-16b has an FOC of 2015 so is considered to already be deployed

In SESAR 2020 Wave 1 a cost range for NM system enablers was identified and this has been included in the CBA to provide a cost envelope to cover PRO-076 and other Network Manager related costs required to deploy PJ.07-W2-40. This envelope will need to be reviewed when there is a view on including the regional aspects in the CDM process.

The current NM cost range has a 'low confidence' level as detailed understanding of the changes that will be required to provide the enabler functionalities still need to be reviewed.

5.3.3 Network Manager costs

Table 21 shows the cost estimation for the MIL-0108 enabler.

Cost category	Network Manager
Implementation costs	6 - 9 M€ (low confidence) 7.5 M€ (mid-point)
Operating costs	No impact on annual operating cost was identified at this stage

Table 21: Cost Range – Network Manager

5.4 Airspace User costs

Civil Airspace Users are not required to invest in any Enablers, either airborne or in their Flight Operation Centres (FOC), for PJ.07-W2-40. DS23 draft shows that AOC-ATM-20 is assigned to the FOC; however, this is not required for the concept validated by PJ.07-W2-40 and are therefore is not included in the CBA.

5.5 Military (WOC) costs

5.5.1 Military cost approach

There is no airborne equipage required for the Military fleet.

The Wing Operation Centre (WOC) systems will need to be upgraded to handle the mission trajectory and airspace management elements related to DMA types 1 and 2. WOC costs cover the Enablers listed in Table 22, the MT and ASM columns indicate which enablers are relevant for each functionality. There are no Optional Enablers allocated to the WOC stakeholder.

OI Steps					Airspace Users		
AUO-0210	AUO-0216	AOM-0208-B	AOM-0304-B	Enabler Code	AU-MIL-W	WOC MT Mission Trajectory	AOC ASM Airspace Management
R				AOC-ATM-14	x	x	
R				AOC-ATM-20	x	x	
R				MIL-0105	x	x	x

OI Steps					Airspace Users		
AUO-0210	AUO-0216	AOM-0208-B	AOM-0304-B	Enabler Code	AU-MIL-W	WOC MT Mission Trajectory	AOC ASM Airspace Management
R				MIL-0106	x	x	x
			R	MIL-0108	x	x	
		R		MIL-AOC-ATM-0108a	x	x	
	R			MIL-AOC-ATM-0108b	x	x	
R				PRO-076	x	x	

Table 22: WOC Required (R) Enablers

Table 23 provides the Enabler Titles.

Enabler Code	Enabler Title
AOC-ATM-14	Upgrade of WOC system to handle improved OAT flight plans
AOC-ATM-20	Sharing of trajectory data between AOC/WOC and the ATM world using B2B web services
MIL-0105	CDM data integrated into the Wing Operations Centre Mission Support System
MIL-0106	Wing Operations Centre Mission Support System enhanced to support the CDM process
MIL-0108	Exchange of specific MT data (ARES description) in standard format
MIL-AOC-ATM-0108a	Integration of DMA type 1 and 2 into the development of MT
MIL-AOC-ATM-0108b	WOC mission support system enhanced to enable converting DMA type 1 and 2 data into the standard format
PRO-076	Procedures for the iSMT in the CDM process

Table 23: WOC Enabler Titles

5.5.2 Military cost assumptions

The costs provided here are to extend the WOC system to implement the PJ.07-W2-40 functionalities, on an already deployed WOC system. This assumes that a WOC system capable of managing dynamic airspace configurations is already operational when PJ.07-W2-40 starts to be deployed in 2028[10].

The costs are provided for two aspects:

[10] It is noted that following updates to some enabler V3 end dates, the Solution Start of Deployment date in DS23 draft has been adjusted to 2024. However, the WOC deployments for PJ.07-W2-40 involve adding additional functionalities to a WOC system, which itself is not expected to be fully deployed by 2027. Therefore the solution has opted to maintain the start of deployment date as 2028 to better reflect the expected deployment potential.

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- Mission Trajectory - the use of DMA Type 1 and 2 as ARES in the WOC MT functions
- Airspace Management - the handling and coordination of the DMA Type 1 and 2 reservations through the civil-military CDM process in the WOC ASM functions

5.5.3 Number of investment instances (units)

The cost has been estimated assuming the deployment of one WOC tool per ECAC state; this is based on the assumptions taken in PJ.08-01 in Wave 1 where the WOC tool is a distributed ASM tool with a central function and one client, see Appendix C for more details.

This approach has been taken as the exact number of clients per state is not known due to differing military organisations in ATM across ECAC states. It is acknowledged that:

- in reality, the detailed deployment is expected to be very specific for each country and could vary significantly from this assumption
- this cost approach may be underestimating the costs if there will actually be multiple clients / multiple WOC tools to be deployed per state

Military	
Ground facilities (WOC)	Air vehicles
44	None required

Table 24: Number of WOC Deployment Locations

5.5.4 Cost Per-Unit

The per-unit cost values provided in Table 25 are a starting point to build the CBA. However, for this, and other per-unit costs, there is expected to be a wide variation in reality due to the different situations in each state.

Cost category	Military	
	Ground facility (WOC)	Air vehicle
Implementation costs	WOC MT: 0.1 - 0.2 M€ per WOC 0.15 M€ (mid-point)	No airborne investment needed
	WOC ASM: 0.4 – 0.5 M€ per WOC 0.45 M€ (mid-point)	
Operating costs	No impact on annual operating cost was identified at this stage	

Table 25: Cost Per-Unit – WOC

5.6 Other relevant stakeholders

No other stakeholders are considered in this CBA.

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5.7 Cost Mechanism Summary

This section provides a summary of how the data in the previous sections is used to feed the CBA model. Table 26, Table 27 and Table 28[11] show the mid-range values that are used to produce the 'base' CBA results while the high range values are used in the sensitivity analysis, see section 8.

ANSP Costs (Civil + Military)

Investments	Cost per-unit		Deployment Locations		Cost
Civil ANSP	4.3 M€ per ACC	x	53	=	228 M€
Military ANSP	4.3 M€ per ACC	x	20	=	86 M€
					314 M€
Operating costs					
Civil ANSP	0.3 M€ per ACC	x	53	=	16 M€
Military ANSP	0.3 M€ per ACC	x	20	=	6 M€
					22 M€

Table 26: ANSP Cost Summary

NM Costs

	Cost per-unit		Deployment Locations		Cost
Network Manager	7.5 M€	x	1	=	**7.5 M€**

Table 27: Network Manager Cost Summary

WOC Costs

	Cost per-unit		Deployment Locations		Cost
WOC - MT	0.15 M€	x	44	=	6 M€
WOC – ASM	0.45 M€	X	44	=	20 M€
					26 M€

Table 28: WOC Cost Summary

[11] Some values are rounded for presentation purposes, however, the more precise values are used in the CBA model

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6 CBA Model

The embedded CBA model is based on the Single Solution CBA model (s7.4.1) produced by PJ.19-04. Scenario 1 includes the data used for the main CBA results in section 7 and Scenario 2 includes the data used for the pessimistic scenario in the sensitivity analysis in section 8.3.

PJ07-S40-CBA_Mod
el-s7.4.1-v5.xlsm

6.1 Data Sources

Cost Inputs

The sources for the Solution cost data are the relevant PJ.07-W2-40 partners. Cost inputs have been provided per Enabler and collated to provide the values in section 5.7.

Benefit Inputs

The source for the benefit calculation inputs are the Performance Assessment Results from the PJ.07-W2-40 Performance Assessment Report [14]. The inputs values for the CBA are listed in section 4, Table 8.

Other Input Parameters

The data sources for the non-Solution specific CBA Model parameters are referenced in the various inputs sheets of the CBA Model with details provided in the sheet 'Source of Reference'. These are all part of the Common Assumptions [9].

7 CBA Results

This section provides the results of the PJ.07-W2-40 V3 CBA that has assessed the deployment of '**Initial 4D Mission Trajectory development with integrated DMA types 1 and 2 supported by automation and dynamic civil-military CDM**' in Very High, High and Medium density en-route airspace. The Solution is applicable in the planning phase and the benefits calculated in the CBA are based on the assumption that the planned trajectories are executed as planned.

The CBA has been built on the following information:

- Investments costs (pre-implementation and implementation costs) have been identified for the ANSPs, the Network Manager and Military WOCs.
- The WOC investments cover the additional functionalities required for PJ.07-W2-40. It is assumed that an underlying WOC system is already in place.
- Benefits (airspace capacity as well as fuel, CO_2 and time efficiency) have been estimated and monetised in the CBA Model for Airspace Users (Scheduled Airlines and Business Aviation).

The CBA results are positive with a **Net Present Value** of **546 M€** (discounted at 8% over the period 2022 to 2043) and **payback year is 2033.**

The sensitivity analysis in section 8 explores these results in more detail to see the impact on the NPV of changing some of the assumptions.

7.1 Discounted Values

The values in this section are discounted to account for the time value of money[12]. Undiscounted values are shown in section 7.2.

Table 29 shows that the CBA, which is based on the assumptions defined in previous sections, results in a **Net Present Value** of **546 M€**. The NPV is discounted at 8% over the period 2022 to 2043. The **payback year is 2033** which reflects the year when the benefits offset the costs (both discounted); this is shown in Figure 9 where the discounted cumulative net benefits line crosses back above the x-axis.

Looking at the discounted results of individual stakeholders in Table 29 it is clear that with the current assumptions and inputs, the expected benefits more than offset the overall costs. However, the split across stakeholders is unequal as ANSPs (including civil and military), the WOC and NM have negative CBAs as they have costs but no monetisable benefits (based on the performance results). While the civil Airspace Users (Scheduled Airlines and Business Aviation) have positive CBAs as they receive the monetisable benefits and have no associated costs.

Discounted 8%	Net Present Value	CAPEX	OPEX	Benefits
ANSP	-234	-152	-82	0
WOC	-13	-13	0	0

[12] The time value of money reflects the idea that 1€ received today has more value than 1€ received in 2043 because it could be invested and earn interest over that period.

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Discounted 8%	Net Present Value	CAPEX	OPEX	Benefits
Network Manager	-4	-4	0	0
Business Aviation	54	0	0	54
Scheduled Aviation	743	0	0	743
Overall	**546**	**-169**	**-82**	**797**

Table 29: PJ.07-W2-40 Discounted CBA Results (per stakeholder and overall)

Figure 9 shows these 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. The payback year is the year where the Cumulative Net Benefits become positive and the line crosses back over the x-axis; in this case in 2033.

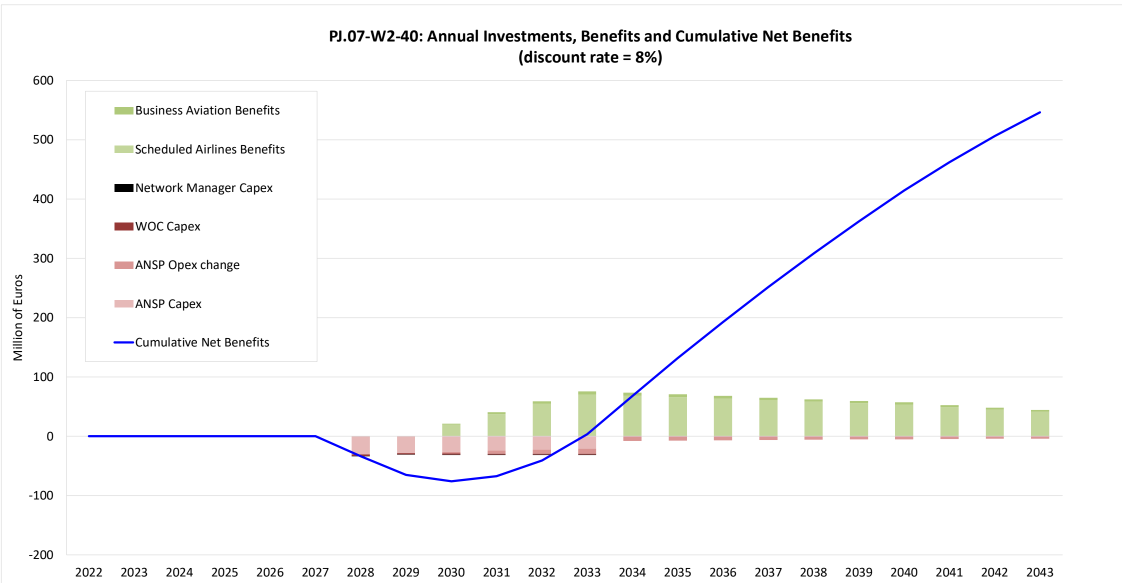

Figure 9: PJ.07-W2-40 Annual Investment Levels and Benefits (Discounted)

Figure 10 shows the same cost and benefit data as Figure 9 but without the cumulative net benefits line so that the scale of the costs and benefits per stakeholder are clearer.

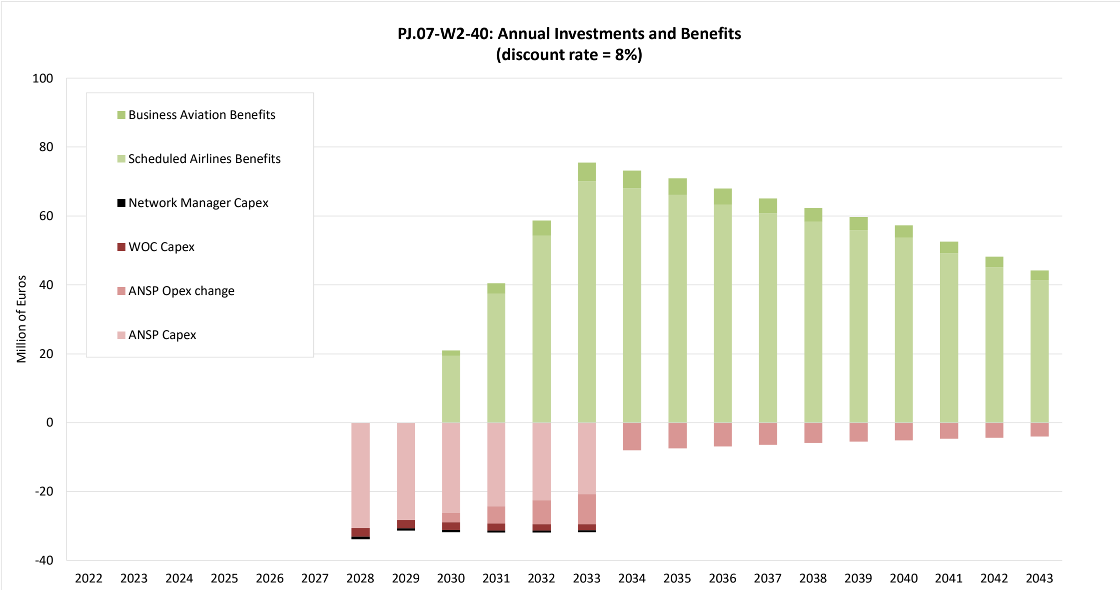

Figure 10: PJ.07-W2-40 Annual Investment Levels and Benefits expanded (Discounted)

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 in 2043 is considered to have the same value as one unit of currency spent or received today.

Undiscounted	Net Benefits	CAPEX	OPEX	Benefits
ANSP	-588	-314	-274	0
WOC	-26	-26	0	0
Network Manager	-8	-8	0	0
Business Aviation	182	0	0	182
Scheduled Aviation	2564	0	0	2564
Overall	**2125**	**-348**	**-274**	**2746**

Table 30: PJ.07-W2-40 Undiscounted Net Benefits (per stakeholder and overall)

Table 30 shows the undiscounted values, which show that without discounting, i.e. doing the CBA calculation with a discount rate of 0%, **the overall net benefits are 2125 M€.**

Figure 11 shows the undiscounted costs and benefits over each year. The undiscounted cumulative net benefits line is not included to avoid readers considering the point it crosses the x-axis as the payback year.

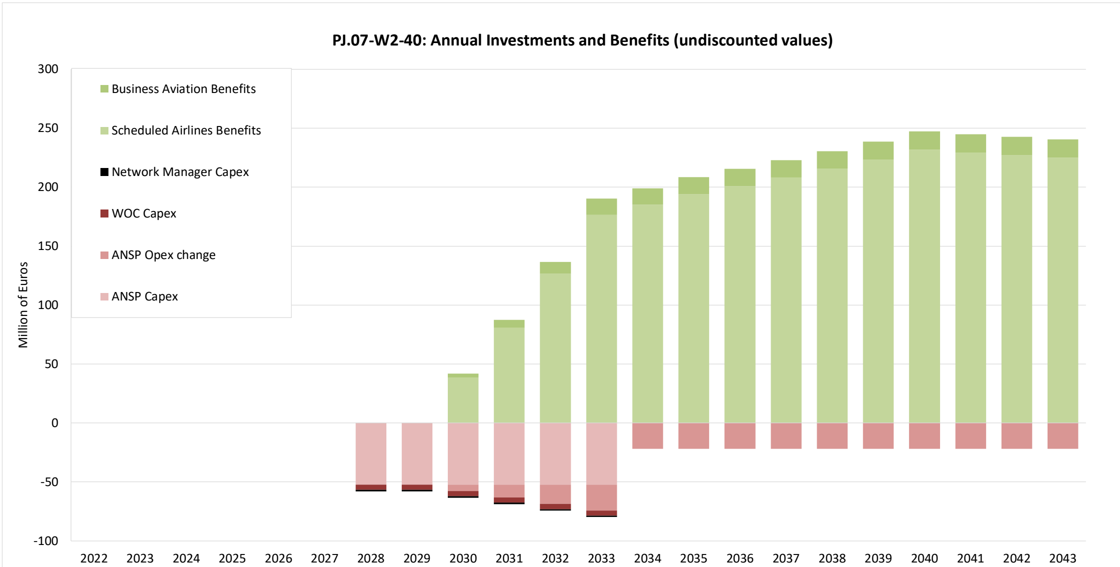

Figure 11: PJ.07-W2-40 Annual Investment Levels and Benefits (Undiscounted)

The undiscounted values are useful, especially for the costs, as they provide an idea of the overall investments that will be required. For example, based on these results, the stakeholders will be required to 'write cheques' totalling 348 M€ in investment costs (CAPEX) to deploy this Solution over the deployment period. The 169 M€ discounted cost value in Table 29 simply reflects the present value of those investments in 2022.

8 Sensitivity and risk analysis

This section[13] provides data on how sensitive the CBA results are to changes in the inputs values. When making investments it is useful to know which values can have the most impact on the results to help focus further work on refining data and assumptions. A pessimistic scenario has also been considered to see what happens when the costs are set to their high end of the range (provided in the cost assessment) and the benefits halved.

8.1 Discount Rate

The discount rate is used to reflect the time value of money[14] so reducing the discount rate reduces the difference between the value of money today and its value in the future. There is often much discussion on which discount rate to use so it is useful to look at a range of values. The undiscounted values included in section 7.2 reflect the 0% case.

For PJ.07-W2-40, the Net Present Value remains positive until the discount rate reaches around 44%.

Figure 12 shows that using a lower discount rate increases the NPV.

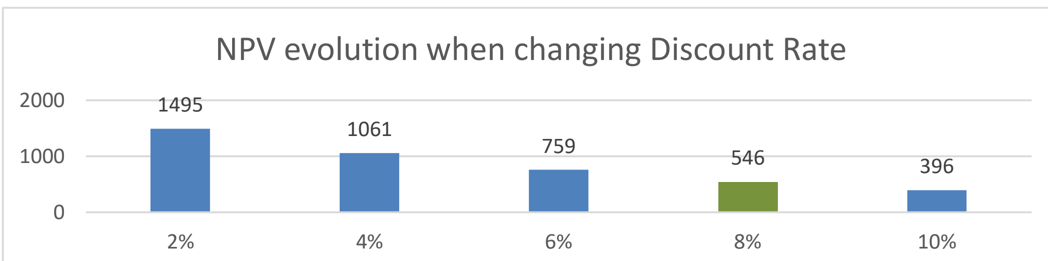

Figure 12: Sensitivity Analysis – Discount Rate

8.2 Sensitivity Comparison

Figure 13 shows the tornado diagram produced when the different cost and benefit inputs were each varied by -10% to +10% of their base value. The input values which produce the larger changes in the NPV are candidates for further investigation before deployment as they have the most potential to negatively impact the NPV.

The figure shows that the **Fuel Efficiency** and **Time Savings** (Time Efficiency) inputs have the largest impact on the results, while **ANSP Ground Operating cost change** (Ground OPEX) is the input with the lowest impact on the results.

[13] Risk Analysis has not been performed for this CBA as the Excel CBA model is not designed to apply Monte Carlo simulation techniques which are needed to calculate the NPV results for thousands of scenarios where different combinations of the input values (taken from probability distributions) are used in each.

[14] The time value of money reflects the idea that 1€ received today has more value than 1€ received in 2043 because it could be invested an earn interest over that period.

For the Fuel Efficiency savings, the tornado diagram shows that a 10% reduction in time saving benefits would result in around a 7% reduction in the Net Present Value. The CBA is considered to be very sensitive to an input value if the impact on the NPV is higher than the change in the input value, e.g. a 10% change in the input value resulted in a 15% change in the NPV.

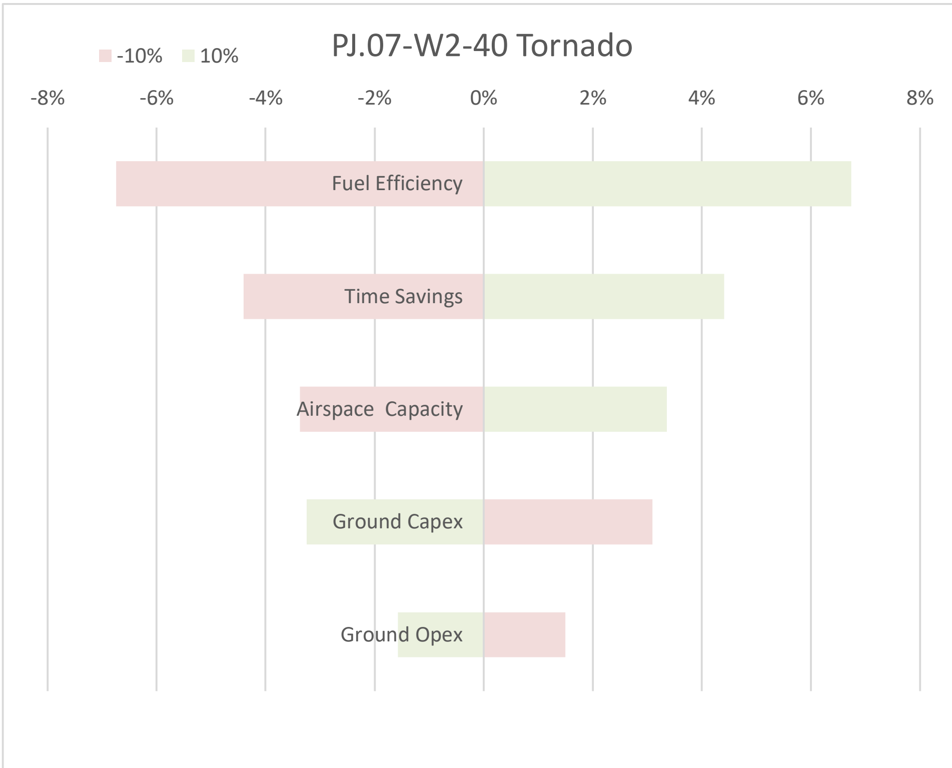

Figure 13: PJ.07-W2-40 Tornado diagram

8.3 Sensitivity Scenario

This section provides the Net Present Value when the cost inputs are set to their high values at the same time that the benefit inputs are halved. This can be considered as a pessimistic view.

The CBA input values are shown in the tables below[15].

Investments	Cost per-unit		Deployment Locations		Cost
Civil ANSP	6.3 M€ per ACC	x	53	=	334 M€
Military ANSP	6.3 M€ per ACC	x	20	=	126 M€
					460 M€
Operating costs					

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Civil ANSP	0.6 M€ per ACC	x	53	=	32 M€
Military ANSP	0.6 M€ per ACC	x	20	=	12 M€
					44 M€

Table 31: ANSP Costs - doubled

<u>**NM Costs**</u>

	Cost per-unit		Deployment Locations		Cost
Network Manager	9 M€	x	1	=	**9 M€**

Table 32: Network Manager Costs - doubled

<u>**WOC Costs**</u>

	Cost per-unit		Deployment Locations		Cost
WOC - MT	0.2 M€	x	44	=	9 M€
WOC – ASM	0.5 M€	X	44	=	22 M€
					31 M€

Table 33: WOC Cost - doubled

8.3.1 Benefits halved

The benefit values shown in section 4 were halved for:

- Airspace Capacity (0.3%)
- Fuel efficiency (3.25kg/flight) which also halves the CO_2 benefits
- Time Efficiency (-0.07%)

8.3.2 Pessimistic Scenario CBA Results

Table 34 shows that in the pessimistic situation where the costs are set to their high values and the benefits halved, the NPV becomes negative at -7 M€.

This shows that there is quite a margin around the costs and benefits before the CBA switches to become negative. The costs (CAPEX + OPEX) increase from 622 M€ (undiscounted) in the section 7 CBA results to 1048 M€ in this pessimistic scenario, a 68% increase.

Discounted 8%	Net Present Value	CAPEX	OPEX	Benefits
ANSP	-387	-223	-164	0
WOC	-15	-15	0	0
Network Manager	-4	-4	0	0
Business Aviation	27	0	0	27

Discounted 8%	Net Present Value	CAPEX	OPEX	Benefits
Scheduled Aviation	373	0	0	373
Overall	-7	-243	-164	400

Table 34: PJ.07-W2-40 Pessimistic Scenario - Discounted CBA results (per stakeholder and overall)

Table 35 shows the undiscounted values for the pessimistic scenario.

Undiscounted	Net Present Value	CAPEX	OPEX	Benefits
ANSP	-1007	-460	-548	0
WOC	-31	-31	0	0
Network Manager	-9	-9	0	0
Business Aviation	91	0	0	91
Scheduled Aviation	1286	0	0	1286
Overall	330	-500	-548	1377

Table 35: PJ.07-W2-40 Pessimistic Scenario - Undiscounted CBA results (per stakeholder and overall)

9 Recommendations and next steps

In summary, the PJ.07-W2-40 V3 CBA results are **positive with a Net Present Value (NPV) of 546 M€** reflecting that the benefits from deploying this Solution are expected to exceed the costs of deploying and operating it. Confidence in the benefits is low as some of the benefits could not be fully assessed in the validation exercises. There were also concerns over the extrapolation of some of the cost data to operating environments where the solution partners do not have direct experience.

These V3 results are based on the assumptions that WOC systems with the functions necessary to manage dynamic airspace configurations are already deployed and that only the additional PJ.07-W2-40 functionalities are included in this CBA. In addition, the initial Operational Air Traffic Flight Plan (iOAT FPL) is also assumed to be deployed as it is needed to share Mission Trajectory (MT) data with NM and ANSPs.

The NPV has been calculated with an 8% discount rate over the period 2022 to 2043, with PJ.07-W2-40 being deployed between 2028 and 2033 and with benefits starting to be realised from 2030[16]. The payback year is 2033, which reflects when the discounted cumulative net benefits will exceed the costs.

The sensitivity analysis shows that in a pessimistic scenario where (a) the costs at all deployment locations are at the high end of the range of assessed values (an increase from 622 M€ to 1047 M€ undiscounted CAPEX + OPEX), and (b) the benefits are half what was expected, then the CBA would switch to become negative with an NPV of -7 M€.

A recommendation for expanding the concept developed in PJ.07-W2-40 CBA is to involve the Regional Air Traffic Flow and Capacity Management (ATFCM) and Airspace Management (ASM) actors in the associated dynamic civil-military CDM.

[16] It is noted that following updates to some enabler V3 end dates, the Solution Start of Deployment (SOD) and Initial Operating Capability (IOC) dates in DS23 draft have been adjusted to 2024 and 2027 respectively (from 2028 and 2030). However, the WOC deployments for PJ.07-W2-40 involve adding additional functionalities to a WOC system, which itself is not expected to be fully deployed by 2027. Therefore the solution has opted to maintain the dates of 2028 for SOD and 2030 for IOC as they better reflect the expected deployment potential.

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10 References and Applicable Documents

10.1 Applicable Documents

[1] SESAR 2020 Project Handbook, edition 02.02.00, 08 June 2020

[2] SESAR Cost-Benefit Analysis Model[17] (Single Solution Wave 2)

[3] EUROCONTROL, Standard Inputs for EUROCONTROL Economic Analyses, Edition 9, December 2020

[4] SESAR 16.06.06-D26_03, Methods to Assess Costs and Monetise Benefits for CBAs, Ed. 00.02.02

[5] EUROCONTROL, Method to assess cost of European ATM improvements and technologies, v1.0, 28 July 2014

[6] SESAR 16.06.06-D26_08, ATM CBA Quality checklist, Edition 02.00.01

[7] SESAR 16.06.06-D26_04, Guidelines for Producing Benefit and Impact Mechanisms, Ed. 03.00.01

10.2 Reference Documents

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

[9] SESAR 2020, PJ19, D4.0.30 S2020 Common Assumptions (2019), Edition 00.00.02

[10] SESAR 2020, PJ19.04, En-route and Terminal Airspace OEs, Edition April 2019

[11] SESAR 2020 W1, SESAR Solution PJ.07-03: Cost Benefit Analysis (CBA) for (ongoing) V3, Deliverable D4.2.040, Edition 00.01.00, 23 September 2019

[12] SESAR 2020 W1, SESAR Solution PJ.08-01 Cost Benefit Analysis (CBA) for V2, Deliverable D2.1.051, Edition 00.01.00, 24 July 2019

[13] SESAR 2020, PJ.07-W2-40, D4.1.012, SESAR Solution PJ07-W2-40 Final SPR-INTEROP/OSED for V3 - Part I, Edition 01.00.00, 30 September 2022

[14] SESAR 2020, PJ.07-W2-40, D4.1.012, SESAR Solution PJ07-W2-40 Final SPR-INTEROP/OSED for V3 - Part V-Performance Assessment Report (PAR), Edition 01.00.00, 30 September 2022

[15] SESAR 2020 D4.7, PJ19.04: Performance Framework (2019), Edition 01.00.01, 30 November 2019

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

[16]SESAR 2020 D4.0.1, PJ19-W2: Validation Targets – SESAR 2020 Wave 2 & Wave 3, Edition 00.01.00, 04 May 2021

Appendix A iMT and DMA types 1 and 2 – OSED data

The following sections are taken from the OSED [13] and included here to provide more details on the initial Mission Trajectory and Dynamic Mobile Areas type 1 and type 2. For additional information see the OSED, section 3.3.2 New SESAR Operating Method.

A.1 Initial Mission Trajectory iMT

Initial Mission trajectory is a trajectory that expresses the intention of military AU, includes both surface and airborne segments, which are built from and updated with the timeliest and accurate data to be integrated into the ATM network operations. In occurrences when dictated by operational needs MT may contain airspace reservation/restriction ARES of different types (Static, VPA, DMA).

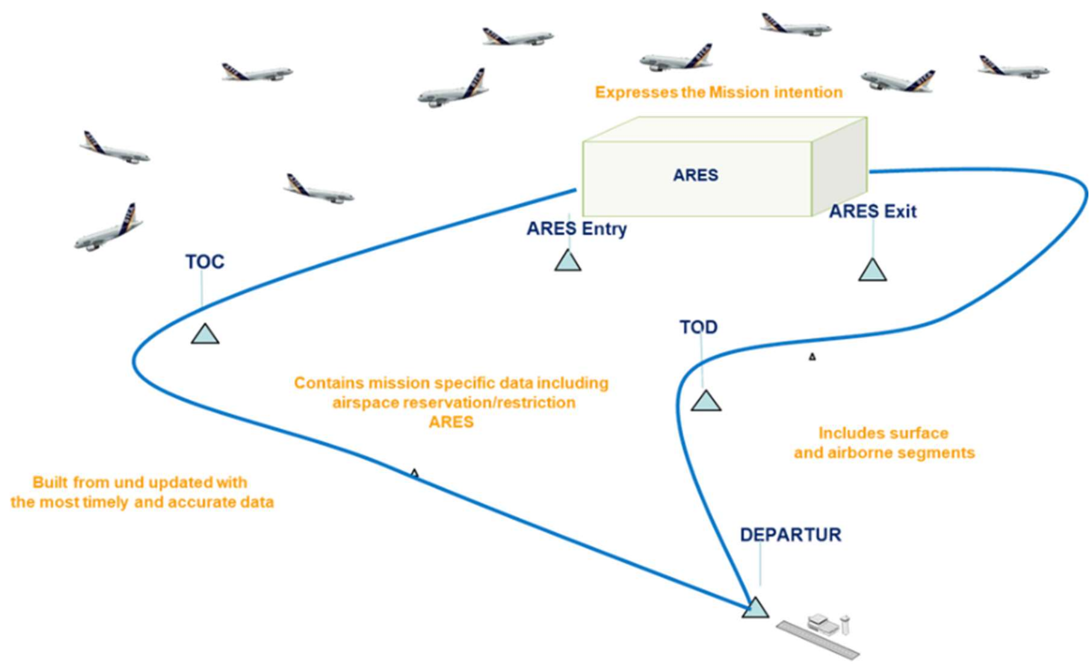

Figure 6: iMT definition

The iMT describes the trajectory with specifics adherent to the mission objectives. The trajectory data set contains a 2D route, multiple values of elapsed time EETs, flight level/altitude, speed, ATM constraints, and data set describing ARES type (Static, VPA, DMA) with flexible parameters when applicable as well as information related to the aircraft type, its equipment, and exemptions when applicable.

The IMT does not include an accurate 4D value in trajectory description, as it would be required to perform the tasks of each flight plan recipient. Therefore, receiving ATM stakeholders have to interpolate a 4D trajectory based on the available iMT data and make assumptions wherever required to close the gaps resulting from limited data delivered by the iOAT FPL. Usage of the correct flight performance information facilitates the mitigation of these gaps through more precise insight on the trajectory profile per flight phase.

The iMT data model will be further developed with respect to the confidentiality of mission specific data. The further harmonisation of iMT data regards eFPL and FF-ICE data models as future reference models to substitute the iOAT FPL allowing military AUs to perform coherent and efficient sharing of 4D trajectory and trajectory management.

In the context of solution PJ.07-W2-40, iMT concerns the development and integration of ARES based on DMA design principle into description of the integrated military ATM demand. Developed in Wave 1 DMA Type 1 and 2 description will evolve to the level of details necessary for new operating methods with focus on the development the iMT data set and DMA flexible parameters with associated thresholds.

Given the diversity of new partners involved in developing the solution, the DMA description will be repeated to provide a consistent view of the taxonomy of the DMA definition and its application.

A.2 Dynamic mobile area DMA type 1 and 2

Dynamic mobile area (DMA) is a new ARES design principle that stands for better dynamicity and flexibility for specific military missions of manned and unmanned aircraft. By design, DMA could be geographically centric and aircraft centric.

The solution is focusing on the geographically centric DMAs while aircraft centric DMA is shifted to the next cycle of R&D activities within the scope of SESAR 3.

However, it should be noted that DMA concept does not replace or overrule the existing concepts using static ARES and to be considered as a complementary solution available to airspace users requiring temporary reservation/restriction of airspace for their activities.

Geographically centric DMA can be allocated within predefined geographic limits according to the parameters set by AU (time or distance flown from airbase) - DMA type 1 or can be allocated along flight profile at any geographic location that satisfies operational necessity of the military mission - DMA type 2.

DMA may contain flexible parameters, which are integrated into the MT dataset and are shared with all pertinent ATM and relevant non-ATM actors concerned. Flexible DMA parameters are used to optimize DMA configuration/geographical location in the scope of dynamic configuration of ATC sectors and traffic volumes in order to satisfy local performance targets. CDM process between ASM ATFCM and WOC actors facilitates agreement on the optimal conflict-free airspace configuration within predefined geographic limits, while preserving the requirements of the military activity.

DMAs are integral part of the trajectory description, expressed in a 4D dataset via DMA specification, for which the three dimensional values (e.g. spatial coordinate's x-y-z), time, and velocity, either constants or variables and depend on the DMA type. The DMA flexible parameters enable dynamicity and flexibility of the military ATM demand.

DMAs are described in a 4D dataset:

- Either as a part of the MT dataset, or
- Separately in the cases where the entire MT is inside the DMA volume, or when MT is entering the DMA volume from unmanaged airspace

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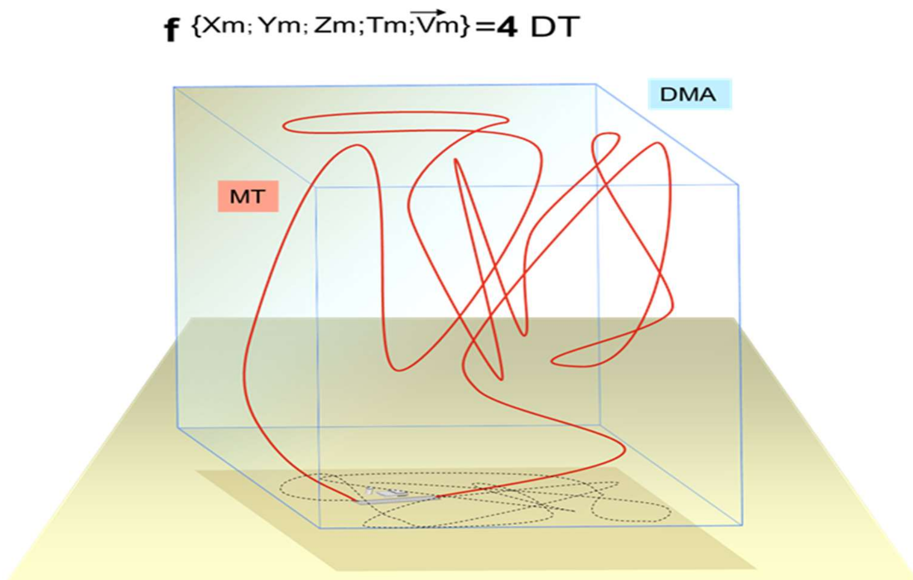

Figure 8: 4D-trajectory description (MT entirely inside DMA)

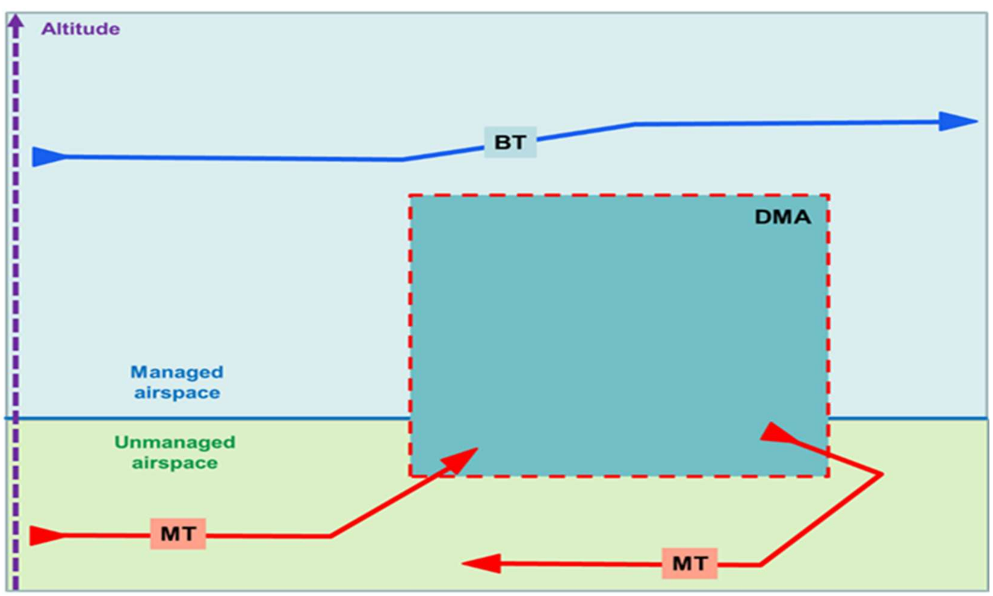

Figure 9: MT in unmanaged airspace and the DMA (in vertical plain)

A.2.1 DMA type 1

DMA Type 1 is a volume of airspace of defined dimensions, described either as an integral part of a MT, or independently at flexible geographic locations agreed upon in a CDM process, satisfying Airspace Users requirements in terms of a time and/or distance constraint parameters from a reference point as specified by AU (e.g. Aerodrome of Departure).

The position of this volume over specific geographic location is variable and negotiated through CDM process. The outcome may require from the AU complete modification of the relevant MT.

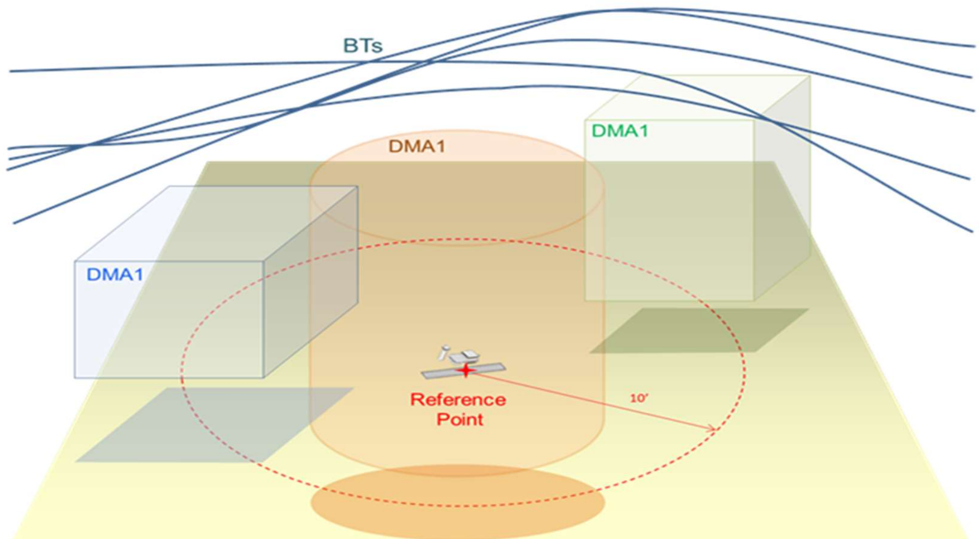

Figure 10: DMA type 1

The timeline set for the DMA type 1 allows previously synchronised trajectories to operate in this volume of airspace during the limited period. The design of such ARES should satisfy operational requirements of the mission and must contain flexible parameters, which facilitate alignment of the geographic location of such volume of airspace. The implementation of the new design principle does not substitute the fixed or VPA designed ARES and applies only when DMA can facilitate accomplishment of the mission objectives.

A.2.2 DMA type 2

DMA Type2 is a volume of airspace of a defined dimension, described as an integral part of the MT and agreed upon in the CDM process, to meet the requirements of airspace users in terms of volume, location and duration. This volume of airspace can be allocated at any geographic location that satisfies operational requirements of the AU. It is used to integrate special en-route activity information into iMT dataset and indicates to all ATM and non-ATM actors concerned, the intention to use the ARES along the intended flight route.

The main feature of ARES DMA type 2 is dependency on the iMT profile. Described as integral part of iMT dataset DMA type 2 contains flexible parameters as a necessary attribute facilitating allocation of ARES and trajectory management. While the flexible parameters are essential for CDM and impact assessments performed by relevant ATM actors, the trajectory management process becomes more complex.

The outcome of the CDM process may require either a modification of the ARES configuration/geographical location or the activation time along the trajectory profile, or a complete adaptation of trajectory and DMA keeping in mind that the objective is to preserve military AU's requirements.

The usage of the allocated DMA by multiple trajectories requires synchronisation and preliminary coordination between the military operational stakeholders before trajectory is sharing with ATM actors concerned.

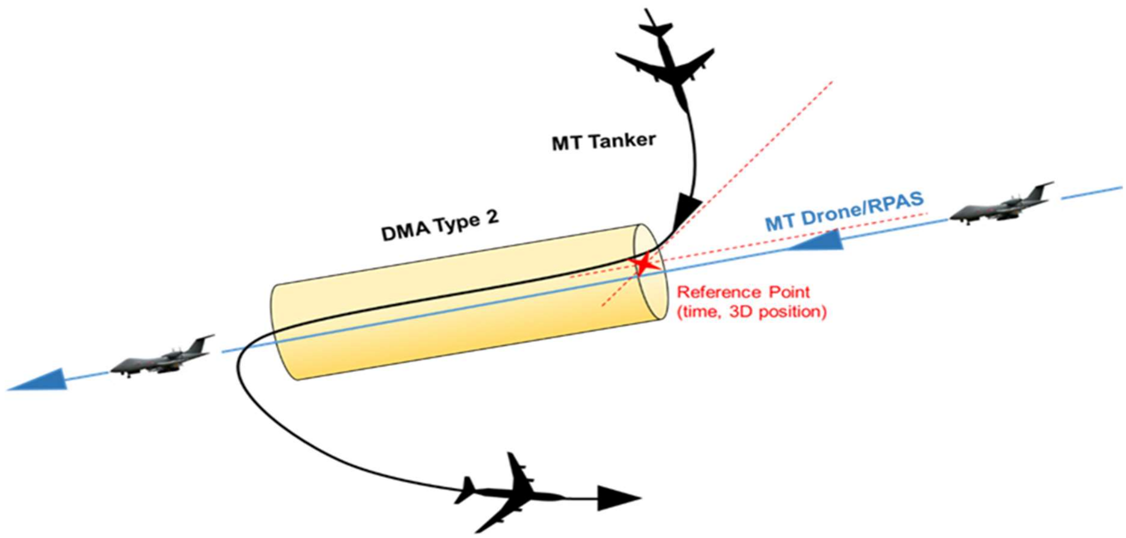

Figure 11: DMA type 2

A.3 DMA design and allocation

DMA design is a process supported by system functionalities based on the predefined algorithms and criteria developed by operational stakeholders in order to define a three-dimensional volume of airspace that satisfies, based on CDM, the operational needs of the military AU and pertinent ATM stakeholders.

DMA design applies in occurrences when military operational stakeholders decide to use DMA type 1 and 2 for their specific mission needs. For DMA design they apply multiple criteria relevant to the aircraft type (manned/unmanned, fighter jet, transport type etc.), type of mission (ground support, air-to-air refuelling, cargo drop etc.) and operational objectives, which fulfilment depend on DMA configuration and geographical position.

The DMA volumes can be of various shapes and must reflect delineation of lateral and vertical boundaries, including the safety buffers. Given the type of mission and the flight performance of the aircraft, the volume of airspace must be optimally sized to meet the objectives of the mission.

There are two possible approaches, but not limited, the operational stakeholders may apply for the DMA design:

1. First option is when military operational stakeholders develop a list of the predefined DMA 3D volumes configured according to the operational requirements and scenarios available per mission type for daily training. The allocation process and time duration still remain ad-hoc and have temporary nature.
2. Second option is when DMA design and allocation are strictly linked to the mission profile (could be more than one mission or more than one DMA) and objectives to be fulfilled inside ARES

temporarily allocated at the predefined geographical location within fixed period of time. The allocation process still remain ad-hoc and activation having temporary nature.

First approach allows developing DMA configurations far in advance and to catalogue it for daily use at geographical locations that suit best a mission type. However, each request may or may not contain flexible parameters linked to the DMA type which can be modified within predefined thresholds unless these parameters have already been fixed and associated with the DMA type 1 volume designed for the specific mission needs.
Flexible parameters are important information elements that facilitate adjustment and modification of the airspace volumes in the context of dynamic airspace configuration within thresholds defined by airspace users. Such thresholds provide clear indication of the perimeter within which the flexible parameters could be used in order to optimise the DMA dimensions and time.

Second approach is more complex as it requires individual approach to each mission type that requires DMA to be designed and allocated along the trajectory profile. In this case, the allocation process requires more information regarding historical data of the traffic flows, ATC volumes, and ATM constraints, which may influence the entire mission trajectory. Additionally, DMA parameters should be converted into 4D trajectory description as it becomes integral part of the mission trajectory profile.

It is a responsibility of the military operational stakeholders to define what type of missions can exploit DMA design principle in order to fulfil operational objectives and ensure effectiveness of the mission.

It should be noted that in congested airspace with high complexity, the DMA size should be tolerated with other elements of the airspace structure and allocation process shall fall under CDM process considering priorities of different categories of airspace users.

The allocation of the DMA type 1 and 2 shall take place in a medium-to-short term planning phase considering ad-hoc nature of the ARES and need to integrate it into ATM network configuration.

In the context of MT concept, the allocation process is associated with Early Flight Intent that introduces request for ARES allocation in medium-to-short term planning phase within time line from 7 days before the day of operations until one day before the day of operations.

It is strongly recommended to adhere to this timeline to ensure a proper balance between allocation of the integrated military ATM demand for DMA and demand of other operational stakeholders for available volume of airspace.

Each DMA type allocated ad-hoc should carry its unique identifier that will be used as a reference for the airspace and trajectory management in planning and execution phases.

Preliminary coordination with other operational stakeholders is a necessary prerequisite to ensure efficient allocation and further use of the DMA type 2. That means that after ASM process is complete the trajectory management takes place and fine-tunes MT data. Synchronisation of several trajectories participated in the allocated DMA is a must to successfully accomplish mission objectives.

It is important to emphasize that the difference between DMA type 1 and DMA type 2 sits in the user-defined parameters and limitations imposed during allocation process.

In case of DMA type 1, the distance and time flown from the reference point e.g. airbase, nav. aid etc. should not exceed a predefined values expressed as a distance or time flown e.g. 60NM or 10 min.

DMA type 2 is not constrained by AU parameters and can be allocated along the intended flight route at any geographic location that suits best the mission objectives. The synchronisation of trajectories using the same DMA becomes a necessary precondition in the iMT management and integration into the ATM network operations

Appendix B Stakeholder Codes

Table 36 expands the stakeholder codes used in DS23 and provides a link to the stakeholder names used in the CBA.

STAKEHOLDER CODE	STAKEHOLDER TITLE	Link to Table 6
ANSP	Air Navigation Service Provider	ANSP
ANSP-CIV-AERO	Civil ATS Aerodrome Service Provider	
ANSP-CIV-AIS	Civil AIS Service Provider	
ANSP-CIV-APP	Civil ATS Approach Service Provider	
ANSP-CIV-CNS	Civil CNS Service Provider	
ANSP-CIV-ER	Civil ATS En-Route Service Provider	
ANSP-CIV-MET	Civil MET Service Provider	
ANSP-CIV-SWIM	Civil SWIM Service Provider	
ANSP-MIL-AERO	Military ATS Aerodrome Service Provider	
ANSP-MIL-AIS	Military AIS Service Provider	
ANSP-MIL-APP	Military ATS Approach Service Provider	
ANSP-MIL-CNS	Military CNS Service Provider	
ANSP-MIL-ER	Military ATS En-Route Service Provider	
ANSP-MIL-MET	Military MET Service Provider	
ANSP-MIL-SWIM	Military SWIM Service Provider	
ANSP-CIV-AMC	**Civil**-Military Airspace Management Cell	AMC
ANSP-MIL-AMC	Civil-**Military** Airspace Management Cell	
AO	Airport Operator	Airport Operators
AP-OPR-CIV	Civil APT operator	
AP-OPR-MIL	Military APT operator	
AU	Airspace Users	Airspace Users
AU-CIV-BA-F	Civil Business Aviation-Fixed Wing	Business Aviation
AU-CIV-BA-R	Civil Business Aviation-Rotorcraft	Rotorcraft
AU-CIV-FOC	Civil Flight Operations Centre	Scheduled Airlines Business Aviation
AU-CIV-GA	Civil General Aviation	General Aviation IFR / VFR
AU-CIV-SA	Civil Scheduled Aviation	Scheduled Airlines (Mainline and Regional)
AU-MIL-F	Military Fighter	Military - Airborne
AU-MIL-L	Military Light Aircraft	
AU-MIL-T	Military Transport	

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AU-MIL-W	Military Wing Operations Centre	Military – Ground
NET-MAN	Network Manager	Network Manager

Table 36: Stakeholder Codes and Titles (with link to Table 6)

Appendix C Military WOC Assumptions

This Appendix provides an overview of the assumptions taken regarding the number of WOC deployments. These assumptions are taken from Wave 1 PJ.08-01. The detail is provided here for transparency and to help with future updates to the CBA.

Introduction

The architecture of military and civil-military ATM organisations across European States is not uniform; consequently, it is difficult to estimate accurately the number of WOC functions at ECAC level.

In Figure 14, the term WOC is used for the single state-level entity, however, some states may use the term WOC to refer to the central entity and/or the individual Military units. Therefore, depending on the state, the figure below could represent 1 WOC or 6 or 7 WOCs.

There are no civil-military WOC functions; they are either military (WOC[18]) or civil (FOC).

It is common among European Military to have a central entity (shown below as 'WOC (state-level)'. This entity collects, de-conflicts, coordinates with Air Defence Control Centres (who control the purely military part of the flight) and approves the airspace reservation requests of military units (wings, squadrons, etc.) before sending a consolidated military airspace request to the Local (state-level) ASM function (currently AMC).

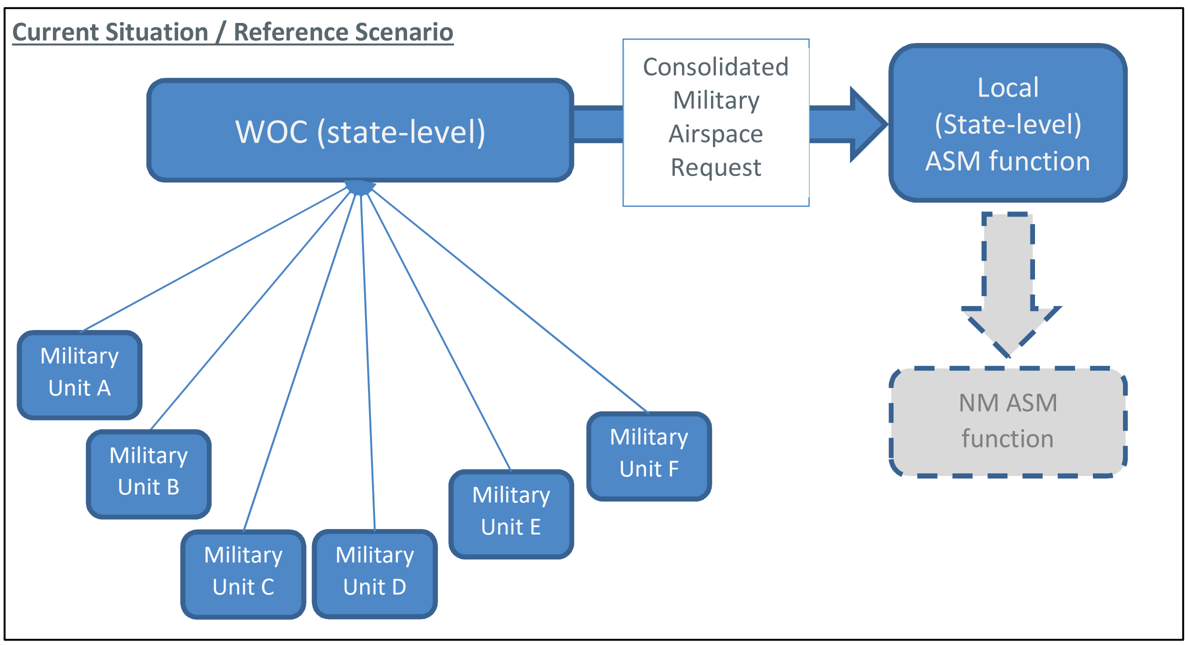

Figure 14: Reference Scenario view on WOC

Figure 15 shows the changes proposed by PJ.08-01 and assumed for PJ.07-W2-40; these are:

[18] Noting that the term WOC is also used for operation centres when the operations are not fully compliant with civil operations, e.g. Airbus testing

- a WOC tool prototype, which is a distributed ASM tool (one central entity connected to clients to capture their operational needs, which then defines and manages ARES)
- DAC tool prototypes that are ASM-ATFCM tools to be used at the local level jointly by the DAC function (currently AMC and FMP).

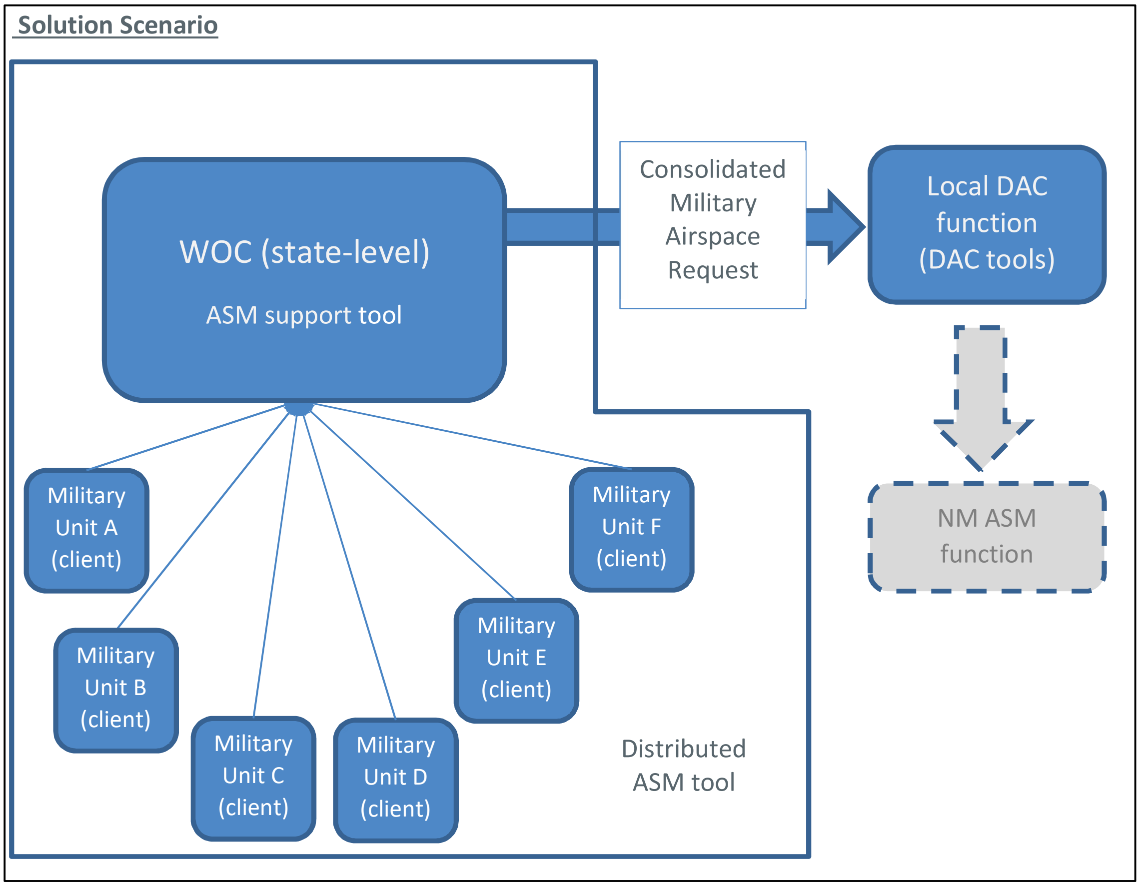

Figure 15: PJ.08-01 Solution Scenario view on WOC

As it is not currently possible to estimate the number of WOC function clients (units, wings, squadrons) at State and ECAC level the CBA uses the following assumptions.

WOC Assumptions

Each ECAC State will deploy one **WOC function** supported by a distributed ASM tool. The stakeholder that will deploy is the State, paying from the MOD budget. The CBA includes the cost of a distributed tool with one client for each of the 44 ECAC States; additional clients will incur additional costs.

Appendix D Mapping

Mapping between ATM Master Plan Performance Ambition KPAs and SESAR Performance Framework KPAs, Focus Areas and KPIs, source reference *[16]*

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

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

Table 37: Mapping between ATM Master Plan Performance Ambition KPAs and SESAR Performance Framework KPAs, Focus Areas and KPIs

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