INDUSTRIAL RESEARCH

D4.2.080-PJ.10-W2-96 AG-TLR6 Final CBAT

Deliverable ID:	D4.2.080
Dissemination Level:	PU
Project Acronym:	PJ.10-W2 PROSA
Grant:	874464
Call:	H2020-SESAR-2019-1
Topic:	Separation Management and Controller Tools
Consortium coordinator:	DFS
Edition date:	17 February 2023
Edition:	00.02.00
Template Edition:	02.00.07

EUROPEAN PARTNERSHIP

Co-funded by the European Union

Authoring & Approval

Authors of the document

Beneficiary	Date
Skyguide	17/02/2023

Reviewers internal to the project

Beneficiary	Date
SKYSOFT-ATM	13/12/2022
LEONARDO	13/12/2022
HUNGAROCONTROL	13/12/2022

Reviewers external to the project

Beneficiary	Date

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

Beneficiary	Date
SKYSOFT-ATM	13/12/2022
LEONARDO	13/12/2022
HUNGAROCONTROL	13/12/2022
NATS	19/12/2022*
SKYGUIDE	19/12/2022*

* Silent approval

Rejected By - Representatives of beneficiaries involved in the project

Beneficiary	Date

Document History

Edition	Date	Status	Beneficiary	Justification
00.00.01	26/08/2022	Interim	Skyguide	Interim draft CBA
00.00.02	27/10/2022	Draft	Skyguide	Update of assumptions, costs and benefits

00.00.03	09/12/2022	Draft	Skyguide	Further updates and assessment of benefits after delivery of initial PAR
00.00.04	07/12/2022	Draft	Skyguide	Further updates including sensitivity analysis, and risk assessment
00.00.05	08/12/2022	Draft	Skyguide	Draft recommendations
00.00.06	09/12/2022	Draft	Skyguide	Minor updates following internal review
00.01.00	19/12/2022	Final	Skyguide	Final version for submission to SJU
00.02.00	17/02/2023	Final	Skyguide	Final version (with updated BIM and CBA run up to the year 2043) after SJU assessment

PJ.10-W2 PROSA

SEPARATION MANAGEMENT AND CONTROLLER TOOLS

This technological solution CBA is part of a project that has received funding from the SESAR3 Joint Undertaking under grant agreement No 874464 under European Union's Horizon 2020 research and innovation programme.

Abstract

Solution PJ.10-W2-96 Attention Guidance (AG) deals with new methods of controller interaction with Human Machine Interface (HMI), implementing a fade-out algorithm in a very high complexity environment to bring a positive effect on the controller productivity with no negative impact on human performance, safety and capacity.

Considering the continuous growth of air traffic, AG is a technology that can help controllers focus their attention on those en-route movements which are most likely to require their attention, ultimately contributing to gains in efficiency, without negatively impacting capacity or safety.

This document aims at presenting the Cost Benefits Analysis (CBA) of the AG function at technology readiness level (TRL) 6.

Table of Contents

List of Tables

List of Figures

1 Executive Summary

The SESAR Solution PJ.10-W2-96 AG deals with new methods of controller interaction with Human Machine Interface (HMI), implementing a fade-out algorithm in a very high complexity environment. This is expected to bring a positive effect on the controller productivity with no negative impact on human performance, safety and capacity. En-route movements which are unlikely to require positive interaction with the controller can be temporarily faded out from the controller screen, pending the prior acknowledgement of the controller.

This document is the final version of the CBA of the Solution PJ.10-W2-96 AG at TRL6 level. It establishes the scope of the technological solution CBA (CBAT), including reference and implementation scenarios, stakeholders and key assumptions. By presenting the operational improvements, key enablers and benefits and costs associated to the solution, the CBAT explains how the implementation of PJ.10-W2-96 AG translates into economic terms.

The CBAT builds on other, related project documents, including the TVALP, TVALR, PAGAR questionnaire and PAR. The key assumptions of the CBAT are consistent with other project documentation.

EUROPEAN PARTNERSHIP

Co-funded by the European Union

2 Introduction

2.1 Purpose of the document

The document analyses the Solution proposed by the PJ.10-W2-96 AG in economic terms, comparing the costs expected to implement Attention Guidance (AG) in the Controller Working Position (CWP) with its potential monetary benefit, as the positive result of the Stakeholders investment. The analysis is provided with a detailed CBA to assess the economic feasibility of solution.

The CBAT is produced using the Reference Methodology as provided by SESAR guidelines on the CBAs, specifically: the Project Handbook [1]; Methods to assess Costs and monetize Benefits [3], and the Cost Analysis Model, among other documents.

2.2 Scope

The document provides the cost benefit analysis to the SESAR solution PJ.10-W2-96 AG at TRL6 level.

The focus is to assess the economic impact of implementing AG as a new method of controller interaction with Human Machine Interface (HMI), implementing a fade-out algorithm in a very high complexity environment to bring a positive effect on the controller productivity with no negative impact on human performance and safety.

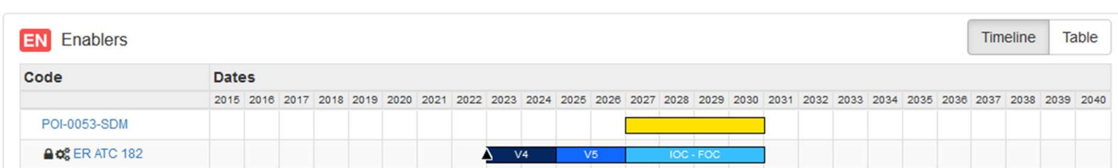
The operation improvement (OI) and technical enabler addressed are:

- **OI POI-0053-SDM: Improving controller productivity by Attention Guidance (AG) at the ER CWP/HMI**.
- **Enabler ER ATC 182: Introduction of new automated functions for Attention Guidance at the CHMI Management ER for improving the controller productivity**.

TIMEFRAME

The CBA for PJ.10-W2-96 AG solution is calculated for the years from 2019 to 2043, as per assumption indicated in [5], taking into consideration the IOC/FOC dates of the Solution [6].

- **IOC: 15/01/2027**
- **FOC: 15/01/2031**



GEOGRAPHIC SCOPE

The geographical scope covers the European Civil Aviation Conference (ECAC) countries. The target Operational Environment (OE) of PJ.10-W2-96 AG covers the En-Route Upper airspace only (above FL355), in ACCs of very high complexity (VHC). This is in line with the exercises performed in:

- **OE: En-route very high complexity (ER VHC).**

EUROPEAN PARTNERSHIP
Co-funded by the European Union

In accordance with information contained in [11], the following en-route ACCs are classed[1] as VHC with operations above FL355, and are hence in scope of the solution:

1. Karlsruhe UAC (Germany, DFS)
2. Zurich ACC (Switzerland, Skyguide)
3. Geneva ACC (Switzerland, Skyguide)

Additional en-route ACCs could be considered in the scope of the solution based on their current or forecasted traffic complexity scores at the IOC/FOC dates of the solution. These have not been considered in the CBA presented in this document.

The CBA presents the results at two levels:

- ANSP level – CBA results for Skyguide (2 ACCs) and DFS (1 ACC), and
- ECAC level – CBA results for three ACCs in scope of the Solution.

2.3 Intended readership

Belonging to a SESAR Technological solution, this CBA is of interest mainly for all enabled SESAR ATM Solutions focusing on defining improved operational processes based on HMI:

- **SESAR JOINT UNDERTAKING (SJU)** as SESAR 2020 Programme coordinator.
- **SESAR PJ.10-W2** consortium members in order to be aware of activities and methods being used to allow for coherency, consistency and comparability of the validation results through all SESAR 2020 solutions.
- **SESAR Solution PJ.10-W2-96 AG** consortium members in order to have a common and shared view on all technologies related to the CWP HMI.
- **SESAR Solution PJ.05-W2-97** consortium members in order to have a common and shared view on all technologies related to the CWP HMI.
- **SESAR PJ.19 Content Integration** that aims at assuring coherency, consistency, and comparability of the validation results throughout all SESAR2020 Solutions.
- **SESAR PJ.22** that maintains the SESAR2020 V&V platforms and Demonstration platforms catalogue.
- Any **SESAR solution**, which wants to use aspects of any development in Solution PJ.10-W2-96 AG.
- **Academic Researchers** in the fields of the AG activities.
- Representatives of civil stakeholders: **ANSPs**.

2.4 Structure of the document

This document is structured in the following chapters or paragraphs:

- **Section 1** provides the executive summary;

[1] Note that the SESAR 2020 Classification Scheme defined in [11] is based on the Aggregated Traffic ComplexitySscores by the ATC Operational Units in 2016.

- **Section 2** provides the overall scope, time horizon, intended audience, structure of the document, background, glossary of terms and acronyms;
- **Section 3** presents the objectives and scope of this CBA, provides a description of the Solution PJ.10-W2-96 AG and the problem addressed by this Solution, identifies the main stakeholders impacted and describes the scenarios assessed in the CBA;
- **Section 4** provides a view on the overall contribution to Key Performance Indicators and a description of the expected benefits;
- **Section 5** describes the cost approach and the main assumptions taken when assessing the cost elements of the Solution and presents the results of the cost assessment;
- **Section 6** provides a description of the CBA model and the sources of data used to build the CBA model;
- **Section 7** provides the CBA results;
- **Section 8** includes sensitivity and risk analysis;
- **Section 9** includes recommendations and next steps;
- **Section 10** includes the references and applicable documents.

The **CBA Model** used to quantify estimated costs and benefits for this CBAT is provided as a supporting document (in MS Excel format) and is part of the Annex.

2.5 Background

The Solution PJ.10-W2-96 AG takes into account the work performed at TRL4 level by S2020 PJ16-04 Wave 1 project. No previous CBA covering this SESAR Solution was performed in Wave 1 or other areas.

This CBA contributes to PJ.10-W2-96 AG reaching TRL6 maturity at the end of Wave 2 activities.

2.6 Glossary of terms

Term	Definition	Source of the definition
Net Present Value	Net Present Value (NPV) is the sum of all discounted cash inflows and outflows during the time horizon period.	*Investopedia*
En-route Very High Complexity	Very High complexity ACCs have a complexity score of equal to or greater than 10.	SESAR 2020 Classification Schema for Operating Environments (OEs)
Cost Benefit Analysis	Quantified statement of the economic worth of a project, in terms of costs and benefits to all parties which takes account of their timings.	SESAR 2020 Methods to Assess Costs and Monetise Benefits [3]
Sensitivity and risk analysis	Analysis of the impact of uncertainties of costs, benefits and parameters figures on the final CBA results.	SESAR 2020 CBA Template for Technological Solution
Sensitivity Analysis	Sensitivity analysis determines how different values of an independent variable affect a particular dependent	*Investopedia*

	variable under a given set of assumptions.	
Risk Analysis	Risk analysis refers to the assessment process that identifies the potential for any adverse events that may negatively affect organizations and the environment.	*Investopedia*

Table 1: Glossary of terms

2.7 List of Acronyms

Acronym	Definition
ACC	Area Control Centre
AG	Attention Guidance
ANSP	Air Navigation Service Provider
AoR	Area of Responsibility
APP	Approach
ATC	Air Traffic Control
ATCO	Air Traffic Controller Operator
ATM	Air Traffic Management
ATS	Air Traffic Services
BIM	Benefit Impact Mechanisms
CAP	Capacity
CEF	Cost Efficiency
CFL	Cleared Flight Level
CLAM	Cleared Level Adherence Monitoring
COF	Change of Frequency
CWP	Controller Working Position
ECAC	European Civil Aviation Conference
ECAT	Exit Conflict Alert Tool
EHS-CLAM	Enhanced Cleared Level Adherence Monitoring
ER	En-Route
FL	Flight Level
FOC	Final Operational Capability
HC	High complexity (airport)

Acronym	Definition
HMI	Human Machine Interface
IFR	Instrument Flight Rules
IOC	Initial Operational Capability
KPA	Key Performance Area
KPI	Key Performance Indicator
LC	Low complexity (airport)
LTCA	Long Term Conflict Alert
MTCA	Medium Term Conflict Alert
NPV	Net Present Value
OE	Operational Environment
OI	Operational Improvement
PIRM	Programme Information Reference Model
PAGAR	Performance Assessment Gap Analysis Report
PAR	Performance Assessment Report
RAM	Route Adherence Monitoring
ROI	Return Of Interest
RTS	Real Time Simulation
SDD	Situation Data Display
SESAR	Single European Sky ATM Research Programme
SSR	Secondary Surveillance Radar
S3JU	SESAR3 Joint Undertaking (Agency of the European Commission)
TMA	Terminal Manoeuvring Area
ToD	Top of Descent
TRL	Technology Readiness Level
TVALP	Technological Validation Plan
TVALR	Technological Validation Report
UC	Use Case
VFR	Visual Flight Rules
VHC	Very High Complexity
XPT	Exit Point

Table 2: List of acronyms

3 Objectives and scope of the CBA

3.1 Problem addressed by the solution

In a very high complexity en-route (ER VHC) environment ATCOs are required to manage large volumes of conflicting traffic, within a complex airspace structure. The throughput of the section is ultimately limited by ATCO workload, the perceived effort required to manage the traffic within a sector. Currently, it is the ATCOs responsibility to develop an understanding of the traffic within the sector, and to identify aircraft which are potentially on a conflicting trajectory. Of course, they are supported by various conflict alert systems, but these are only activated when there is a risk of the safety margins being violated. There is currently no system which allows ATCOs to develop an early understanding on which aircraft can pass through the sector without intervention, and which will require ATCO instruction to maintain the required safety levels.

AG aims to reduce this workload by focusing the attention of the ATCOs on aircraft, which require action due to a potentially conflicting trajectory. The algorithm will do this by "fading-out" traffic, which do not require ATCO intervention, hence visibly highlighting the aircraft which do require attention. This will ultimately lead to a reduction in ATCO workload and a throughput within these sectors.

3.2 SESAR Solution description

Controllers in Air Traffic Control (ATC) centres rely on the HMI of their CWP to manage the separation of traffic within their airspace. This is especially true for the CWP's Situation Data Display (SDD) with regard to safely controlling current air traffic. Situational awareness and attention are two important skills that controllers need to keep at a high level when controlling aircraft at a radar screen.

For safety and efficiency reasons, most CWPs issue a series of notifications with increasing severity (such as information, warning, alert and finally alarm), allowing the Controller to take action in due time if a potentially dangerous traffic situation is detected to occur in the near or medium future. Because in ER VHC environment Controllers are subject to a large volume of potentially crossing traffic, the Solution PJ.10-W2-96 AG aims at reducing workload by guiding the attention of the ATCOs to focus only on those flights which will possibly interact with each other during their flights across the controlled airspace.

The Operational Improvements (OI) and Enabler associated with solution PJ.10-W2-96 AG are the following:

SESAR Solution ID	OI Steps ref.	OI Steps definition	OI step coverage	Source reference
PJ.10-W2-96 AG (Attention Guidance)	POI-0053-SDM	Improving controller productivity by Attention Guidance (AG) at the ER CWP/HMI	Fully	TVALP [8]

Table 3: SESAR Solution P.10-W2-96 AG Scope and related OI steps

OI Steps ref.	Enabler[2] ref.	Enabler definition	Enabler coverage	Applicable stakeholder	Source reference
POI-0055-SDM	ER APP ATC 182	Controller productivity enhancements by Attention Guidance at the CWP/HMI	Required Full coverage	ANSP Industry	TVALR [15]

Table 4: OI steps and related Enablers

3.3 Objectives of the CBA

The purpose of this document is to provide a quantitative cost-benefit analysis, given the objective to reach the TRL6 status of the solution. The CBAT aims to compare the costs and benefits of the solution, considering the costs for the actors involved and benefits. The analysis provides results at the ECAC level, to assess the viability of deploying the solution on a European scale.

The CBAT also thoroughly tests the cost and benefit results based on sensitivity analysis in multiple areas, and a risk analysis. The sensitivity analysis aims to provide more certainty around the variables most surrounded by uncertainty and enable a robust recommendation to be made.

Building on the outcome of the Performance Assessment at Solution level, the goal of the CBAT is to validate and monetise the gains in productivity of ATCOs and the increase in the efficiency of ATM as a result of the implementation of the Solution PJ.10-W2-96 AG.

3.4 Stakeholders[3] identification

The main stakeholders of the Solution PJ.10-W2-96 AG are the ANSPs which will be the ones to perform the investment and enjoy the benefits.

Stakeholder	The type of stakeholder and/or applicable sub-OE	Type of Impact	Involvement in the analysis	Quantitative results available in the current CBA version
ANSP	En-Route ANS, Very High complexity ACCs	ANSP will have to invest in upgrade of systems with AG and in training of ATCOs.	Skyguide (Switzerland) was involved in planning, preparation, conducting and reporting of the RTS validation activities. This included:	Available

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

3 Note that the terminology used to describe AU stakeholders in the CBA differs from that associated with Enablers in the dataset. This is due to costing being provided for different types of aircraft regardless of the operations they perform.

Stakeholder	The type of stakeholder and/or applicable sub-OE	Type of Impact	Involvement in the analysis	Quantitative results available in the current CBA version
		ANSP will benefit from increased efficiency, productivity, and situational awareness of ATCOs.	• Assessment of the technical feasibility, efficiency and cost of fade out implementation above FL355 in very high complexity environment. • Assessment of the impact on performance: Safety and Human performance expected to be at least maintained. • Assessment of the adequacy and reliability of advanced ATC support tools (Conflict detection and resolution, Monitoring aids, electronic coordination support tools) in this environment. • ATCOs were involved in the definition of the concept and participated in the single validation exercise.	
Airport Operators	No Impact foreseen imputable to PJ.10-W2-96 AG			
Network Manager	No Impact foreseen imputable to PJ.10-W2-96 AG			
Scheduled Airlines	No Impact foreseen imputable to PJ.10-W2-96 AG			
Business Aviation	No Impact foreseen imputable to PJ.10-W2-96 AG			
Rotorcraft	No Impact foreseen imputable to PJ.10-W2-96 AG			
General Aviation IFR	No Impact foreseen imputable to PJ.10-W2-96 AG			
General Aviation VFR	No Impact foreseen imputable to PJ.10-W2-96 AG			
Military – Airborne	No Impact foreseen imputable to PJ.10-W2-96 AG			
Military – Ground	No Impact foreseen imputable to PJ.10-W2-96 AG			
Other impacted stakeholders	No Impact foreseen imputable to PJ.10-W2-96 AG			

Table 5: SESAR Solution PJ.10-W2-96 AG CBA Stakeholders and impacts

3.5 CBA Scenarios and Assumptions

3.5.1 Reference Scenario

The CBA Reference Scenario is the baseline against which the costs and benefits of PJ.10-W2-96 AG are compared. The reference scenario represents the operational situation *without* PJ.10-W2-96 AG, i.e., without the operational and other benefits enabled by AG and without the costs associated with the implementation.

3.5.2 Solution Scenario

The CBA takes a 'delta' approach, so the aspects that are monetised are the differences between the Reference and Solution scenarios. The approach is considered in this section for the description of the Solution scenario. This implies the differential benefits and costs associated to the implementation of the AG solution.

The costs and benefits are first quantified on a local level (for the specific en-route ACC involved in the validation exercises), based on the input from Skyguide and Skysoft-ATM, the solution partners, and coordinated output of the Performance Assessment done at Solution level. We assume the overall solution scenario is consistent with the other solution deliverables, particularly in the terms of deployment scope, the deployment timeline, solution enablers and OIs of solution PJ.10-W2-96 AG. These inputs and results are applied to the geographic area of scope of the deployment, considering the different stakeholder operational environments, member states and the ECAC level.

The Solution Scenario includes the deployment of the full list of use cases listed in Table 6. The complete description of each is available at the PJ.10-W2-96 AG Technical Specification [9].

Name	Description
UC-10-96-TRL6-TS-101	Guiding the ATCO's attention on relevant air traffic *Flights that are largely non-conflictual are put in "fade-out" status. Supporting the controller in maintaining timely the relevant flights to scan in normal display and fading-out the others leads to increase the ability to focus on relevant flights and may at the end increase efficiency and safety as well as reduce workload.*
UC-10-96-TRL6-TS-102	ATCO's input triggering the fade out algorithm Flights that are largely non-conflictual are put in "fade-out" status. If the ATCO performs an input on the flight, the fade out algorithm is processed.
UC-10-96-TRL6-TS-103	Acknowledgement of a flight in "intermediate fade-out" status A flight in "intermediate fade-out" status is acknowledged by the ATCO to keep the situation awareness
UC-10-96-TRL6-TS-104	Flight turning to "intermediate normal display" status When in "fade-out" status, the flight turns to "intermediate normal display" status if the minimum lateral distance is strictly lower than 18 NM with another flight during 3 track updates.

Name	Description
UC-10-96-TRL6-TS-105	Acknowledgement of a flight in “intermediate normal display” status A flight in “intermediate normal display” status is acknowledged by the ATCO to keep the situation awareness
UC-10-96-TRL6-TS-106	Refusal of a flight in “intermediate normal display” status When in “intermediate normal display” status, a manual refusal is performed by the ATCO to turn the flight in “normal display” status if the minimum lateral distance is higher than 10 NM.
UC-10-96-TRL6-TS-107	Impossibility to refuse a flight in “intermediate normal When in “intermediate normal display” status and a manual refusal is performed by the ATCO, an indication is displayed to inform of the impossibility to refuse the flight if the minimum lateral distance is below 10 NM.
UC-10-96-TRL6-TS-108	Warn ATCO in case the Top of Descent is reached In case a flight is in fade-out status, the system raises an alert when the Top of descent is reached (TOD1 or TOD2).
UC-10-96-TRL6-TS-109	Warn ATCO in case the flight is at a certain distance from the XPT In case a flight is in fade-out status, the system raises an alert when the track is at a certain distance from the XPT.
UC-10-96-TRL6-TS-110	Warn ATCO in case an exit conflict is raised In case a flight is in fade-out status, the system raises an alert if two flights exit the centre at the same point, the same level and more or less the same time.
UC-10-96-TRL6-TS-111	Warn ATCO in case an electronic coordination is received and does not trigger a conflict In case a flight is in fade-out status, the system raises an alert when an electronic coordination is received and does not trigger a conflict
UC-10-96-TRL6-TS-112	Warn ATCO in case an electronic coordination is received and triggers a conflict In case a flight is in fade-out status, the system raises an alert when an electronic coordination is received and triggers a conflict. The flight is displayed in “normal display” status and flashes.
UC-10-96-TRL6-TS-113	Warn ATCO in case the system raises a RAM alert In case the flight is in fade-out status, the system raises a RAM alert when the flight does not follow its route. The flight turns to “normal display” status and flashes.

Name	Description
UC-10-96-TRL6-TS-114	Warn ATCO in case the system raises a CLAM alert In case the flight is in fade-out status, the system raises a CLAM alert when the flight does not follow the CFL. The flight turns to "normal display" status and flashes.
UC-10-96-TRL6-TS-115	Warn ATCO in case the system raises an EHS CLAM alert In case the flight is in fade-out status, the system raises an EHS CLAM alert when the ATCO does not follow the selected altitude of the flight. The flight turns to "normal display" status and flashes.
UC-10-96-TRL6-TS-116	Warn ATCO in case the SSR code is set to 7500, 7600 or 7700 In case the flight is in fade-out status, the system raises an alert when the SSR code of the flight is set to 7500, 7600 or 7700. The flight turns to "normal display" status and flashes.
UC-10-96-TRL6-TS-117	Warn ATCO in case of emergency In case the flight is in fade-out status, the system raises an alert when the flight is in emergency. The flight turns to "normal display" status and flashes.
UC-10-96-TRL6-TS-118	Warn the ATCO in case of conflict when changing a level In case of a level change on a non-fade-out flight, the system shall warn the user on levels potentially in conflict with fade-out flights.

Table 6: Solution 96 used cases deployed in the CBA

3.5.3 Assumptions

Due to the complexity of the analysis, several assumptions are considered. These are listed in this section, along with a description when necessary.

3.5.3.1 Timeframe of the CBA

Start year of the CBA is **2019**. This is the year to which the annual cash flows will be discounted (not the year that the costs will start). End year of the CBA is **2043**. This period is in line with Common Assumptions [5].

Several other assumptions apply for deployment period, taking into consideration the IOC/FOC dates of the Solution [6]:

- Implementation and deployment of the solution across ECAC is distributed over a **four-year deployment period (2027-2030)** starting in IOC and ending before FOC dates.
- Both ANSPs in the scope of the Solution will implement in the same time.
- **80% of Operating costs and Benefits** will start to be noted on the first year after the implementation of the solution, so in **2031**; **100% in 2032**.

3.5.3.2 Geographic scope

The geographical scope covers the ECAC countries.

The target OE of PJ.10-W2-96 AG covers the en-route upper airspace only (above FL355), in ACCs of very high complexity (VHC). In accordance with information contained in [11], the following en-route ACCs are classed as VHC with operations above FL355, and are hence in scope of the solution and this CBA:

1. Karlsruhe UAC (Germany, DFS)
2. Zurich ACC (Switzerland, Skyguide)
3. Geneva ACC (Switzerland, Skyguide)

Based on more recent or forecasted traffic at the IOC/FOC dates of the solution, other en-route ACCs could be classified as very high complexity. These include:

4. Maastricht UAC (MUAC)
5. London ACC (United Kindom, NATS (continental))
6. Reims ACC (France, DSNA)

These additional ACCs have not been considered in the CBA presented in this document.

3.5.3.3 Discount rate

The discount rate refers to the interest rate used in discounted cash flow analysis to determine the present value of future cash flows.

A discount rate of 8 % is used for this CBA in the NPV calculation. This value is in line with Common Assumptions [5]. In addition, discount rate values of 4 % (standard discount rate proposed by Eurocontrol [13]) and 12 % (own assumption) are applied for sensitivity analysis as low and high estimates.

3.5.3.4 Cost assumptions

Costs are derived from assumptions agreed with Skyguide and industry partners of PJ.10-W2-96 AG. A certain number of assumptions have been taken into account:

- Implementation occurs in a **4-year transition period**, where total estimated costs have been spread equally.
- Investment is **performed per ANSP** (within the scope of the solution).
- Reference (investment) scenario assumes that all other elements of the ATM environment are equal. Therefore, we consider in the reference scenario, that no investments are made during the timeframe of the CBA that affect ATCO productivity or ATCO workload within the airspace volume in scope.

In addition, it is assumed that, in order to implement the Solution, **the following functionalities are already present on the CWPs**:

- Conflict Detection Tools:
  - The MTCA (Medium Term Conflict Alert) tool allows to detect potential conflicts between two aircraft based on their cleared data (CFL, Heading, direct) with a medium look ahead time (2.5 minutes).

  - The LTCA (Long Term Conflict Alert) tool allows to detect potential conflicts between two aircraft considering cleared data (CFL, heading, direct), local proposed data (level, heading, direct), and local transfer data with no look ahead time limitation.
  - ECAT (Exit Conflict Alert Tool) is a process which monitors potential conflict between two flights regarding exit conditions (exit point, exit level and exit time).
- Transfer of Control: The Change of Frequency (COF) process allows a transferring controller to inform the next (downstream) sector that the flight has been instructed to change frequency and contact the next sector on frequency. This process is performed by the ATCO.
- RAM: Route Adherence Monitoring (RAM) is a process, which raises an alert to the ATCO, whenever a flight trajectory diverges from the cleared tactical route.
- CLAM / EHS CLAM: Cleared Level Alert Monitoring (CLAM) monitors 2 types of deviations from cleared level:
  - Deviation of the current aircraft vertical evolution against the ATC clearance.
  - Deviation of the aircraft intention Selected Altitude against the ATC clearance (CFL).
- Electronic coordination: The e-Coordination allows coordination of transfer conditions such as specific level, a direct to a waypoint, a heading, or a speed. It replaces, when possible, the verbal inter-sector coordination by phone.
- Emergency flight: There are two kinds of emergency:
  - Emergency coming from the ATCO: An ATCO can mark an aircraft in emergency.
  - Emergency coming from the pilot: A pilot can set the SSR code to one of the following:
    - 7500: Hijack
    - 7600: Radio Communication Failure
    - 7700: Emergency

3.5.3.5 Benefit assumptions

In this CBA, the benefits in Flights per ATCO-Hour on duty (CEF2) are quantified, representing the main expected measurable benefit deriving from the deployment of the Solution PJ.10-W2-96 AG.

The below table summarises the assumptions related to ATCO-hours and ATCO employment costs used in order to quantify the ANS Cost Efficiency benefits, using the ATCO productivity monetisation mechanism detailed in Section 4.2.1.

Category	Sub-Category	ANSP/ACC		Source
		Skyguide (2019)	**DFS (2019)**	
ATCO employment cost (EUR)	Total number of ATCOs in OPS (FTE)	350	1,773	ATM Cost-Effectiveness Benchmarking Report (2014-2019) [14]
	Annual employment cost for ATCOs in OPS (EUR)	84,668,000	435,550,000	
	Annual employment cost for one ATCO in OPS (EUR)	*241,909*	*245,657*	*Calculated*
		Geneva + Zurich	**Karlsruhe UAC**	
ATCO-hours on duty	Total number of ACC ATCOs in OPS (FTE)	191	396	ATM Cost-Effectiveness Benchmarking Report (2014-2019) [14]
	Total ACC ATCO-hours on duty	**258,703**	**356,178**	

	Annual hours per one ACC ATCO in OPS	*1354.47*	*899.44*	*Calculated*

Table 7: ATCO-hours and ATCO employment cost assumptions

In addition to the above figures, ATCO salary increase of 1% per year has been assumed.

EUROPEAN PARTNERSHIP

Co-funded by the European Union

4 Benefits

The present section provides with a detailed description of the monetised expected benefits derived from the implementation of the Solution PJ.10-W2-96 AG in the scenario previously described. The estimation of benefits is based on the Performance Assessment carried out at Solution level and the Benefit Impact Mechanisms (BIMs) presented in the Technological Validation Plan (TVALP). The estimations follow the document SESAR 16.06.06, Methods to Assess Costs and Monetise Benefits for CBAs [3], when relevant.

4.1 Identification of benefits

Benefits have been identified on the basis of the Validation targets, benefit impact mechanisms described in the Validation Plan for TRL6 [8], SESAR Performance Metrics presented in [7], and the results of the Technological Validation Exercise reported in the TVALR [15].

4.1.1 Validation Targets

The SESAR2020 Wave 2 and Wave 3 Validation Targets allocated to the Solution PJ.10-W2-96 AG are presented in the below table using the qualitative scale defined in ranges as follows [12]:

- No Impact: No Validation Target Assigned
- Impact Level 1: (0 – P10]
- Impact Level 2: (P10 – P70]
- Impact Level 3: (P70 – MAX]

SESAR Solution ID	SAF	FEFF1	TEFF1	CAP3	CAP1	CAP2	PRD1	PUN1	CEF2	CEF3	HP
PJ.10-W2-96 AG	ISI	N/I	N/I	N/I	N/I	N/I	N/I	N/I	3	N/I	YES

Table 8: Solution 96 Validation Targets

The Performance Expectations specified in the excel file embedded to [12] are the following:

SESAR Solution ID	KPI	Performance Expectation
PJ.10-W2-96 AG	SAF	No direct impact on safety, but HP improvements might be achieved with indirect impact on safety (e.g. workload and human error).
	CEF2	Increased Cost Efficiency optimization for ANSP due to technological Enablers that will increase the efficiency in ATC.
	HP	AG is designed primarily to assess where a controller is looking at and lead the controller to focus on more important events. It is anticipated that the system will move ATCO's attention to spots which require more awareness. Similarly, workload is anticipated to be decreased and usability of the HMI system shall have a straightforward interpretation, and will support ATCOs to reach goals efficiently and effectively. Roles and responsibilities, operating procedures, team composition and communication remain unchanged.

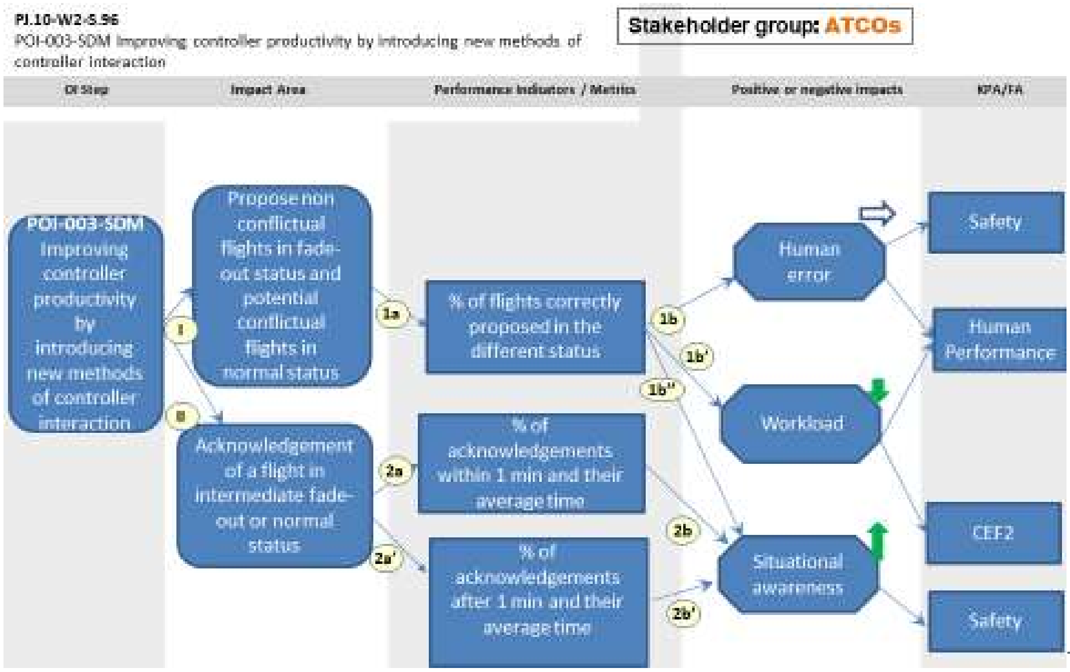
Table 9: Solution 96 Performance Expectations

EUROPEAN PARTNERSHIP

Co-funded by the European Union

4.1.2 Benefit impact mechanisms

For the Solution PJ.10-W2-96 AG, the benefits affect the stakeholder group ANSPs, and more specifically ATCOs, and they fall into the categories of **ANS Cost Efficiency (CEF2), Safety and Human Performance.** Refer to [16] for details.



The benefits mechanism corresponding to POI-0053-SDM is shown in below:

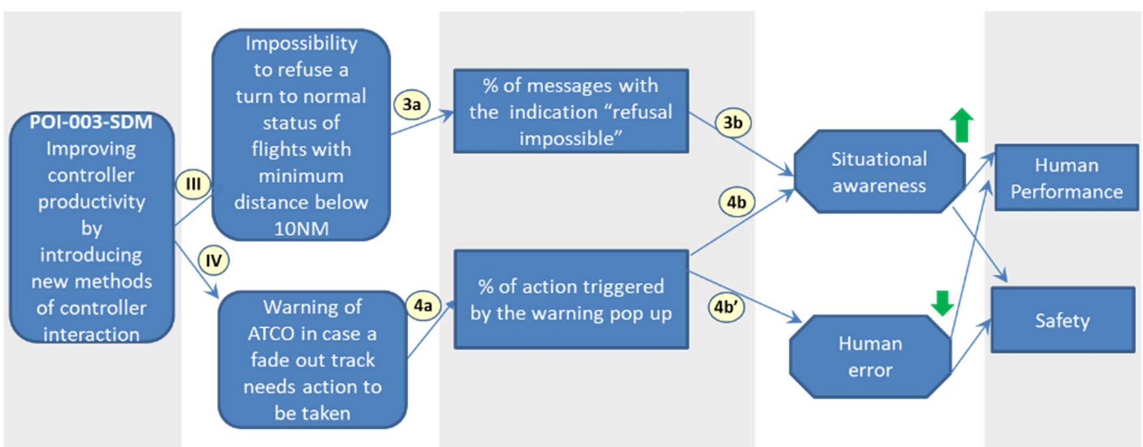


Figure 1: Benefits mechanism for POI-0053-SDM

4.1.3 Performance metrics

Based on the benefits mechanisms presented in Figure 1, the following ***Cost efficiency*** performance metric was identified, representing the main expected measurable benefit deriving from the deployment of solution SESAR PJ.10-W2-96 AG:

- ***CEF2 Flights per ATCO-Hour on duty***: As the result of the deployment of the Solution PJ.10-W2-96 AG, an increase in the number of flights per ATCO hour may be observed. In the long-term this may potentially allow to decrease the number of ATCOs per hour in very high complexity ACCs, compared with the reference case, and leading to a reduction in ATCO employment costs for the provision of ANS services to a given number of flights.

4.1.4 Validation exercise and Performance assessment results

The final version of the Technological Validation Report [15] and initial Performance assessment report [16] provided evidence for the effectiveness of AG deployment during the validation exercises performed at Skyguide (Geneva ACC). The documents however did not provide suitable quantitative data allowing the direct financial assessment of the benefits of AG in terms of CEF2. There were no assessment results nor extrapolation of performance in the area of Cost efficiency.

Therefore, the obtained workload reduction results have been used [16]:

'From a Human Factor aspect, the ATCO has been asked to indicate how much effort certain tasks took from "none" (score of 1) up to "extreme" (score of 7). The date showed that, during the reference scenarios, ATCOs reached 38.3% of the highest possible workload score. During the solution scenarios ATCOs reached 34.9% of the highest possible workload score. This means that the workload was 3.4% lower in the solution than the reference runs. This is a very small reduction which does not reflect the controllers' subjective reports in the debriefings. Also considering that the gain on cognitive capacity will be taken on other/more tasks, it would therefore be reasonable to say that the workload reduction could reach a minimum of 5%.'

In accordance with the assumption that the Solution is applicable only above FL355, the workload reduction achieved for the whole Skyguide' ACC is therefore 1.625%, when assuming 32.5% of all ACC traffic being above FL355. This was calculated based on the following:

$$
\begin{aligned}
&Overall\ workload\ reduction\ (\%)\\
&= workload\ reduction\ \ in\ the\ airspace\ in\ which\ solution\ is\ implemented\\
&\times percentage\ of\ traffic\ in\ the\ airspace\ in\ which\ solution\ is\ implemented\\
&+ workload\ reduction\ \ in\ the\ airspace\ in\ which\ solution\ is\ not\ implemented\\
&\times percentage\ of\ traffic\ in\ the\ airspace\ in\ which\ solution\ is\ not\ implemented\\
&= 5\%\ \times 32.5\% + 0\%\ \times 67.5\% = 1.625\%
\end{aligned}
$$

Using the SESAR Performance Framework [7], this workload reduction was converted into a productivity gain with the following formula[4] to calculate a corresponding potential productivity change:

$$\boldsymbol{Increase\ in\ productivity}\ (\%) = \left(\frac{\mathbf{1}}{\mathbf{1} - \frac{\mathbf{0.75} \times \boldsymbol{workload\ reduction}}{\mathbf{2}}} - \mathbf{1} \right) \times \mathbf{100}$$

The calculated ATCO productivity increase for Skyguide ACC is 0.613%.

4.2 Calculation of solution benefits

In this CBA, the benefits in ***CEF2 Flights per ATCO-Hour on duty*** are quantified.

Performance Framework KPA[5]	Focus Area	KPI/PI from the Performance Framework	Unit	Metric for the CBA	Unit
Cost Efficiency	ANS Cost efficiency	**CEF2** Flights per ATCO-Hour on duty	Nb	ATCO employment Cost change	€/year

Table 10: KPAs impacted by the Solution 96

4.2.1 Benefits quantification for CEF2 Flights per ATCO-Hour on duty

The CEF2 aims to assess the impact of the introduction of the fade out algorithm on ATCO productivity in en-route very high complexity (ER VHC) airspace.

Assuming that each ATCO can perform the same increased number of flights per hour after the deployment of AG, the en-route ACC can provide the same level of service with a reduced number of ATCO-hours. The **ATCO productivity gain** brought about by the deployment of AG, therefore represents a theoretical **ANS cost-efficiency gain** for the ANSPs in the scope of solution. Using the ATCO productivity monetisation mechanism shown below, the CBA model transforms this into **ATCO employment cost change** (saving).

[4] Note that in the formula the workload reduction is expressed as a decimal fraction (i.e. 10% = 0.1).

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

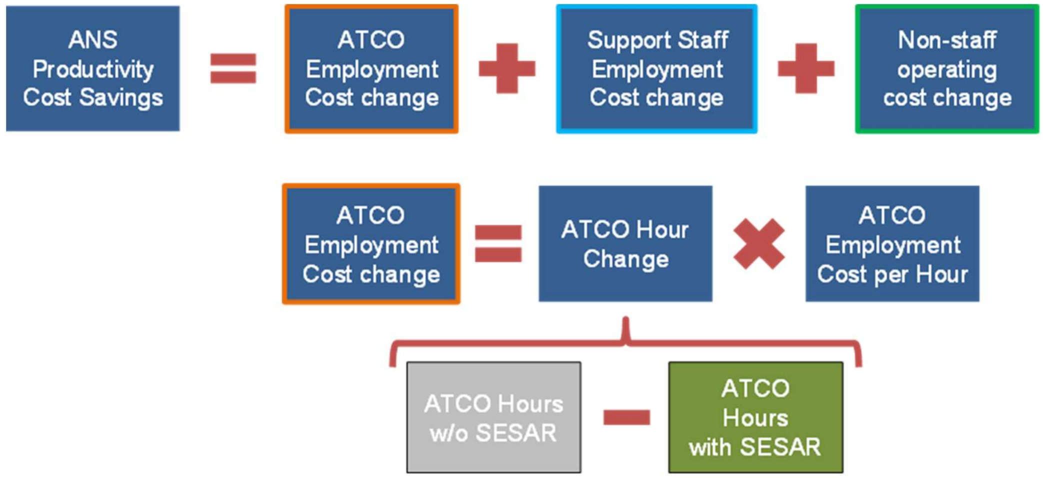


Figure 2: ATCO productivity monetisation mechanism [7]

4.3 Overall benefit from PJ.10-W2-96 AG

The above benefits were quantified at the level of ANSP and at ECAC level. Overview of monetised benefits (CEF2) in real terms (in 2019 Euros) is provided below.

KPA	KPI/PI	Metric for the CBA	Level	2030	2031	2032
Cost Efficiency	**CEF2** Flights per ATCO-Hour on duty	ATCO employment cost change (€/year)	ANSP (Skyguide, 2ACCs)	0	255,370	322,405
			ANSP (DFS, 1ACC)	0	537,663	678,800
			ECAC (2 ANSPs, 3ACCs)	**0**	**793,033**	**1,001,204**

Table 11: Results of the benefits monetisation per KPA

5 Cost assessment

Given the nature of the Solution, the Stakeholders involved in the analysis of the costs considered for all UCs analysed in the Solution can be limited to ANSPs (including ATCOs).

Costs incurred by solution developers during the development of PJ.10-W2-96 AG in the past are not included in the CBA. However, incremental costs for the ongoing development of AG – as opposed to the reference case – should be reflected in the CBA, if such costs are likely to be incurred by the developers.

5.1 ANSPs costs

The following cost categories apply to ANSPs:

1. *Pre-Implementation Costs*: all costs that need to be used up to define the needs, to develop solutions (R&D), to decide which solution best serves the needs. Some of these are costs already incurred in the SESAR Development Phase and therefore not included in the cost assessment; this also includes studies conducted by individual ANSPs to assess the possible implementation within their specific organisational and operational context;
2. *Implementation costs*: are incurred during the implementation period. They include one-time implementation estimated costs, one-off implementation estimated costs and ground/space estimated costs that require capital replacement over time.
3. *Operating costs*: routine costs. Costs that will incur every year in order to assure the running and maintenance of the delegation procedures in addition to normal operation.

Table 12 provides an overview of the individual ANSP cost categories to be assessed in the CBAT.

Cost Item	One-off or routine cost	Cost assessors
Pre-implementation studies	One-off	ANSPs
Installation/Commissioning, incl. integration with existing systems	One-off	ANSPs
Certification	One-off	ANSPs
Initial Training	One-off	ANSPs
Project Management	One-off	ANSPs
Administrative estimated costs	One-off	ANSPs
Yearly Equipment maintenance	Operating cost	ANSPs
Controllers training	Operating cost	ANSPs
Licences	Operating cost	ANSPs
Project Management and administrative cost	Administration	ANSPs

Table 12: Overview of ANSPs cost items

5.1.1 Cost assumptions

Refer to section 3.5.3.4.

5.1.2 Number of investment instances (units)

The implementation of PJ.10-W2-96 AG is only applicable to en-route airspace that is characterised by very high complexity, with an estimated number of investment instances of 3 ACCs within 2 ANSPs (as defined in Section 2.2).

Airport				Terminal Airspace				En-route			
HC	HS	LC	LS	VH	H	M	L	VH	H	M	L
								2 ANSPs			

Table 13: Number of investment instances - ANSPs

Table 14 presents the number of ATC units providing ATC services in scope of the solution, as per information defined in Section 2.2.

Number of units	2019
ANSP	2 (Skyguide and DFS)
Area Control Centres (ACC)	3 (Zurich, Geneva, Karlsruhe)

Table 14: Number of Units - ANSP

5.1.3 Identification of ANSP costs

Previously identified cost are now decomposed and calculated. Rather than a single figure, a range with probable values is later tested in the sensitivity analysis.

The main source for the below base costs are Skyguide' experts.

Implementing costs (per ANSP) include:

- Acquisition, installation, configuration, testing/certification and setting to work AG **infrastructure equipment** comprising the hardware/software platform required for the AG functionality and connection/integration to CWPs. It is assumed that:
  - Implementation is per ACC;
  - The infrastructure architecture may be based on either physical servers associated with each CWP or centralised in a virtualised server environment;
  - Includes back up/failure provision; and
  - Is compliant to any required technical standard.
    - ***Skyguide: 500k EUR***
    - ***DFS: 400k EUR (assumption: 20% less than in case of Skyguide due to only one ACC in scope, compared to two ACCs for Skyguide)***
- Acquisition, installation, configuration, testing/certification and setting to work of **AG related functions** for the CWPs. This includes the set up and configuration of the AI/ML algorithms using locally recorded pilot/ATCO voice command exchanges.
    - ***Included above***
- **Initial Training** for controllers: Initial training is assumed to comprise ***one day*** of training in a training facility with a qualification test at the end of the training period.

- ➢ ***Skyguide: ca. 305k EUR (assumption: one day of training (per ca. 1.6k EUR = cost of 8 ATCO-hours in 2030 based on assumptions in Section 3.5.3.5) for each ATCO in ACC; 191 ACC ATCOs in total (Geneva and Zurich ACCs))***
- ➢ ***DFS: ca. 965k EUR (assumption: one day of training (per ca. 2.4k EUR = cost of 8 ATCO-hours in 2030 based on assumptions in Section 3.5.3.5) for each ATCO in ACC; 396 ACC ATCOs in total (Karlsruhe UAC))***

- **Project management**, update of local manuals and procedures, certification and validation and general **administration** in relation to the installation of AG AI/ML functionality at an ACC.
  - ➢ ***Skyguide: 375k EUR (assumption: 15 months x 20FTE x 1,250 Eur)***
  - ➢ ***DFS: 300k EUR (assumption: 20% FTEs less than in case of Skyguide due to only one ACC in scope, compared to two ACCs for Skyguide; 15 months x 16FTE x 1,250 Eur)***

Operating costs (per ANSP) include:

- **Yearly equipment maintenance,** hardware equipment replacement Installation & Commissioning as needed.
  - ➢ ***Assumption: 5% of one-off implementing costs for infrastructure equipment***
    - ***Skyguide: 25k EUR / year***
    - ***DFS: 20k EUR / year***
- **Controller training,** scheduled training to maintain controller's licence including new functionalities of the AG if any. Training to new controllers in AG functionalities.
  - ➢ ***NIL - there is no additional cost other than the initial training***
- AG functionalities **licences** and updates if any.
  - ➢ ***NIL - there is no licences needed***
- **Project management**, and general **administration** in relation to the maintenance of AG AI/ML functionality at an ACC/ approach centre.
  - ➢ ***NIL - there is no additional cost as it is included in the implementing costs***

Deployment costs per ANSP are summarised below and presented by cost category and as a range of values:

Cost category	ANSP	Unlikely (<EUR)	Median (EUR)	Unlikely (>EUR)
Pre-Implementation costs	Skyguide	N/A	N/A	N/A
	DFS	N/A	N/A	N/A
Implementation costs	Skyguide	944k	1,180k	1,415k
	DFS	1,332k	1,665k	1,998k
Operating costs (per year)	Skyguide	20k	25k	30k
	DFS	24k	20k	16k

Table 15: Cost per Unit - ANSP

5.2 Other stakeholders

No other stakeholder is required to invest for this Solution.

6 CBA Model

The final CBA model for the Solution PJ.10-W2-96 AG is enclosed below.

D4.2.080 -
PJ.10-W2-96 AG-TLR6

7 CBA Results

This section presents the results of the Technological CBA:

- Per ANSP:
  - Skyguide: 2 ACCs,
  - DFS: 1 ACC,
- At consolidated ECAC level, covering both ANSPs above.

7.1 CBA Results for Skyguide

The following graphs present the evolution of the real-term and discounted cash flow thanks to the solution implementation in Skyguide, covering two very high complexity ACCs (Geneva and Zurich).

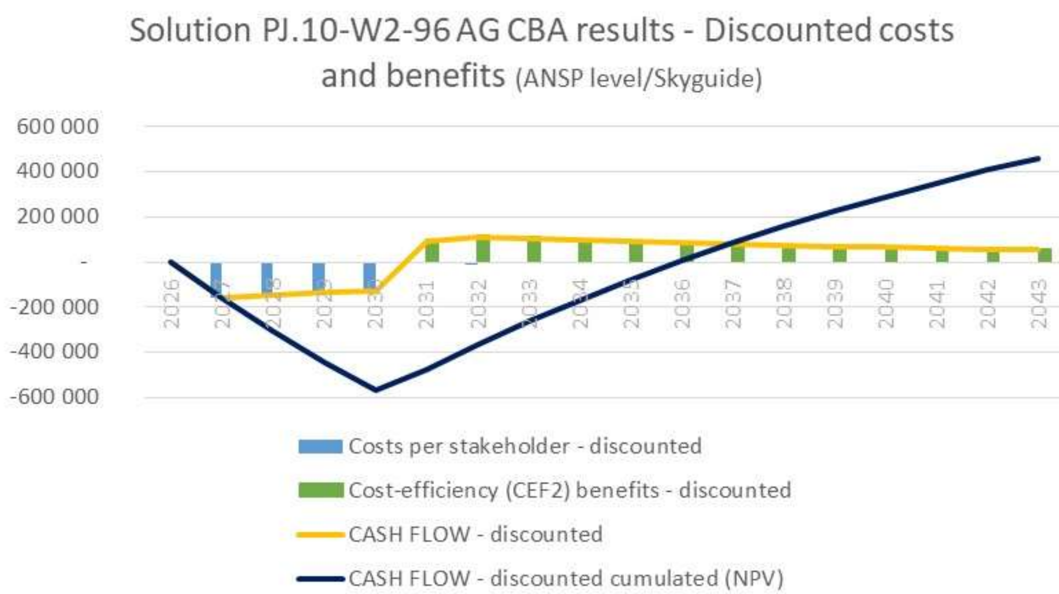


Figure 3: CBA results: Real terms costs and benefits (in 2019 euros) - Skyguide

The results underline a total discounted cost of 652k EUR (1,5 million in real terms), with a low portion of operating costs (around 20%). This indicates an important investment for the ANSP during the implementation period to equip the different ATCO positions in the two ACCs. After this initial cost the solution seems to have little impact on the ANSP cost structure.

The benefits monetized in the CBA thanks to the solution implementation in Skyguide ACCs sum up to 1 110k EUR in discounted terms (around 4,4 million in real terms). The benefit generation are relatively steady on an annual basis of around 90 discounted k EUR annually (330k EUR in real terms).

The combination of both the costs and benefits specificity leads to relatively low profitability of the investment and an important period of 10 years to recover from the initial investment. However, some non-monetised benefits brought by the AG solution such as decrease of ATCO workload, increase of human performance should also be taken into account for Skyguide in regards to the relatively low cost of the solution implementation.

The following table presents the CBA indicator results of the solution for Skyguide.

CBA indicator	
NPV	€ 459 K
PayBack period	2036
ROI	0.7

Table 16: CBA Results - Skyguide

7.2 CBA Results for DFS

The following graphs present the evolution of the real-term and discounted cash flow thanks to the solution implementation in DFS, covering one very high complexity ACC (Karlsruhe).

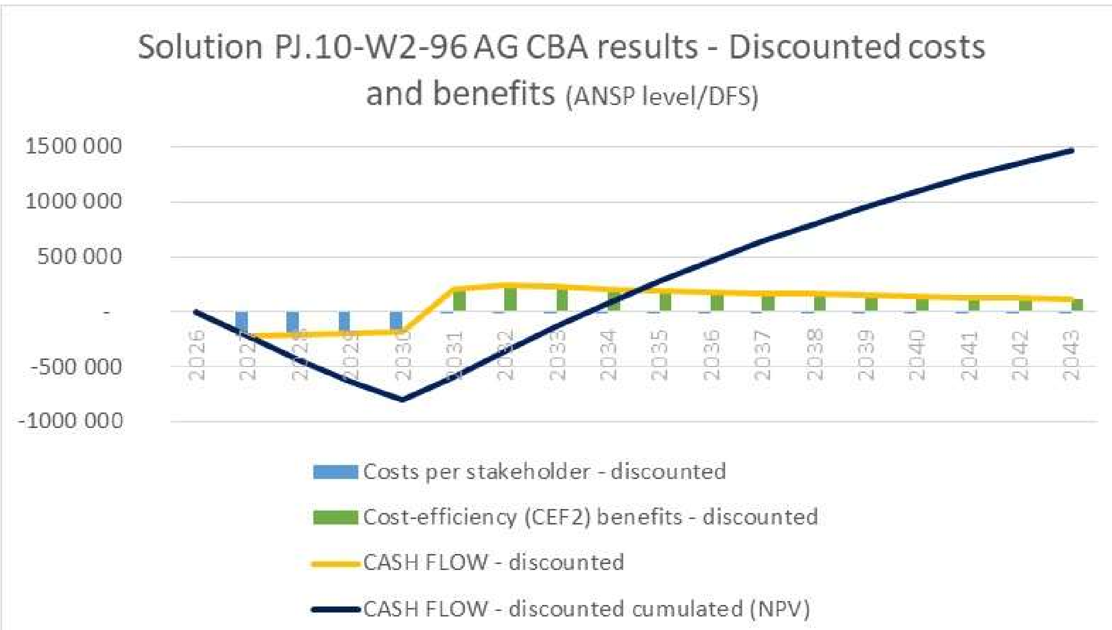


Figure 4: CBA results: Real terms costs and benefits (in 2019 euros) - DFS

The results underline a total discounted cost of 870k EUR (1,9 million in real terms), with as for Skyguide a low portion of operating costs (less than 15%). The cost structure and therefore impact on the solution profitability is similar to the one presented in the previous section. However, DFS presents an economy of scale on the one-off costs assumption as they are only equipping one ACC, i.e. configuration costs of the software. This assumption explains the relatively small difference in terms of implementation costs in regards to the number of ATCO's at Skyguide and DFS ACCs.

The benefits monetized in the CBA thanks to the solution implementation in Karlsruhe sum up to 2 400k EUR in discounted terms (around 9 million in real terms). The benefit generation are relatively steady on an annual basis of around 180 discounted k EUR annually (700k EUR in real terms). The difference in terms of benefits compared to Skyguide ACC is mainly driven by the number of ATCO that will benefit from the solution implementation.

The relatively steady cost and the important increase in benefits thanks to the volume of ATCO productivity generated in Karlsruhe ACC leads to an improvement at the solution profitability outcome.

The following table presents the CBA indicator results of the solution for DFS

CBA indicator	
NPV	€ 1,470.4 M
PayBack period	2034
ROI	1,69

Table 17: CBA Results - DFS

7.3 CBA Results at ECAC level

This section presents the results of the CBA at ECAC level, covering the two ANSPs above.

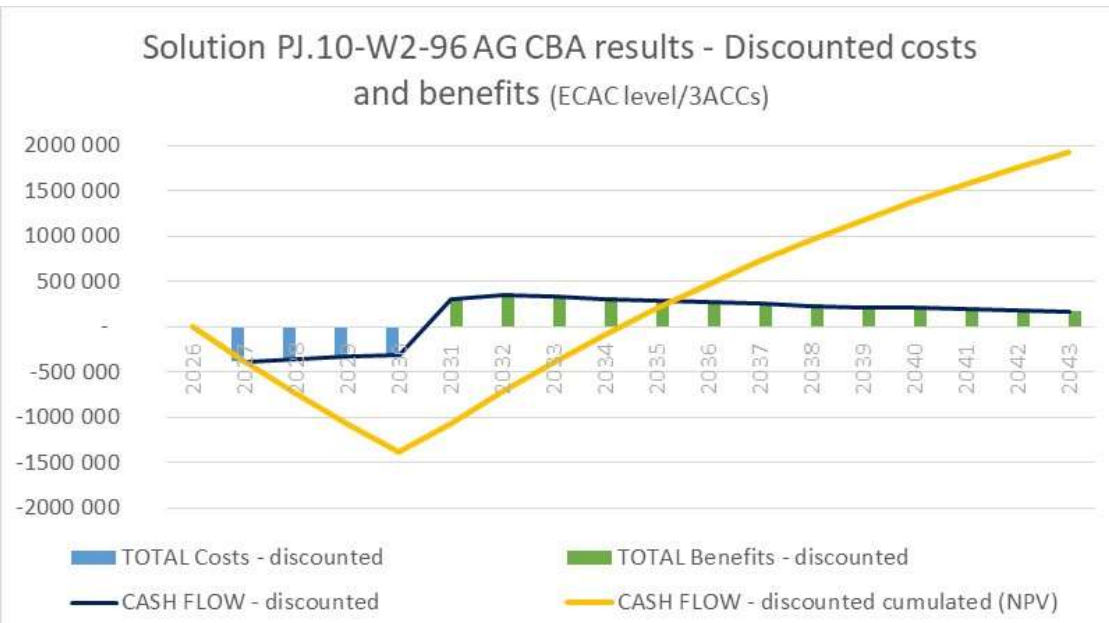


Figure 5: CBA results: Discounted costs, benefits and solution's cash flow- ECAC

The following table presents the CBA indicator results of the solution at ECAC Level.

CBA indicator	
NPV	€ 1,929.8 M
PayBack period	2035
ROI	1,27

Table 18: CBA Results – ECAC area

8 Sensitivity and risk analysis

The CBA results presented in section in 7 have underline that the costs and benefits rationale are relatively similar for both Skyguide and DFS. The sensitivity analysis will therefore focus on the impact of an assumption variation at ECAC level.
As presented previously in this document several of the costs monetized in this CBA are based on a series of assumptions considered in the CBA model. The sensitivity analysis aims at measuring the impact of a variation of one input of the model on the CBA's results, all other things being equal.

This section presents the results of the sensitivity analysis on the CBA for the following parameters:

- Discount Rate: Low 4% and High 12%
- Implementation cost: Low 80% and High 120% (20% variation)
- ATCO productivity: Low 0,49% and High 0,736% (20% variation)

The results on the Net Present Value (NPV) outcome of all sensitivity modelling are presented in the following table.

Sensitivity Result on the NPV	Low value	Base Case	High value
Discount rate	4,421 M euros	1,930 M euros	806k EUR
Total costs	2,234 M euros	1,930 M euros	1,625 M euros
ATCO productivity increase	1,239 M euros	1,930 M euros	2,620 M euros

Table 19: NPV Sensitivity Analysis Results

The results underline that the AG solution overall profitability is strong as none of those produced a negative NPV. The discount rate assumption has a significant impact on the profitability volume as most of the costs are burdened during the first four years with little operational costs.

The Net Present Value variation compared to the base solution scenario is presented below:

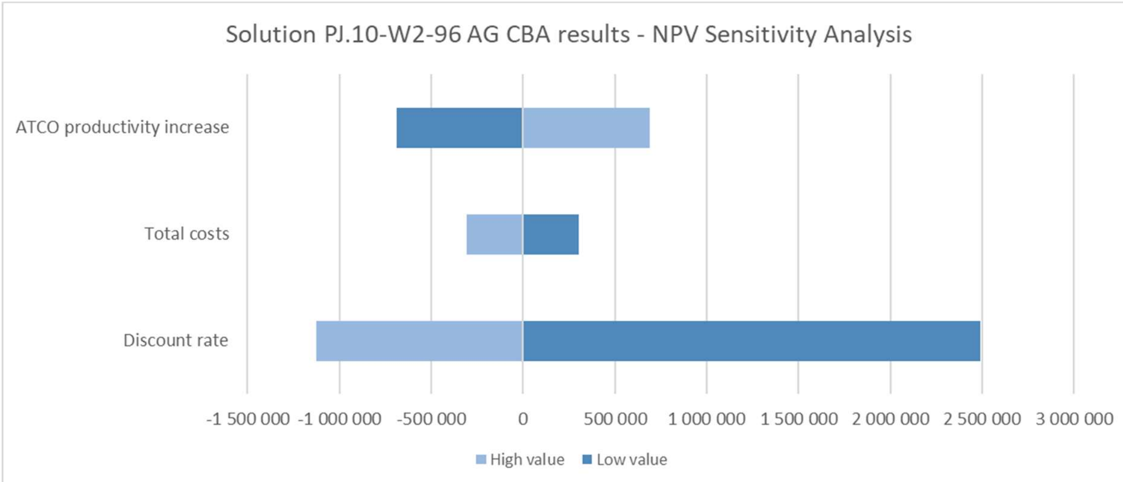


Figure 6: NPV Sensitivity Analysis[6]

The comparative analysis underlines that the +/-20% variation on the ATCO productivity assumption has a higher impact on the NPV results compared to the same variation of the costs of the AG solution. This assumption should therefore be monitored to see if there are some areas of improvement to enhance the overall profitability of the solution implementation for both ANSPs.

[6] In the graph the 0 limit represents the NPV from the base case scenario (1,930 M euros).

9 Recommendations and next steps

Based on the output of the solution datapack, the PJ.10-W2-96 AG solution brings a positive effect on the controller productivity with no negative impact on human performance, safety and en-route capacity. The Cost Benefits Analysis of the solution implementation presents positive results regarding the profitability of the investment for the ANSP stakeholders, individually and at ECAC level.

Two main assumptions are constraining the overall profitability of the solution implementation, first of all the geographical scope at ECAC level, which is relatively small in terms of ACCs that could benefit from it (only three ACCs considered in this CBA). It is also restrictive within a given ACC as it only applies from FL355 and above. Further analysis could be performed to assess the profitability of the solution when deployed in other ACCs (like MUAC) that are, or are forecasted to be, of very high complexity at the IOC/FOC date. It could also be assess if this geographical scope could be extended to other ANSP stakeholders, or to lower flight levels (below FL355), in the En-Route airspace of high and very hight complexity. Extending the geographical scope of the solution would potentially increase further the NPV results.

The other assumption that could be further analysed is the ATCO productivity increase. Indeed, the sensitivity analysis underlined that a small increase could lead to an important increase in NPV for the solution implementation. In addition, the assessment of the solution implementation on the airspace capacity could also be developed to assess if the solution implementation could benefit to other stakeholders such as Airspace Users.

EUROPEAN PARTNERSHIP

Co-funded by the European Union

10 References and Applicable Documents

10.1 Applicable Documents

[1] SESAR Project Handbook

[2] Guidelines for Producing Benefit and Impact Mechanisms

[3] Methods to Assess Costs and Monetise Benefits

[4] ATM CBA Quality checklist

10.2 Reference Documents

[5] SESAR 2020 Common assumptions

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

[7] SESAR 2020 Performance Framework

[8] SESAR 2020 D4.2.040 – PJ.10-W2-96 AG Final TVALP - Part I, ed 00.02.00, July 2021

[9] SESAR 2020 D4.2.010 – PJ.10-W2-96 AG-TRL6 Initial TS/IRS, ed 00.01.00, September 2021

[10] SESAR 2020 D4.0.1 – PJ19-W2: Validation Targets - SESAR2020 Wave 2 & Wave 3, ed 00.01.00, May 2021

[11] En-route & Terminal Airspace OEs_April 2019 Version (1_0) (Excel file)

[12] PJ19-W2: Validation Targets - SESAR2020 Wave 2 & Wave 3, Edition 00.01.00, 04 May 2021

[13] EUROCONTROL Standard Inputs for Economic Analyses, 9.0, December 2019

[14] EUROCONTROL, ATM Cost-Effectiveness Benchmarking Report (2014-2019)

[15] SESAR 2020 D4.2.080 - TVALR - PJ.10-W2-96 AG, ed 00.02.00, November 2022

[16] SESAR Solution 96 - Performance Assessment Report (PAR), ed 00.02.00, February 2023

11 Appendix

Mapping between ATM Master Plan Performance Ambition KPAs and SESAR Performance Framework KPAs, Focus Areas and KPIs, source reference *[7]*

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
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

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
	PA2 - 3-6% reduction in flight time			(FEFF3)	Reduction in average flight duration
	PA3 - 5-10% reduction in fuel burn	Environment	Fuel efficiency	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
	PA10 - No increase in ATM related security incidents resulting in traffic disruptions			(SEC1)	Personnel (safety) risk after mitigation
				(SEC2)	Capacity risk after mitigation
Security		Security	Self- Protection of the ATM System / Collaborative Support	(SEC3)	Economic risk after mitigation
				(SEC4)	Military mission effectiveness risk after mitigation

Table 20: Mapping between ATM Master Plan Performance Ambition KPAs and SESAR Performance Framework KPAs, Focus Areas and KPIs

EUROPEAN PARTNERSHIP

Co-funded by the European Union

-END OF DOCUMENT-