INDUSTRIAL RESEARCH

SESAR SOLUTION PJ.10-W2-93: COST BENEFIT ANALYSIS (CBA) FOR V3

Deliverable ID:	**D3.2.180**
Dissemination Level:	**PU**
Project Acronym:	**PJ10-W2 PROSA**
Grant:	**874464**
Call:	**H2020-SESAR-2019-1**
Topic:	**SESAR-IR-VLD-WAVE2-10-2019 PJ.10 W2 Separation Management and Controller Tools**
Consortium coordinator:	**DFS**
Edition date:	**19 June 2023**
Edition:	**00.00.10**
Template Edition:	**02.00.04**

EUROPEAN PARTNERSHIP

Co-funded by the European Union

Authoring & Approval

Authors of the document

Beneficiary	Date
ENAV Group	28/02/2023

Reviewers internal to the project

Beneficiary	Date
DSNA	23 Feb 2023
COOPANS	20 Feb 2023
DFS	22 Feb 2023
ENAIRE	20 Feb 2023
Eurocontrol	21 Feb 2023
INDRA	24 Feb 2023
NATS	23 Feb 2023
SKYGUIDE	23 Feb 2023

Reviewers external to the project

Beneficiary	Date

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

Beneficiary	8 March 2023
DSNA	8 March 2023
COOPANS	8 March 2023
DFS	8 March 2023
ENAIRE	8 March 2023
Eurocontrol	8 March 2023
INDRA	8 March 2023
NATS	8 March 2023
SKYGUIDE	8 March 2023

Rejected By - Representatives of beneficiaries involved in the project

EUROPEAN PARTNERSHIP

Co-funded by the European Union

Beneficiary	Date

Document History

Edition	Date	Status	Beneficiary	Justification
00.00.01	30/06/2022	Initial Draft	ENAV	Initial Draft based on SOL93, OSED and VALP
00.00.02	11/01/2023	Advanced Draft	ENAV	Intermediate Draft based on SOL93's OSED, VALP, VALR (Draft)
00.00.03	17/02/2023	Final Draft	ENAV	Final Draft based on SOL93's OSED, VALP, VALR and PAR
00.00.04	28/02/2023	Released	ENAV	Final Version, APPROVED by Partners, based on SOL93's OSED, VALP, VALR and PAR
00.00.05	17/03/2023	Revision version	ENAV	Answers to SJU comments
00.00.06	13/04/2023	2 Round Revision	ENAV	2 Round Revision
00.00.07	17/04/2023	Final Version	ENAV	Final Version with the comments integrated by SJU
00.00.07	17/04/2023	Final Version	ENAV	Final version for submission to SJU after Maturity Gate
00.00.08	05/06/2023	Final Version compared with PAGAR	ENAV	Final version with updated values
00.00.09	14/06/2023	Final Version with SJU comments	ENAV	Final submission to SJU
00.00.10	19/06/2023	Allignment Value of CEF2	ENAV	Final Version for sumbission

PJ.10-W2-PROSA

SEPARATION MANAGEMENT AND CONTROLLER TOOLS

This Cost Benefit Analysis Deliverable is part of a project that has received funding from the SESAR Joint Undertaking under grant agreement No 874464 under European Union's Horizon 2020 research and innovation programme.

Abstract

The objective of the SESAR Solution PJ.10-W2-93 is to explore the different possible cases of delegation of provision of ATM Services amongst ATSUs based on traffic/organisation needs (either static on fix-time transfer schedule - Day/Night - or dynamic e.g., when the traffic density is below/over certain level) or on contingency needs.
In the scope of V3 operational thread activities, this document analyses the costs and the benefits of the application and execution of the delegating ATM services provision in normal and abnormal conditions considering the use cases performed and planned for this solution.

Table of Contents

EUROPEAN PARTNERSHIP
Co-funded by the European Union

List of Tables

EUROPEAN PARTNERSHIP
Co-funded by the European Union

List of Figures

EUROPEAN PARTNERSHIP

Co-funded by the European Union

1 Executive Summary

This document provides the Cost Benefit Analysis (CBA) related to SESAR Wave 2 Solution PJ.10-W2-93 V3, Delegation of Air Traffic Management (ATM) Services amongst ATSUs, that has been partially assessed (Delegation of Airspace during night-time operations only – UC #1) during validation activities at V2 level.

The objective of the CBA for PJ.10-W2-93-V3 is to complete the study and to demonstrate the feasibility by analysing the economic aspects of the periodical Delegation of ATM services provision among ATSUs in normal operations during an identified time period or in case of a contingency caused by an unpredicted event impacting ATM services at a given ATSU.

The possibility to Delegate the Airspace under certain condition of traffic can allow cost optimization and load balancing of the ATC Sectors. Furthermore, according to the delegated ATC Sector/s, the receiving ATSU might evaluate the possibility to optimize the sectorization and so determine an improvement in the ATC Capacity of both the Area of Responsibilities and the airspace Area; then, as a positive consequence, it might be possible to optimize the flight trajectories and a higher availability of ATCOs among different ATSUs, as well it might increase the total amount of flights that can be handled during peaks period. Assuming that, a seamless ATM services provision in the Delegated Airspace will be guaranteed, as well as the Air Navigation Service quality, safety and flight efficiency.

The analysis on the economic Costs assessment is addressed basing on some assumptions from the involved ATSUs, starting with the possibility to use a single or multiple ADSPs according to the architecture defined in PJ10 (architecture Y, D, U) relying on the Virtual Centre concept, to manage and process additional sectors from a delegated airspace, without any kind of technical impediments or failures.

This assumption has been tested primarily by one Real Time Simulation (RTS) during the V2 phase; and following, some other RTSs have been conducted during the actual V3 of the Wave2.
EXE1 at V2, in particular, demonstrated the opening point where the benefit measurement process started, analysing the Use Case of the Delegation during Night-Time, even if the solution study has been concluded at the end of the process in 2023 at V3 level; the CBA is conducted analysing both the quantitative and the qualitative aspects of the benefits that the solution could have following the implementation of the operational concept, even if only the quantitative ones determinate the output and the Net Present Value (NPV).

Based on the Validation Targets addressed to the ATM Solution 93, the expected benefits are measured from the analysis of the flight trajectories' management and the better management of the traffic that interests the sectors of involved ACCs. The quantitative assessment benefits are extrapolated from the Performance Assessment Report (PAR)[8] that will cover the following KPAs Capacity, Fuel Efficiency, Predictability and Cost Efficiency, while other expected qualitative assessments will analyse Scalability, Human Factors (HF) and Flexibility (FLX) KPIs.

The following deliverable is focused on the implementation of the Architecture Y while in the Sensitive analysis paragraph are analysed also the other two architectures (D and U).

The results of the V3 CBA analysis demonstrate the ECAC-wide economic viability of Solution 93 over the SESAR Wave 2 time period of 2022 to 2043; the NPV expected in 2043 has been quantified in

approximately ***438.2.5 Millions of Euro***. It represents a significant and encouraging economic value, especially because it is highlighted at ECAC Level, which leads to continue the development of the operational concept during the incoming year in the Real Operational Environment.

The CBA provides results at ECAC level about the economic and financial viability of deploying at the ECAC scale. Therefore, it will not provide sufficient detail to fully support individual deployment decisions that must consider local environment situation and use them to characterize their local CBAs.

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-W2-93 V3 in economic terms, comparing costs expected to implement and execute the Delegation of ATM services provision among ATSUs with its potential monetary benefit, as the positive result of the Stakeholders investment to the entire ECAC ATM system. This kind of analysis has been provided with a detailed CBA in order to assess the economic feasibility of solutions and to help compare different alternatives.

This analysis considers the entire operational process as described with a static bi-directional airspace Delegation between two independent ATSUs, including several operational assumptions depending on the different UCs, architecture and some operational constraints in terms of Complexity of Airspace (e.g., Airspace traffic).
For the UCs coming from the VALP V3 analysed and assessed, the entire process has been explained highlighting the costs and the consequent benefits. Moreover, constraints and risks have been considered to have the most objective analysis.
During validation this phase V3 the assessment does not only provide a measurement of some quantitative KPIs in Cost Efficiency, Fuel/Time efficiency, ATC Capacity, Predictability, such as costs and benefits, but also a qualitative assessment of KPAs such as Safety, Security and Human Performance. At the end of V3 the CBA includes as output a first order of magnitude of benefits and the Net Present Value (NPV), with some other Sensitive Analysis to better analyse the results and to offer the comparison of multiple options.

2.2 Scope

To perform the CBA, the Solution scenario has been studied and compared with the Reference scenario focusing on the economic aspects in the adoption of this solution.

The focus is to assess the economic impact of the Delegation during a predefined event, triggered by traffic and organization specific needs, in particular, it has been considered a standard scenario that try to summarize and harmonize all the information related the EXEs tested during this V3 in order to gain the information related to the UCs selected and architectures for this solution.

The CBA will provide a specific valorisation of the costs and benefits outcome considering the deployment of the Solution and the performance analysis of the Validation EXEs executed to assess all the UCs planned with the aim to test and to validate the economic feasibility of the Delegation of ATM Services extrapolated at ECAC level.

The Concept of Delegation can also be applied when an ATSU, not being able to provide the ATM service of its airspace anymore for an unexpected event, decides to delegate its sector to another ATSU, as it is described in the UC Contingency of the OSED.
Based on the V2 CBA results, the Delegation in case of Contingency is not mature enough to allow a full CBA study. The contingency case is a very critical incident, ATSUs prepare contingency plans in order to predefine necessary steps in case of emergency. The contingency plan is part of the overall Delegation Agreement, but it was not considered a whole of the emergencies for all the Solution 93.

EUROPEAN PARTNERSHIP

Co-funded by the European Union

Anyway, dedicated qualitative analysis has been assessed to validate the Contingency Use Case with the aim to complete the global operational scenario with all the possible planned variables described within the OSED/VALP/TS-IRS.

The V3 CBA considers the outcomes of the Validation Exercises to identify a more accurate cost evaluation of these Solution compared the analysis already performed for the V2.

2.2.1 Timeframe scope

The CBA for SESAR PJ.10-W2-93 solution was calculated for the years 2023-2043.

2.2.2 Geographic scope

The geographical scope covers the European Civil Aviation Conference (ECAC) countries.

2.3 Intended readership

This document has been prepared in order to allow SJU to have a complete view of the solution being studied.

The intended readership of the present document is as follows:

- **SESAR JOINT UNDERTAKING (SJU)** as SESAR 2020 Program coordinator
- **SESAR 2020 PJ.10-W2-93** all involved actors/partners
- **SESAR 2020 PJ.10-W2-73 Flight Centred** ATC and Improved Distribution of Separation Responsibility in ATC - Coordination contact (s)
- **SESAR 2020 PJ.19 Content Integration** that aims at assuring coherency, consistency, and comparability of the validation results throughout all SESAR Solutions.
- **SESAR 2020 PJ.20** European Master Planning of objectives - Coordination contact (s)
- **SESAR 2020 PJ.09-W2-44** Dynamic Airspace Configuration (DAC) - Coordination contact (s)
- **PJ33-W3 FALCO** - Flexible ATCO Endorsement and LDACS Complement - Coordination contact (s)

External to the SESAR project, other stakeholders are to be found among:

- *ANS Providers;*
- *ATM infrastructure and equipment suppliers;*
- *Airspace Users;*
- *Network Manager;*
- *Affected NSA.*

SESAR 2020 W3 Projects:

- *PJ32 Virtual Centre*
- *PJ.33-W3-01 Increased flexibility in ATCO validation*

2.4 Structure of the document

The CBA Document is structured in the following chapters or paragraphs:

1. Executive Summary
2. Introduction, providing with an overall view of both this document and the Solution
3. Objective and scope of the CBA
4. Benefits
5. Cost assessment
6. CBA Model
7. CBA Results
8. Sensitive and risk analysis
9. Recommendations and next steps
10. References and Applicable Documents
11. Appendix
12. Annexes

2.5 Background

In SESAR 2020 Wave 1, PJ.16-03 was designated as an enabling solution to assess the feasibility of the Delegation of ATM Services supported by ADSPs. During the TRL2 gate, a lack of Operational definition was identified in the solution PJ.16-03 and it was transferred to the solution PJ.15-09.

Nevertheless, it was decided to continue PJ.16-03 as an Enabling solution to reach TRL6 Gate at the end of Wave 1 and reduce the scope of PJ15.09 to the definition of potential UCs for the Delegation of airspace and Contingency. PJ.10-W2-93 was then built as a follow up to the SESAR 2020 Wave 1 projects PJ15.09 "Delegation of airspace and Contingency" and PJ16.03 "Enabling rationalisation of infrastructure using virtual centre technology".

PJ15.09 "Delegation of airspace and Contingency" has reached, at the end of the Wave 1, the V1 maturity level. A first CBA has been delivered in the V1 data pack [6] , consisting in a preliminary and qualitative description of the benefits and cost of the different Use Cases identified by the solution to the impacted stakeholders.

PJ.10-W2-93 aims to enhance the preliminary CBA introducing the quantitative evaluation of the costs and benefits of the Delegation of ATM services provision among ATSUs, exploring the different options derived from the application in operation of UCs identified and described in the OSED.

The cost benefit analysis followed the plan of the Solution, providing a first analysis for the V2 maturity gate, and a new, and more complete one, for the V3 maturity gate. In particular, for the V2 CBA, the analysis has been focused on the first UC that has been taken into consideration for an in-depth study by the solution, the UC #1 Delegation at Night-Time.

In this V3, all the UCs have been evaluated considering the results of the EXEs performed for V3 in order to have a complete view of the Solution.

EUROPEAN PARTNERSHIP

Co-funded by the European Union

2.6 Glossary of terms

Term	Definition	Source of the definition
Air traffic services (ATS)	ATS is the core service that maintains separation between aircraft, expedites and maintains an orderly flow of air traffic. Clearances are issued by air traffic control units to pilots to provide separation. The provision of ATS by controllers relies on the underlying ATM data services.	Airspace Architecture Studies (AAS)
ATM Data services	In the SESAR virtual centre solution, the core of the ANS flight and other information management capabilities and further automated control functions are considered candidate to be defined as what is called an ATM Data Service. Whereas the geographical coverage of these capabilities is currently coinciding with the area of responsibility of each ANSP, decoupling these services from the actual operational service provision, would allow each service to support any arbitrary geographical scope. The ATM data services perform functions like flight correlation, trajectory prediction, conflict detection and conflict resolution, safety nets, arrival management planning. They are consuming underlying integration services for weather, surveillance and aeronautical information. The high level of technical interoperability that allows any ATSU to connect to different ATM Data Service providers (ADSPs), requires standardised service-oriented interfaces between ATSU and ADSP. Their design is performance and model driven, cyber-secured and building on open standards.	Airspace Architecture Studies (AAS)

Delegation of the provision of Air Traffic Management services	To explore different possible uses cases, these includes the Delegation of ATM services in a general ATSU scale based on traffic and organization needs, either static on a fix-time transfer scheduling Day/Night or dynamic when the traffic density is below/over a certain level. The uses case also cover Delegation to support contingency needs, allowing ATSUs to transfer responsibility in case of the services degradation of failure.	PJ.15-09 solution
Integration Services	The integration services for aeronautical information management (AIM), surveillance (SUR) and weather combine the geographically constrained scope of the underlying provision services in a service with a broader geographical coverage. By building on performance-based service requirements and standardised interfaces, these services can be built up from different underlying geo-graphically fixed services with different qualities from different providers (e.g. satellite ADS-B or radar-based surveillance services).	Airspace Architecture Studies (AAS)
Rating	indicates the type of service which the licence holder is authorised to provide	Reg (EU) 2015-340
Sector	means a part of a control area and/or part of a flight information region or upper region	Reg (EU) 2015-340
Virtual Centre	A virtual centre is a single Air Traffic Service Unit (ATSU) or a grouping of collaborative ATSUs using data services provided by ATM Data Service Provider (ADSP). The concept provides, at least, geographical decoupling between ADSP (s) and some ATSU (s), through service interfaces defined in Service Level Agreements. One ATSU may use data services from multiple ADSPs, just as an ADSP may serve multiple ATSUs.	PJ.16-03 solution
Virtualisation and ATM data services	Virtual centre is one or more Air Traffic Service Units using ATM data services provided remotely. The concept	Airspace Architecture Studies (AAS)

Co-funded by the European Union

	provides for geographical decoupling between ATM data service providers and ATSUs. One ATSU may use ATM data services from multiple providers, just as one data provider may serve multiple ATSUs. The ATM data services provide the data required for ATS. It includes functions like flight correlation, trajectory prediction, conflict detection and conflict resolution, arrival management planning. These services rely on underlying integration services for weather, surveillance, and aeronautical information. They also include the coordination and synchronisation of ATM data in function of all trajectory interactions by the providers of ATS.	
Business Case	The Business Case is the main document that a Business Analyst produces in the face of its mandate to recommend the solution of a problem or how to seize an opportunity. The structure of the business case by phase allows decisions to be taken on each phase, avoiding unnecessary investments.	SESAR 16.06.06, ATM CBA for Beginners, D26-01, October 2014
Cost Benefit Analysis and Time Horizon	Time horizon refers to a definite time window period during which all cost and benefits related to a given project occur.	SESAR 16.06.06, ATM CBA for Beginners, D26-01, October 2014

2.7 List of Acronyms

Acronym	Definition
AAS	Airspace Architecture Study
ACC	Area Control Centre
ACE	ATM Cost-Effectiveness
ADSP	ATM Data Service Provider
ANS	Air Navigation Services
ANSP	Air Navigation Service Provider
APP	Approach Control Unit

ATC	Air Traffic Control
ATCO	Air Traffic Control Officer
ATFCM	Air Traffic Flow and Capacity Management
ATM	Air Traffic Management
ATS	Air Traffic Service
ATSU	Air Traffic Service Unit
AU	Airspace Users
AUC	Airspace Users Costs
BCR	Benefit Cost Ratio
CAP	Capacity
CBA	Cost Benefit Analysis
CEF	Cost Efficiency
CFL	Cleared flight Level
CMC	Civil Military Coordination
COMM	Communication
COTS	Commercial Off-Trade Services
CR	Change Request
CWP	Controller Working Position
DAC	Dynamic Airspace Configuration
DDR2	Demand Data Repository 2
EATMA	European ATM Architecture
EC	European Commission
ECAC	European Civil Aviation Conference
ER	En-Route
EXE	Executive
FDP	Flight Data Processing
FEFF	Fuel Efficiency
FL	Flight Level
FLAS	Flight Level Allocation Scheme
FLX	Flexibility
FMP	Flow Management Position
FOC	Full Operational Capability

EUROPEAN PARTNERSHIP

Co-funded by the European Union

GAT	General Air Traffic
HC	High Utilization Complex Layout
HCA	High Complexity Area
HD	Hardware
HF	Human Factors
HS	High Utilization Simple Layout
ICAO	International Civil Aviation Organization
ID	Identification
INTEROP	Interoperability
IOC	Initial Operational Capability
IRS	Inertial Reference System
IT	Information Technology
KPA	Key Performance Area
KPI	Key Performance Indicator
LC	Low Utilization Complex Layout
LOA	Letter Of Agreement
LS	Low Utilization Simple Layout
NM	Network Manager
NPV	Net Present Value
NSA	National Supervisory Authority
OE	Operational Environment
OI	Operational Improvement
OPS	Operational
OSED	Operational Service And Environment Definition
PA	Performance Ambition
PAR	Performance Assessment Report
PI	Performance indicator
PJ	Project
PP	Payback Period
PRD	Predictability
PROSA	PROvision of Separation in ATM
PU	Public

EUROPEAN PARTNERSHIP

Co-funded by the European Union

PUN	Punctuality
RBT	Reference Business Trajectory
RES	Resilience
ROI	Return of Investment
RTS	Real Time Simulation
SAF	Safety
SDM	SESAR Deployment Manager
SEC	Security
SES	Single European Sky
SESAR	Single European Sky Atm Research Programme
SJU	Single European Sky ATM Research Joint Undertaking
SOL	Solution
SPR	Safety And Performance Requirements
SDD	Service Description Document
STATFOR	EUROCONTROL Statistics and Forecasts Service
SVC	Service Virtual Centre
SW	Software
TMA	Terminal Maneuvering Area
TRL	Technology Readiness Level
TS	Technical Specification
TSA	Temporary Segregated Area
UC	Use Case
VALP	Validation Plan
VC	Virtual Centre
VHC	Very High Complexity
VT	Validation Target

EUROPEAN PARTNERSHIP

Co-funded by the European Union

3 Objectives and scope of the CBA

3.1 Problem addressed by the solution

Nowadays, the control rooms and the equipment rooms are usually co-located in the same building and each ATSU is served by its individual ATM system. This provision model is used by many ANSPs for years, but it has limitations when it comes to flexible service provision as anticipated by the Airspace Architecture Study (AAS)

The Delegation of ATM services provision among ATSUs wants to provide the continuity of the ATM services when, in a predefined operational situation, an ATSU decides to delegate one or more of its ATC sectors to another ATSU. This operation will increase the Resilience of the ATM system, due to better efficiency and responsiveness of the system also in a situation of operational distress.

Each ACC includes a closely integrated flight data processing system that feeds processed local flight information, weather, surveillance, and aeronautical information to the controller operating position in support of traffic planning, separation, conflict detection, and safety nets. These flight data processing systems are often limited in their automation. Humans have a significant role in the planning and execution of conflict detection and resolution tasks. The limitation is due to the fact that each ACC has its own local physical network, which contains CNS and MET sensors, as well as ground-ground communications for connectivity with other ACCs, network managers, and airports. However, communication with these actors is restricted. As a result, any operational actor outside the ACC has limited situation knowledge of any modifications in the flight trajectory enforced by the ACC's air traffic control.

Because of limitations in routing flexibility, controller allocation flexibility, and the fragmentation of the underlying ATM infrastructure, the ATM system as a whole has poor scalability and is limited in its capacity to provide air traffic services at the right time (including peak times), in the right place.

The solution ensures the possibility to have and maintain a flexible system that can be adapted, into Contingency and Delegation Use Case irrespective to the architecture in a VC context.

3.2 SESAR Solution description

The Delegation of ATS provision among ATSUs applies when an ATSU delegates a portion or the entire of its airspace to another ATSU based on a particular condition. The Solution project has investigated some Use Cases for the Delegation of ATS and Contingency in conjunction with the Virtual Centre Technology, where the ATM Data Service Provider (ADSP) is geographically separated from the Virtual Centre ATSU providing ATS to a region of airspace.

The aim of the solution is to support the AAS and prove the feasibility of a seamless ATM services provision in the delegated airspace, as well as the air navigation service quality, without reducing any kind of safety parameters but improving the traffic flows' management.

Consequently, based on the new operational opportunities offered by the Virtual Centre concept, a set of Delegation Use Cases have been selected, with the aim to further investigate and develop dynamic airspace configuration and advanced ATFCM capabilities. These will allow a completely new architecture and totally new way to provide Air Traffic Management Services.

These Use Cases will consider the operational procedures and resource management to support static and dynamic Delegation of ATM services provision among ATSUs.

The role of the ATSEP has been incorporated into the procedures for delegation and contingency defined in the OSED document and evaluated in the following paragraphs.

This agility will lead to greater opportunities to provide the geographical distributer Service for both from a technical and operational perspective, leading to flexible use of resources, which in turn leads to improve overall performance.

In this section is reported an evaluation of the services/enablers according to the different architectures considered the Virtual Centre Infrastructure (Y, U, D). The work of this analysis has been coordinated with the EUROCAE WG-122 for the standardization and the taxonomy of the services.

The Following Table depicts the OI step SDM-0217 which is linked to the operational Solution PJ.10-W2-WP3 which is supported by three technical Solutions PJ.10-W2-93A-C which have their own POIs and linked Enablers. The tables that present the POIs and Enablers of the technical Solutions

SESAR Solution ID	SESAR Solution Title	OI Steps ID	OI Steps Title	Enabler ID	Enabler Title	OI Step/Enabler Coverage
PJ.10-W2-93	Delegation of ATM services provision between ATSUs	SDM-0217	Delegation of ATM Services between ATSUs			Fully
PJ.10-W2-93	Delegation of ATM services provision between ATSUs			REG-0546	Regulatory provisions for delegation of ATM services provision among ATSUs	n/a[1]
PJ.10-W2-93	Delegation of ATM services provision			CR 07428 (PRO-267)	Procedure for Delegation of ATM Services provision between ATSUs	Fully

[1] The Solution didn't work on the area of regulation. This Enabler is created to indicate that for a deployment of the concept regulatory efforts are necessary. Thus, it is declared as n/a here.

Co-funded by the European Union

	between ATSUs					
PJ.10-W2-93	Delegation of ATM services provision between ATSUs			CR 07429 (HUM-067)	Updated role/responsibilities for ATCOs in context of the delegation of ATS between ATSUs	Fully
PJ.10-W2-93	Delegation of ATM services provision between ATSUs			CR 07430 (HUM-068)	Updated role/responsibilities for ACC/Approach/TMA Supervisor in context of the delegation of ATS between ATSUs	Partial
PJ.10-W2-93	Delegation of ATM services provision between ATSUs			CR 07431 (HUM-069)	Updated role/responsibilities for ATSEPs in context of the delegation of ATS between ATSUs	Partial
PJ.10-W2-93	Delegation of ATM services provision between ATSUs			CR 07432 (HUM-070)	Updated role/responsibilities for Technical Supervisor in context of the delegation of ATS between ATSUs	Partial

Table 1: SESAR Solution PJ.10-W2-WP3 Scope and related OI step

The tables below present the POIs and Enablers of the technical Solutions

EUROPEAN PARTNERSHIP

Co-funded by the European Union

Enabler	Service	SDM-217	POI "Y"	POI "D"	POI "U"	Initial Maturity	Target Maturity
SVC-008	Provision and Consumption of FlightDataDistribution Service in the context of Virtual Centres.	n/a	Optional	Optional	n/a	TRL6	TRL6
SVC-009	Provision and Consumption of FlightDataManagement Service in the context of Virtual Centres	n/a	Optional	Optional	n/a	TRL6	TRL6
SVC-010	Provision and Consumption of CoordinationAndTransferManagement Service in the context of Virtual Centres	n/a	Optional	Optional	n/a	TRL6	TRL6
SVC-013	Provision and Consumption of Airspace Status Distribution Service	n/a	Optional	Optional	n/a	TRL6	TRL6
SVC-014	Provision and Consumption of Arrival Sequence Distribution Service	n/a	Optional	Optional	n/a	TRL4	TRL4
SVC-015	Provision and Consumption of Arrival Sequence Management Service	n/a	Optional	Optional	n/a	TRL4	TRL4
SVC-016	Provision and Consumption of Correlation Distribution Service	n/a	Optional	Optional	n/a	TRL6	TRL6
SVC-017	Provision and Consumption of Correlation Management Service	n/a	Optional	Optional	n/a	TRL6	TRL6
SVC-018	Provision and Consumption of Medium Term Conflict Detection Distribution Service	n/a	Optional	Optional	n/a	TRL4	TRL4

Co-funded by the European Union

SVC-019	Provision and Consumption of Medium Term Conflict Management Service	n/a	Optional	Optional	n/a	TRL4	TRL4
SVC-020	Provision and Consumption of Monitoring Aids Distribution Service	n/a	Optional	Optional	n/a	TRL4	TRL6
SVC-021	Provision and Consumption of Operational Configuration Distribution Service	n/a	Optional	Optional	n/a	TRL4	TRL6
SVC-049	Operational Configuration Distribution of Working Position Preview Mode, and Neighbouring ATSU Sector configuration for ATM Service Delegation	n/a	Optional	Optional	n/a	new	TRL6
SVC-022	Provision and Consumption of Operational Configuration Management Service	n/a	Optional	Optional	n/a	TRL4	TRL6
SVC-050	Operational Configuration Management of Working Position Preview Mode, and Neighbouring ATSU Sectors for ATM Service Delegation	n/a	Optional	Optional	n/a	new	TRL6
SVC-023	Provision and Consumption of Safety Net (SNET) Alert Distribution Service	n/a	Optional	Optional	n/a	TRL4	TRL4
SVC-024	Provision and Consumption of SSR Code Distribution Service	n/a	Optional	Optional	n/a	TRL4	TRL4
SVC-025	Provision and Consumption of SSR Code Management Service	n/a	Optional	Optional	n/a	TRL4	TRL4
SVC-026	Provision and Consumption of Support Functions Distribution Service	n/a	Optional	Optional	n/a	TRL4	TRL4
SVC-027	Provision and Consumption of Support Functions Management Service	n/a	Optional	Optional	n/a	TRL4	TRL4

SVC-028	Provision and Consumption of Surveillance Data Distribution Service	n/a	Optional	Optional	n/a	TRL4	TRL4
SVC-029	Provision and Consumption of Technical Supervision Distribution Service	n/a	Optional	Optional	n/a	TRL4	TRL6
SVC-031	Provision and Consumption of Time-based Separation Distribution Service	n/a	Optional	Optional	n/a	TRL4	TRL4
SVC-032	Provision and Consumption of Time-based Separation Management Service	n/a	Optional	Optional	n/a	TRL4	TRL4
SVC-033	Provision and Consumption of Voice Comm Information Distribution Service	n/a	Optional	Optional	n/a	TRL6	TRL6
SVC-034	Provision and Consumption of Voice Comm Management Service	n/a	Optional	Optional	n/a	TRL6	TRL6
ER APP ATC 184	ATM Data Service Provider for ATC services in a Virtual Centre context	n/a	Required	Required	n/a	TRL6	TRL6
ER APP ATC 185	ATM Data Service Provider for Voice services in a Virtual Centre context	n/a	Required	Required	n/a	TRL6	TRL6
ER APP ATC 186	Virtual Centre ATSU	n/a	Required	Required	n/a	TRL6	TRL6
ER APP ATC 193	Management in the VC ATSU of a CWP preview mode during delegation of ATS Provision between ATUs	n/a	Required	Required	Optional	new	TRL6
ER APP ATC 194	Management in the ADSP of a CWP preview mode during delegation of ATS Provision between ATUs	n/a	Required	Required	Optional	new	TRL6

ER APP ATC 195	Management in the VC ATSU of Delegation of ATS Provision between ATUs with Static AoRs for Y-Architecture	n/a	Required	n/a	n/a	new	TRL6
ER APP ATC 196	Management in the VC ATSU of Delegation of ATS provision between ATUs with Dynamic AoRs for U-Architecture	n/a	n/a	n/a	Required	new	TRL4
ER APP ATC 197	Management in the ADSP of Delegation of ATS provision between ATUs with Dynamic AoRs for U-Architecture	n/a	n/a	n/a	Required	new	TRL4
ER APP ATC 215	Management in the VC ATSU of Delegation of ATS Provision between ATUs with Static AoRs in a D-Architecture	n/a	n/a	Required	n/a	new	TRL4
ER APP ATC 216	Management in the ADSP of Delegation of ATS provision between ATUs with Static AoRs in a Y-Architecture	n/a	Required	n/a	n/a	new	TRL6
ER APP ATC 217	Management in the ADSP of Delegation of ATS provision between ATUs with Static AoRs in a D-Architecture	n/a	n/a	Required	n/a	new	TRL4
ER APP ATC 218	Management in the VC ATSU of Delegation of ATS provision between ATUs with Dynamic AoRs in a Y-Architecture	n/a	Optional	n/a	n/a	new	TRL6
ER APP ATC 209	Management in the ADSP of Delegation of ATS provision between ATUs with Dynamic AoRs in a Y-Architecture	n/a	Optional	n/a	n/a	new	TRL6
STD-097	EUROCAE ER for Taxonomy of Services between ATSU & ADSP(s), and between ADSP &ADSP	n/a	Optional	Optional	n/a	TRL4	TRL4

Table 2: Solution 93 Enabler's

3.3 Objectives of the CBA

The purpose is to develop a quantitative Cost Benefits Analysis comparing the costs and benefits of the solution at ECAC network level, considering the costs for all actors involved and all the benefits expected by the capacity increase, fuel efficiency, reduction in the number of ATCOs etc for the whole ATM system. The solution impact at regional level will be used to measure the results at ECAC network area.
The CBA conducted for V3 analyses the application of the Delegation procedure performed for all the UCs detailing the results considering the relevant information from all the EXEs planned for V3 and their contribution to the whole solution PJ.10-W2-93.

The CBA is elaborated on the Performance target values obtained by the post analysis of the Validation Exercises at the V3 level, inserted within the PAR, which goal is to validate the Air Traffic Management Service (ATM) Delegation procedures & requirements based on a Virtual Centre (VC) infrastructure, with major positive results that will cover the following KPAs: Capacity (CAP), Operational Efficiency (FEFF/TEFF), Predictability (PRD1) and Cost Efficiency (CEF); while other expected qualitative assessments will analyse both Human Factors (HF), Safety (SAF), Resilience (RES) and Flexibility (FLX) KPIs.

The Validation EXEs planned and performed in this V3 have analysed all the UCs described within the OSED and the VALP.
In the CBA the information related to the Real Time Simulations (RTS) performed have been collected and examined first separately and then, to analyse the Costs and Benefits related to the whole Solution 93, have been harmonised in a single solution scenario.

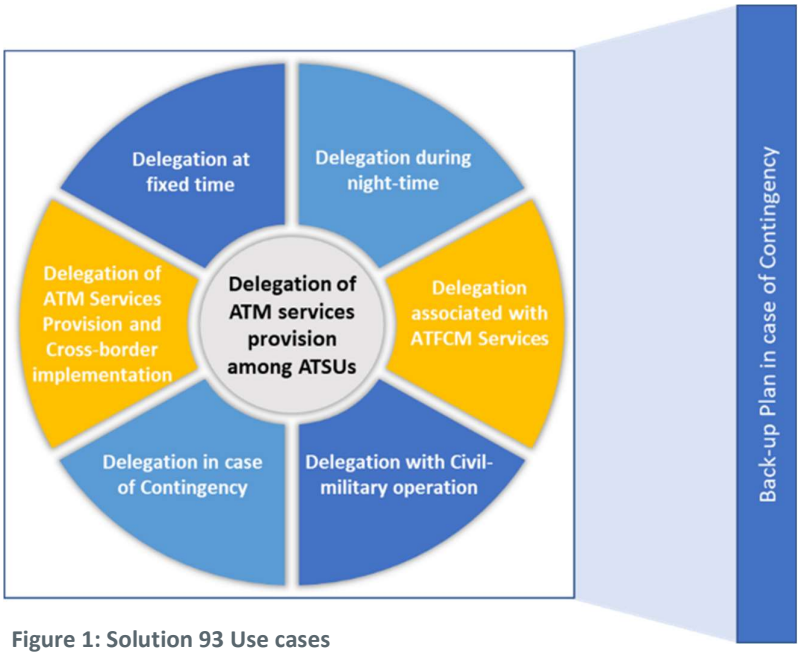

Figure 1: Solution 93 Use cases

The Delegation of ATS operational concept can be supported by three different architectures, as “Y”, “D” and “U”. Each of them has been developed in a specific technological solution and referenced as SESAR PJ.10-W2 Technological Solutions Architectures “Y, D and U”.

In the scope of PJ.10-W2-Solution 93, only Solution 93A is planned to reach TRL6 and be officially proposed for supporting PJ.10-W2-Solution 93 to reach V3. However, this analysis aims to develop the cost of the technical elements developed for the three Technological Solutions Architectures “Y, D and U”, maintaining a clear separation between the common architecture parts and the specific ones.

Each of these Technological Solutions is corresponding to a particular Virtual Centre architecture as proposed in the taxonomy issued by the EUROCAE WG122.

3.3.1 Analysis Architecture “D”

The delegation of ATM services provision, as described by the ATM solution Delegation of ATM Services provision between ATSUs by the Operational Concept, may be achieved with different system architectures.

This solution focuses on the “D” architecture relying on a delegation between 2 ATSUs, each one with its own ADSP, and using Virtual Centre (service) interoperability for remotely connecting CWPs from the receiving ATSU to the ADSP of the delegating ATSU without affecting the respective ATSU AoRs.

The provision of Virtual Centre standardized services allows a CWP to subscribe to services of different ADSPs. In particular, an ATSU supported by a specific ADSP can delegate ATM services provision to another ATSU, served by another ADSP, by just allowing CWPs of this ATSU to subscribe to the other ADSP services, thus keeping the ATSU AoRs unchanged. This delegation configuration set-up is referenced as the “D” architecture. Such an architecture is also well fitted for supporting ATSU contingency scenarios.

The Cost analysis of this architectures are reported in the Sensitive analysis in the Section 8.2

3.3.2 Analysis Architecture “U”

A delegation of ATM services provision may be achieved by transferring an ATSU AoR, or a piece of AoR, to another ATSU. In this set-up, the receiving ATSU provides both the CWPs and an extension of its AoR in the system, while at the same time the AoR of the delegating ATSU is reduced accordingly. This principle is based on the capability of the systems to exchange the required information at the right time in order to provide the relevant information to the CWPs taking the delegation(s). This delegation configuration set-up is referenced as the “U” architecture. This architecture can be applied to any combination of Virtual Centres and/or non-Virtual Centres.

The Cost analysis of this architectures are reported in the Sensitive analysis in the Section 8.2

3.4 Stakeholders[1] identification

ANSPs or other ATM entities that will be impacted by PJ.10-W2-93, directly or indirectly, are listed into the following Table, each one for the expected type of benefit, introduced by the Delegation of ATM services among ATSUs.

Below are the stakeholders' high-level expectations of the validation exercises.

Stakeholder	Involvement	Why it matters to stakeholder
ANSPs	Direct To implement the Virtual Centre solutions	Expect to improve cost efficiency through an optimum use of available human and technical resources. Expect technology costs reduction Improve resilience (e.g., in contingency situations) The business case for investments in VC architecture, services and ALL other investments or costs related to creating the capability to delegate ATM services shall be favourable for each individual ANSP.
AUs	Indirect	No increase of User charges
Industry	Direct To provide trial platforms	Opportunity to develop new markets based on large scale shared ADSPs. Positioning in European Markets thanks to a long-term vision. Develop new and sustainable technologies in ATM.
EUROCAE	Direct Service definition to support the exercise and contribution to technical and operational solutions for the set-up of the exercise.	Major contributor to the standardisation of ATM services.

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

Stakeholder	Involvement	Why it matters to stakeholder
SJU	Indirect Programme coordinator	Ensure that the concept definition and the technical validation activities comply with the SESAR programme guidance and approach. Help deliver AAS - European Airspace Architecture Study
European Commission	Indirect Participation through SJU	Expect to increase economic power and position of Europe in the air-traffic sector. Expect to increase airspace capacity and efficiency. Support for the implementation of the SES.

Table 3: Stakeholders' expectations

The entire ECAC Network and ATM System, including ANSPs, will remain the main recipient of the benefits, especially in respect of the Scalability and Flexibility KPA as recommended in the Airspace Architecture Study [*2*]. Also, Airspace Users (AUs) might receive benefits by the Delegation and the handle of the Air Traffic Services from another ATSUs, due to operational trajectory improvement or in case of Contingency when any ATFCM assignment might be avoided.

However, neither their role nor their responsibility will change due to the Delegation.

Stakeholder impacted

In the following table the main stakeholder impacted have been identified, considering as drivers for the identification:

- Stakeholders that will have to make investment
- Stakeholders that have to change the way they work and/or establish common procedure
- Stakeholders that have to implement common infrastructures (ADSPs) procedures
- Stakeholders that will get the benefits (ATSUs – ADSPs – AUs – NM)

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/TMA ANS, High	Investments, way of work, infrastructure; Enjoy benefits in operations; Support operation.	Provided inputs, Reviewed results.	Yes

Co-funded by the European Union

	Complexity ACCs[2]			
Airport Operators	N/A	N/A	N/A	N/A
Network Manager	TMA and En-route ANS	Enjoy benefits in operations; Support operation.	N/A	N/A
Airspace Users (AU)	Airspace Users	Enjoy benefits in operations.	No direct involvement	Yes, but only in case of Contingency
Military – Airborne	Military ATSU	Support Operations	No Direct involvement	N/A
Military – Ground	N/A	N/A	N/A	N/A
Other impacted stakeholders (ground handling, weather forecast service provider, NSA….)	N/A	N/A	N/A	N/A

Table 4: SESAR Solution 93 CBA Stakeholders and impacts

3.5 CBA Scenarios and Assumptions

With the aim to analyse and to evaluate the feasibility, under the economic point of view, of the Validation Scope of the Solution, it is necessary to calculate and assess costs and benefits resulting from the implementation of a new Operational Scenario that can further enhance the benefits both for the AUs than for ATSUs. With the result of:

- Several Operational improvements, as for instance ATC Capacity, ATCO resources optimization, resilience as well as Operational Efficiency and other KPAs/KPIs;
- Improved utilization and management of ATCOs (human resources) following improved sector opening schemes and shared resources.

The scope of the Solution is based on the "possibility that ATSU1 has to delegate to ATSU2 within its airspace/AoR the management of ATC services, and all the other linked ATM services, within multiple different Operational situations and at different time windows of the day".

[2] Even if the operational environments examined for this V3 is VHC and/or HC, the same operational outputs (in terms of procedure and/or HR involvement) should be applied for different environment, either more or less complexity as well as different day time.

EUROPEAN PARTNERSHIP

Co-funded by the European Union

Whenever two ATSUs need to establish a Delegation Procedure, a specific Agreement must be shared between the parties. The Agreement shall contain the exact condition that will trigger the Delegation, including at least the timing and the expected traffic scenarios and all the other Operational ATC items.

To accomplish the scope, all service levels must be specified as well, and data availability must be ensured to ATSU 2. And finally, to ensure a successful Delegation, ATSU 2 needs to have sufficient computing capability and human resources to handle the additional delegated airspace.

3.5.1 Reference Scenario

Nowadays, the Delegation of ATM services provision among ATSUs is a procedure rarely used, with some exception related to internal procedure of single ANSPs, without Delegation between different countries. For example, Bristol and Cardiff airports in the UK manage the terminal airspace up to FL165 during the day but delegate it to NATS's Swanwick Area Control centre overnight. Even in Germany, for example, there are some areas that are controlled by different Control Centres at different points in time.

Currently, no ANSP uses a Service Oriented Architecture system (SOA) that allows a delegation process but a properly open interface or legacy architecture without any possibility to connect different ANSPs. The ATSU's live operational scenarios in ECAC, so called scenario AS-IS, is described in detail within the VALP and it represent the Reference Scenario used for the scopes of the Solution 93. Most importantly, there is no Delegation in place from one ATSU to another one, and sector's consolidation isn't foreseen for ATSU 1.

Solution PJ.10-W2-93 aims to continue the development of the VC concept to ensure the adequate support to the implementation of the different ATM delegation use cases even if it is not the main objective of the VC concept. A complete explanation of the use of the VC concept is in the paragraph 5.1.1.

The Reference Scenario is as per current operating method in the ECAC airspace, that is, with no possibility to consider the delegation of ATM services provision.

The main characteristics of the Reference Scenario to be considered for each one of the use cases addressed by the validation activity is described below:

- Delegation of ATM services provision on-demand
    - No delegation
    - No cross-border sectorisation
    - ATFCM measures: ATFM regulations, ATFM scenarios, capacity measures, tactical STAM

The traffic sample corresponds to traffic from 2019 (pre-SARs-CoV-2).

3.5.2 Solution Scenario

The Solution scenarios include the Delegation of ATM services between 2 ATSUs that agreed a Delegation procedure. For the scope, as a standard, each ATSU controls its own ATC sectors using ADSP and VC technology, both in a static and/or dynamic AoR as described in detail within the VALP deliverable. According to the target architecture per Exercises, the ADSP was connected with specific interface to an external ATSU (centralized Network Manager and/or Civil/Military ATSUs) which is handled by the local Flow Manager Position (FMP).

It's important to underline that all the UCs related to the solution have been considered in the analysis, so the solution scenario foreseen the possibility to apply:

- Delegation of ATM Services Provision at Night;
- Delegation of ATM Services Provision at fixed Time;
- Delegation of the ATFCM service and load balancing between ATSUs;
- Delegation between Civil and Military ATSUs;
- Delegation of ATM Services Provision and Cross-border implementation.

Those new ATS delegation procedures have been defined safely and minimize any possible service interruption by the ADSPs, in order to guarantee benefits at all actors involved. Furthermore, the application of these procedures won't compromise the safety, security and human performance aspects.

The delegation in case of Contingency has been analysed separately in the Annex 1 because perform an economic evaluation of such an uncertain and unpredictable event is extremely complex, as the number of assumptions needed to identify a specific situation to assess cost and benefits, would lead to an analysis too specific, not applicable to the contingency UC as a whole.

3.5.3 Assumptions

The main assumptions are:

- The timeframe considered for the analysis is:
  - Implementation phase: 2026 - 2032;
  - IOC: 01/01/2028;
  - FOC: 01/01/2033.
- In the reference scenario, ATSU1 does not consolidate its operational ATC configuration during different time of the day;
- The delegation provides by ATSU2 defined as HC/VHC ATSU (Very High/High Complexity). ATSU1, and ATSU2 as well, can be anyone of the 92 ATSUs in ECAC area;

EUROPEAN PARTNERSHIP

Co-funded by the European Union

- The Delegation takes place 24 hours /7 day, both during night and day-time, in a predetermined timeframe and for both Medium and High Scenario Complexity with different peaks of traffic considered during the day (24 hours), and so different traffic conditions;
- Delegation process is regulated by bilateral agreements between ANSPs, which also specify the quality and the high-level characteristic of service and the economic issues;
- Each ATCO of ATSU2 involved in the Delegation ATS process must have the specific license to manage the Flights for the delegated airspace and the involved ATC sectors;
- Consolidation of the delegated sectors before or after the ATS Delegation does not impact the costs or benefits;
- In case of operational emergency situation within the ATSU2' premises, the ATSU that provides the Delegation Services will guarantee the continuity of the ATC management service for the Delegated Airspace by using its internal Contingency procedure;
- During Delegation of ATS, the entire or part of the airspace of ATSU1 that is delegated, and all the involved staff, might be on duty within the other ATC configuration in ATSU1. Meanwhile, no changes are needed for Supervisor, FMP and ATSEP that will remain to guarantee the operational management of ATSU1;
- Nowadays, no ANSP uses a Service Oriented Architecture system (SOA) but a properly open interface or legacy architecture. In order to assess the Delegation process, a VC system or legacy with the ADSP architecture has been considered already implemented for the ANSPs involved in all the EXEs of the V3.

EUROPEAN PARTNERSHIP

Co-funded by the European Union

4 Benefits

The Validation Targets expected from SESAR PJ19.04 (visible into the released document, present in STELLAR, called ***PJ19-W2: Validation Targets - Wave 2***) are based on the below KPA/KPIs. The related performance targets are also defined for each KPI and for all the SESAR W2 solutions. The VTs values (absolute values) are listed into the ***Validation Targets W2 Excel file as:***

- CEF2: ATCO Productivity
- CEF3: Technology Cost
- CAP1: TMA Capacity
- CAP2: En-Route Capacity
- FEEF1: Fuel Efficiency
- PRD1: Predictability
-

The Validation Targets (VT), based on a qualitative scale, apportioned to Solution PJ.10-W2-93 in the PJ19 Validation Targets - SESAR2020 Wave 2 & Wave 3 (ed. 2022) document, are listed below; the coloured scale allows a better vision of the expectation impact for the SESAR Performance, planned to be accomplished with the Wave 2 of the SESAR 2020's expected benefits.

SOL. CODE	SAF	FEEF1	TEFF1	CAP3	CAP1	CAP2	PRD1	PUN1	CEF2	CEF3	HP
PJ.10-W2-93	YES	3	N/I	N/I	3	3	2	N/I	3	3	YES

Table 5: Validation Targets apportioned to the SESAR PJ.10-W2-93 Solution

The validation exercises, both for V2 and V3, have been planned to demonstrate the validity and the feasibility of all the assumptions that have been provided as for Delegation of ATM services provision and Contingency in a Virtual Centre environment. The Solution is tested to validate the economical and ATM positive added value, in term of NPV and performances for each of the KPA.

It is worth mentioning that, based on the procedures for delegation and contingency described both in the VALP and in the SPR-INTEROP/OSED and TS-IRS, the actual status is that the ADSPs are not fully interoperable in a wide scale. In the future, as it is demonstrated with the validation exercises, the resources are provided in a more centralised manner enabling interoperability systems and ADSP.

This approach promises a more flexible way for delegation Air Traffic Services by validating the operational feasibility and acceptability and evaluating impact of ATM delegation in En-Route, ATFCM provision and TMA environment.

Therefore for the CEF2 KPA, a huge analysis was performed in conjunction with PAGAR project to assess the average at Solution level considering the Services applied for Delegation of ATS compared with the Virtual Centre Architectures (Y,D and U).

According to PJ.19, the airspace under analysis is considered as En-Route MC (ENAIRE, COOPANS, ENAV) and VHC (skyguide). However, the actual classification of this airspace in the context of Network Operations is En-Route HC and VHC. The project considers, as reported in the VALR, that the results obtained are representative of high and very high complexity environments.

The PAR estimates an ECAC level contribution of 5.9% in CEF2.

Performance Framework KPA[4]	Focus Area	KPI/PI from the Performance Framework	Unit	Metric for the CBA	Unit	Year 2028	Year 2035	Year 2043
Cost Efficiency	ANS Cost efficiency	**CEF2** Flights per ATCO-Hour on duty	Nb	ATCO employment Cost change	€/year	*2.91 M€*	*178.56 M€*	*469.01 M€*
				Support Staff Employment Cost Change	€/year	*N/A*	*N/A*	*N/A*
				Non-staff Operating Costs Change	€/year	*N/A*	*N/A*	*N/A*
		CEF3 Technology cost per flight	EUR / flight	G2G ANS cost changes related to technology and equipment	€/year	*0.769 M€*	*47.213 M€*	*124.010 M€*
Capacity	Airspace capacity	**CAP1** TMA throughput, in challenging airspace, per unit time	% and # movements	Tactical delay cost (avoided-; additional +)	€/year	*N/A*	*N/A*	*N/A*
			% and # movements	Strategic delay cost (avoided-; additional +)	€/year	*N/A*	*N/A*	*N/A*
		CAP2 En-route throughput, in challenging airspace, per unit time	% and # movements	Tactical delay cost (avoided-; additional +)	€/year	*N/A*	*N/A*	*N/A*
			% and # movements	Strategic delay cost (avoided-; additional +)	€/year	*N/A*	*N/A*	*N/A*

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

Performance Framework KPA[4]	Focus Area	KPI/PI from the Performance Framework	Unit	Metric for the CBA	Unit	Year 2028	Year 2035	Year 2043
Predictability and punctuality	Predictability	**PRD1** Variance of Difference in actual & Flight Plan or RBT durations	Minutes^2	Strategic delay cost (avoided-; additional +)	€/year	*N/A*	*N/A*	*N/A*
Environment	Time Efficiency	**FEFF3** Reduction in average flight duration	% and minutes	Strategic delay: airborne: direct cost to an airline excl. Fuel (avoided-; additional +)	€/year	*6.406 M€*	*393.440 M€*	*1,033.4 M€*
	Fuel Efficiency	**FEFF1** Average fuel burn per flight	Kg fuel per movement	Fuel Costs	€/year	*1.552 M€*	*293.496 M€*	*819,715 M€*
	Fuel Efficiency	**FEFF2** CO2 Emissions	Kg CO2 per movement	CO2 Costs	€/year	*2.388 M€*	*95.333 M€*	*250.404 M€*
Civil-Military Cooperation & Coordination	Civil-Military Cooperation & Coordination	**CMC2.1a** Fuel saving (for GAT operations)	Kg fuel per movement	Fuel Costs	€/year	*N/A*	*N/A*	*N/A*
		CMC2.1b Distance saving (for GAT operations)	NM per movement	Time Costs	€/year	*N/A*	*N/A*	*N/A*

Table 6: Results of the benefits monetisation per KPA

Table 5. above summarises the assessment outcomes per KPI. The solution has impacted more KPA, from the Operational Efficiency to the Cost Efficiency and to the Capacity and so on (see PAR for details).

The following file represent the calculation models and the costs and benefits of the PJ10 Solution 93:

CBA - ENAV Template_SOL_93_V

.

5 Cost assessment

The implementation of the Solution entails a series of costs that impact the stakeholders involved. 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 and Industry Companies that revolve around the world of technology linked to the ATM world (communication and data, system and hardware, etc). Therefore, the Stakeholders involved in the quantification of costs are only these two categories for all UCs treated in the Solution, even if only ANSP costs will incur into the economic evaluations.

No other Stakeholder will incur in any costs as the equipment is already deployed and available in the Reference Scenario (for clarify, Reference Scenario is based on the Baseline Scenario assessment – the actual status of the ATM System – with the VC concept already implemented as an assumption).

In the following paragraphs the costs of the Delegation are described in detail.

Note: ANSPs and ATCOs are identified as directly impacted Stakeholder groups; ATCOs are part of ANSPs' organisations and therefore the costs associated with them are included within the ANSP analysis presented in the following sections.

The analysis on the economic Costs assessment, as the entire Virtual Centre and the associated use cases, wish to assess the economic benefit considered in the CBA. This analysis is based on some assumptions that involve the investments of the ATSUs in ECAC, starting with the possibility to use a single or multiple ADSPs up the architecture's choices by stakeholders.

The strategy to define the investment at ECAC level, aimed at implementing the VC, took into account the fact that all, or most of the ATSUs in ECAC, should be compliant with a common Infrastructure Architecture that will allow them to apply a delegation of the ATS services and contingency by using the VC services rather than if all the architectures adopted will be standardized with functional services for the virtual Centre.
The figure below reports the timeframe assumed within the CBA for this implementation. It must be coordinated at ECAC level in order to obtain a common architecture feasible for the VC concept within the same timeline and also define a cost optimization irrespective to the target architecture.

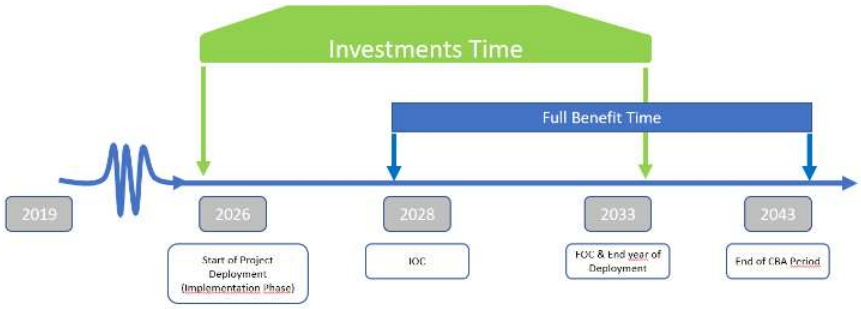

Figure 2: Investment Timeline

Co-funded by the European Union

5.1 ANSPs costs

The CBA needs to consider the investment costs of preparing the OPS Room's layout (additional ***ATCO's CWPs*** and ***Supervisor Delegation Tool***) to allow the implementation and the Operational process of *Delegation of Airspace among ATSUs*, as well as the project management involved with installation, testing, transition periods, developing and documenting procedures, training costs, etc. (i.e., everything needed to get the systems and the operational concept available).

It is also necessary to assess the impact on Operating costs during the CBA period. For example, what is the impact on maintenance costs or ongoing training – will they increase, decrease or remain stable, and going ahead with the other cost items.

ANSPs will incur the costs. No other stakeholder will incur any costs considering the relevant scenarios.

Solution 93 impacts only on ANSPs in the assessment of costs; and it is also considering the alignment of the systems to allow the delegation progress. No other stakeholders are interested by costs in a consistent manner, considering all the relevant operational scenarios.

5.1.1 ANSPs cost approach

Three costs groups have been considered during the CBA:

1. *Pre-Implementation Costs*: all costs required to define the needs, to develop solutions (R&D), to decide which solution best serves the needs. These costs are already incurred in the SESAR Development Phase. Any pre-implementation surveys/investigation conducted locally are assumed to be part of Implementation costs; therefore, no pre-implementation costs are identified.
2. *Implementation costs*: all costs related to the acquisition and implementation of the Solutions scope, such as Hardware, Software, training, license, patent, program management, etc. It is assumed that implementation will commence in 2026, based on the Timeframe scope presented in Section 2.2.
3. *Operating costs*: Costs required for the day to day running and maintenance of the solutions in addition to current normal operation without the Solutions.

5.1.1.1 Quantitative Analysis *Solution 93 - Delegation of Airspace*

Costs are categorized by the:

- ✓ deployment (initial installation and link connection) and on-going maintenance of the ***ATCO's CWPs*** and related technological (Hardware & Software) infrastructure to be installed within the ***Delegated ATSU*** OPS room to allow the Delegation process.
- ✓ deployment (initial installation and link connection) and on-going maintenance of the ***Supervisor Delegation Tool*** and related technological (Hardware & Software) infrastructure to be installed at the Supervisor Working Position within ***both ATSUs' OPS rooms.*** This approach allows following the Delegation progression throughout the process lifetime (before, during and after). Moreover, the Tool should also consider traffic allocations, ATC sectorization, ATCO endorsement, a rostering plan, shift and technical constraints.

EUROPEAN PARTNERSHIP

Co-funded by the European Union

- ✓ initial and on-going training of ***ATCOs*** (all the ATCOs initially assigned to start implementing the Delegation Process) and ***ATCO Supervisors*** in the use of the ATC Delegation operational procedures, as well as initial and on-going training for technical specialists that are in charge to withstand and to support the electronics and software which enable ATS systems to function (***ATSEPs***).
- ✓ initial deployment, update and maintenance of ATCO's operational procedures, certifications and guidance material for local application of the ***Delegation Processes,*** and also for Technicians and all the other actors involved.
- ✓ initial deployment of a VC environment considering the implementation of the Y Architecture essential to ensure, the application of the Delegation of ATS and Contingency with different ATSUs. Moreover, the comparison between architectures (Y, D, U) has been fully explained in the Sensitive Analysis.

As presented in Section 2.2, ***Solution 93*** is planned to be validated to ***EnRoute Operating Environment*** only, at this stage EnRoute Airspaces categorized as ***Very High*** & ***High Complexity***.

Implementing costs:

- ***Acquisition, installation, configuration, testing, certification and setting to work*** of the *ATCO's CWPs equipment* (***1 CWPs*** for each EXE & PLN, so ***2 CWPs*** for each Operational position) required depending on the amount of ATC Sectors that will be involved for the Delegation of Airspace, as well as for the ***Supervisor Delegation Tool*** (1 on-line and one on stand-by), comprising dedicated Data-Link interface with the NM System.
  It is assumed that:
  - ✓ implementation is per ***ACC*** (*Airspace Control Centre*) and fully interoperable with the FDP Network System;
  - ✓ includes back up/failure provision (both for ATCO's CWPs and for Supervisor Delegation Tool);
  - ✓ is compliant to any required operational and technical standards, as for certification for systems and licences.

The cost driver is:

*[(**Cost of HMI (ATCO CWP & Accessories) & SW**)] + [**Cost of Comms network** (Datalink)]*, where:

- ➢ ***HMI (CWP & Accessories) & SW*** = Cost of [acquisition + installation + configuration + testing and certification to applicable standards + operational deployment]. It is assumed that for each ATSU/ACC's OPS room there will be allocated ***6 CWPs (3 ATC Operational Positions – 2 ATC operational positions online and 1 spare for back-up)***, both for Operational needs and for back-up as well.
- ➢ ***Cost of communications network*** *(CWPs' Datalink)* = Cost of [acquisition + installation + configuration + testing and certification to applicable standards + operational deployment]
- ➢ ***HMI (Supervisor Delegation Tool & Accessories) & SW*** = Cost of [acquisition + installation + configuration + testing and certification to applicable standards + operational deployment].

Co-funded by the European Union

It is assumed that *for each Supervisor position*, within both ATSU/ACC's OPS room, there *will be allocated **2 HMIs**, both for Operational needs and for back-up too*.

- ***Cost of communications network*** *(Supervisor Delegation Tool's Datalink)* = Cost of [acquisition + installation + configuration + testing and certification to applicable standards + operational deployment]

In accordance with SESAR CBA guidance (STELLAR FAQ_CBA_v4_ (1_1)) the overall scales of *Cost of Server & SW* and *Cost of Comms Network* are estimated rather than the individual aspects. (*Source: Stakeholder Judgement*).

***ATSU/ACC** – Very High & High OEs (**Source**: Stakeholder Judgement)*

Item	Low (K€)	Medium (K€)	High (K€)
ATCO's CWP *(Hardware)* ***(Quantification is for 6 CWPs)***	***135***	***180*** ***(30*6)***	***225***
Licenses, Server & SW Update & Maintenance	***2,700***	***3,600*** ***(600*6)***	***4,500***
Comms to Network	***225***	***300*** ***(50*6)***	***375***
Supervisor Delegation Tool *(Hardware)* ***(Quantification is for 2 devices)***	***24***	***30*** ***(15*2)***	***40***
Licenses, Server & SW	***520***	***600*** ***(300*2)***	***700***
Comms to Network	***6***	***10*** ***(5*2)***	***20***
Total	***3,610***	***4,720***	***5,860***

- ***ATM Infrastructure for the Delegation Service***
  - ***Acquisition, installation, configuration, testing, certification and setting to work*** of the Virtual Centre with the related architecture serving the implementation of the Services and identified as "Y" architecture, essential to ensure, among operational requirements, the application of the Delegation of ATS and Contingency with different ATSUs for the services

EUROPEAN PARTNERSHIP

Co-funded by the European Union

identified, to guarantee the operational procedures as detailed and described in the OSED Deliverable.

Based on the current Services, for the rationalization of the infrastructure already defined in SESAR 2020-Wave 1 PJ16.03, according to the different architecture defined in PJ32 and EUROCAE Working group 122.

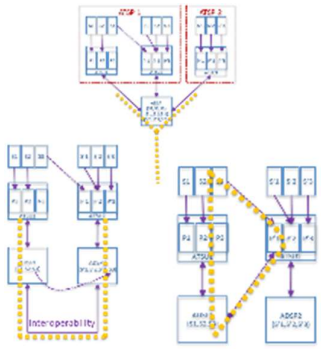

Figure 3 : ATM Infrastructure for the Delegation Service

It is important to highlight that, not all the costs gathered for the implementation and maintenance of the VC are strictly related to the Delegation, this is the reason it has been applied a certain percentage in order to consider for the part strictly related to the delegation to ATS according to the Architecture validated.

The cost of each Service has been evaluated considering the specific weight and relevant of the Service in respect to the total cost of a VC Implementation.

Consequently, can be assumed that, by applying an Impact on the Delegation ATS, percentage to the quality of the services analyzed, an associated economic value might be obtained to guarantee the implementation of the technical requirements needed for Delegation and Contingency of ATS.

Services Used for Infrastructure as a Service	Cost of Virtual Centre Digital Evolution (K€)	Impact on the Delegation Process (%)
Airspace Status Distribution	**138**	**5%**
Arrival Sequence Management	**358**	**5%**
Coordination and Transfer Management	**992**	**10%**
Correlation Data Distribution	**331**	**5%**
Flight Data Distribution	**3,142**	**30%**

Monitoring Aids Distribution	**220**	**5%**
Operational Configuration Distribution	**1,543**	**20%**
Technical Supervision Distribution	**772**	**20%**
Surveillance Data Distribution	**275**	**5%**
Voice Comm Information Distribution	**1,102**	**20%**
Operational Configuration Management Service	**1,212**	**20%**
Total cost "Y Architecture"	***10,085***	***5%***

Table 7: Solution 93 Architecture Y costs

Having therefore defined the quantification of the economic values for the cost items referred to in the table above, can be assumed the amount for the planned investment in the architecture of the Virtual Centre, in the contest of the application of the Delegation of ATS, for the purposes of implementing the services for architecture "Y" will correspond to approximately € ***10.085 MLN***.

ATM Data layer infrastructures is the key element of this question. Rationalization /Optimization of data production for the SUR, FDP led to staff and cost saving due to horizontal integration to the transition in data production infrastructures. This integration will induce a significant implementation cost in case of definition of the entire ATM systems (approximately 95%) or adding a new entrance being internally restructured to be aligned with the services interfaces proposed.

Therefore, the quantification of Costs at 5 %, associated to the definition of the Costs of the Virtual Center Architecture, are linked to the specifications to be ensured in order to be able to apply the services of the delegation of ATS. Those Services are detailed in Table 6, as the output of the comparison between the technological infrastructure and CNS departments of the different ADSPs.

Complementing, based on the analysis reported in the Table 6, the remaining 95% of the full costs related to the entire ATM infrastructure isn't directly associated with the needs of the Delegation but to the entire ATM Architecture as a whole. Indeed, the economical quantification is connected and associated with the ATS services used for the rationalization of infrastructure and specifications of the entire ATM system as well.

standing to this principle, artificially, it is assumed that all the ATSUs had at the stage, the same capabilities and the same Exchange Information Required for the ATS services; indeed, the required services (and associated costs) listed and shown in Table 6 represent a minimum set required in order to ensure that the Delegation services are reasonable for the purpose of validation.

Therefore, several recommendations are reported to all the stakeholders, industry and regulator will aim:

- Foster and cost-efficient delivery of the services to maintain different level of charges,
- Support efficient gains and innovation over the time;

- Ensure an adequate offer of the services /quality
- Continuing the update of the interface up the competitive market close to the IT technology innovation

- ***Training of personnel involved within the Delegation Process***

  - ***Training of ATCOs***: the number of ATCOs (***EXEs and PLNs***) needed to be qualified for the Delegated ATSU/ACC, in the first phase and with the aim of allowing the implementation of the Airspace Delegation process, is based on an analysis of the number of ATC Sectors that must be moved (pre-defined by the shape of the Airspace that has to be delegated).
    Having assessed that the Delegation of Airspace among ATSUs will be *bidirectional,* it means that *ATSU_#1 will assure the management of the ATC Sectors previously identify of ATSU_#2 and vice-versa the same will be assured by ATSU_#1.*
    Anyway, for this study the Cost quantification *will be calculated one way only*.

    Assuming that the shape of the *Airspace* that will be delegated, and the *Sector Configuration* necessary to handle it, it requires an effort of ***2 ATC Sectors***, we can define that a similar *ATC Configuration* with a similar layout quantifies an initial amount of ***25 EXEs and 25 PNLs*** fully qualified for the Airspace to manage within the Delegated ATSU, and ready to be assigned on duty.

    The quantification considers the number of ATCOs on position, the associated relief and the other ATCOs that have to be available in case of holidays or sickness or similar needs.

  - ✓ ***Training for ATCO Supervisor***: in parallel to the ATCOs that need to be trained to obtain the qualification for the Delegation process, the ATCO Supervisors that have to handle the entire process (preparation phase, transit in operations and to supervise the whole process) need to have the same training period in parallel with the ATCOs. And within the same course with the aim to handle the process within the simulation room.
    As well as for the ATCOs, the same programme must be planned for the Supervisor, that means that *the same number of Supervisors must be qualified for both ATSUs due to the bidirectional process previously described.*
    It is assumed that the number of ATCO Supervisors that must be qualified to manage the Supervisor Delegation Tool for the scope of the Delegation process will be ***15 per ATSU*** and they will be inserted ***3 per ATCOs training courses***.
    For the scope of the Delegation process and the necessity to have continuous supervision and constant coordination about the traffic situation and its management, it is assumed that it is mandatory to qualify the same amount of ATCO Supervisors for both ATSUs; for these reasons the cost assessment will be calculated for both ATSUs.

  - ✓ ***Training for Technicians Operational Experts (ATSEP)***: ATSEPs are *engineers and electronic technicians (specialists in communications, navigation, surveillance (CNS) and air traffic management (ATM) engineering systems) who work in the field of civil aviation with tasks that have an impact on the safety of air traffic control services*.
    ATSEPs need to be trained to obtain the qualification for the surveillance and correct management of the *Supervisor Delegation Tool*, as well as for the other ATC Devices (CWPs or

Frequencies apparatus) that are within the OPS Room with the aim to manage the ATC of flights within the AoR of the ATSU.
It is assumed that the number of ATSEPs that must be qualified to manage the Supervisor Delegation Tool will be ***20 per ATSU*** and they will be included ***4 per ATCOs training courses*** planned for the ATCOs. For the scope of the ATSEPs, the number of training days is fixed in ***5 working days (one week).***
For the scope of the Delegation process and the necessity to have continuous situation awareness both on the HW & SW essential for the Supervisor Delegation Tool, it is assumed that it is mandatory to qualify the same amount of ATCO Supervisors for both ATSUs; for these reasons the cost assessment will be calculated for both ATSUs.

No extra effort for ATCO Supervisor neither *other extra effort nor Technicians* on duty is necessary to handle the Delegation Process; both the Supervisors as well as the Technicians on duty for the own ATSU's Airspace will be allocated to support the Delegated Airspace too.

Having defined the quantification of ***ATCO Personnel & ATCO Supervisor*** to qualify, it is assumed that to cover the *Initial Training Section* comprises ***10 working days (2 weeks)*** in the *Remote Training facility* (a theoretical session of ***3 days/8 hours per day*** + ***7 days/8 hours per day*** with practical exercises into the training facility that will consider a qualification test at the end of the training period (*Source: Stakeholder Judgement*).

The cost is assumed to comprise two elements:

- the ***cost of the training course*** to the ANSP, which may be provided by a third-party provider or could be "internal charging" to an in-house provider; and
- the ***cost of the ATCOs*** & ***Supervisors attending the training***, which could be regarded as the additional cost of employment for the additional training days or as the opportunity cost for the time they are not available for operational duty.

The cost driver is:

[Cost of Training Course * # of courses] + [Cost of an ATCO attendance * # of ATCOs] where*:*

- ***Cost of Training Course*** *= [# of days in training course * cost of training day],* where:
  - ✓ # of days in training course is **10, *#3*** *days of theory in classroom and* ***#7*** *days in the Simulation Room* (*Source: Stakeholder Judgement*)
  - ✓ cost of ***training day***, based on ***3 trainers*** (*preparing material, supporting theory, simulation runs, ATCO guidance and support and final exam for the qualification*) + simulation facility + materials, this last prepared by **1 administrative operator**.
    Unlikely to be less than ***€3K***, median ***€8K***, unlikely to be more than ***€16K*** (*Source: Stakeholder Judgement*)
  - ✓ Therefore, ***Total Cost of training course*** (*10 days, 3+1 Training people*) could be quantified between €***133.5K*** and €***222.5K*** with a median value of €**178*K***

- ***# of Courses*** *= [# ATCOs / # of ATCOs at each training session],* where*:*
  - ✓ # ATCOs is ***50*** (*25 EXEs + 25 PLNs*) per ATSU – *Very High/High OEs* (*Source: Stakeholder Judgement*)
  - ✓ # ATCO Supervisors is ***15*** per ATSU – *Very High/High OEs* (*Source: Stakeholder Judgement*)

EUROPEAN PARTNERSHIP
Co-funded by the European Union

- ✓ # of ATCOs at each ***training course*** is ***13*** *(5 EXEs + 5 PLNs + 3 Supervisors)* (*Source: Stakeholder Judgement*)
- ✓ Therefore, ***# of Courses*** is ***5*** for ***ATSU*** (*50 working days/10 working weeks*) – *Very High/High OEs*.

➢ ***Cost of an ATCO attendance*** *= **[# ATCO training days * # ATCO Hours/Day * ATCO cost/hour],*** where:

- ✓ # of ***ATCO*** training days is **10** (*source: Stakeholder Judgement*)
- ✓ # of ATCO Hours/Day is **8** (*source: SESAR common assumptions*)
- ✓ ATCO cost/hour is **€127.0** (*source: Pan-European system cost-effectiveness performance in 2019 - ACE 2019 Benchmarking Report with Special Focus on COVID-19 Impacts in 2020*
- ✓ Therefore, Cost of an ***ATCO*** attendance is **€ 10,2 K**
- ✓ And consequently, Total Cost for ***ATCOs*** attendance is about **508K**.

- ✓ # of ***ATCO Supervisor*** training days is **10** (*source: Stakeholder Judgement*)
- ✓ # of ATCO Supervisor Hours/Day is **8** (*source: SESAR common assumptions*)
- ✓ ATCO cost/hour is **€127.0** (*source: Pan-European system cost-effectiveness performance in 2019 - ACE 2019 Benchmarking Report with Special Focus on COVID-19 Impacts in 2020*
- ✓ Therefore, Cost of an ***ATCOs Supervisors*** attendance is **€ 10,2 K**
- ✓ And consequently, Total Cost for ***ATCOs Supervisors*** attendance is about **153K**.

- ✓ # of ***ATSEP*** training days is **5** (*source: Stakeholder Judgement*)
- ✓ # of ATSEP Hours/Day is **8** (*source: SESAR common assumptions*)
- ✓ ATCO cost/hour is **€ 65.0** (*source: Pan-European system cost-effectiveness performance in 2019 - ACE 2019 Benchmarking Report with Special Focus on COVID-19 Impacts in 2020*
- ✓ Therefore, Cost of an ***ATSEP*** attendance is **€ 2,6 K**
- ✓ And consequently, Total Cost for ***ATSEP*** attendance is about **52K**.

➢ ***# of Personnel per ATSU =*** **50** ATCOs +**15** ATCO Supervisors + **20** ATSEPs (assumption).

ATSU/ACC *– Very High & High OEs* (***Source****: Stakeholder Judgement*)

Item	Low (K€)	Medium (K€)	High (K€)
Cost of ***Training*** Session ***(ATSU_#1)***	***80***	***107***	***134***
Cost of ***Supervisor*** Attendance ***(ATSU_#1)***	***115***	***153***	***191***
Cost of ***ATSEP*** Attendance ***(ATSU_#1)***	***39***	***52***	***65***
Cost of ***Training*** Session ***(ATSU_#2)***	***134***	***178***	***223***
Cost of ***ATCO*** Attendance ***(ATSU_#2)***	***381***	***508***	***635***

Cost of ***Supervisor*** Attendance ***(ATSU_#2)***	***115***	***153***	***191***
Cost of ***ATSEP*** Attendance ***(ATSU_#2)***	***39***	***52***	***65***
Total	***903***	***1203***	***1504***

Table 8: Solution 93 Training costs

- ***Project management and other necessities to accomplish for the Delegation Process***

  - **Project management**, **update of Local Manuals** and **Procedures**, *Certification and Validation and General Administration* in relation to the entire ***Delegation Process*** per each ***ATSU/ACC***.

    - ✓ Regarding ***Certification*** and ***Validation*** aspects, it is estimated, based on similar activities in the past *(Source: Stakeholder Judgement)*, that this would be equivalent of ***2 Administrative staff*** over a period of ***2*** week (a total of ***10 working days***).
      The cost driver is, therefore:

[Cost of Certification/Validation] = [Cost of Admin staff/hour * # of hours/day * # of days] * # of Admin Staff, where:

- ✓ Cost of Administrative staff/hour is ***€64.0*** (*Source*: *Pan-European system cost-effectiveness performance in 2019 - ACE 2019 Benchmarking Report with Special Focus on COVID-19 Impacts in 2020*) *Employment costs for non-staff operating costs (23.8% of total support costs)*
- ✓ # of hours/day is ***8***
- ✓ # of days is ***10***
- ✓ # of Admin Staff is ***2***

The median cost of Certification/Validation is, therefore, between ***€7,7K*** and ***€12.8K*** with a median value of ***€10.24K***.

- ✓ Based on the experience of implementing similar technological advances, a range of bundled values have been determined with the aim to provide a detailed breakdown of the remaining ***Project Management, Documentation (Internal Procedures*** and ***check list material*** for ATCOs***, Letter of Agreement*** with bordering ATSUs***, Bilateral Agreement*** between ATSUs to allow the Delegation of Airspace***, etc)*** and ***General Administration one-off costs***.

The quantified assessment amounts (similar to the ***Cost of Certification/Validation***) to ***4 working weeks (20 working days)*** for PM and manuals/procedures updates ***(# 2 Administrative Units***).

It is assumed that the above assumptions will be calculated for both ATSUs because it is mandatory to be put in place and to harmonize within both ATSUs all the procedures and certifications for the scope of the Delegation process; for this reason, the ***amount of costs listed below will be doubled.***

ATSU/ACC *– Very High & High OEs (**Source**: Stakeholder Judgement*)

EUROPEAN PARTNERSHIP

Co-funded by the European Union

Item	Low (K€)	Medium (K€)	High (K€)
PM, Documentation, Admin	***14***	***20***	***26***
Certification & Validation	***8***	***10***	***13***
Total	***22***	***30***	***39***

Table 9: Solution 93 Administrative costs

In summary, the estimated One-Off/Implementation Costs for ***Solution 93-V3*** are shown in the following table.

Cost Item	Short description	Median Cost (K€)	Source
ATSU/ACC – Very High & High OEs			
Cost of VC implementation	All the costs related to acquisition, installation, configuration, testing, certification and setting to work of the Virtual Centre	10,085 M€	*Stakeholder judgement*
Cost of Training Sessions *(Calculated x 2 ATSUs)*	All the costs related to prepare and to manage the training Courses for ATCOs, Supervisors & ATSEPs to be qualified for the *Delegation of Airspace* and the *Supervisor Delegation Tool*	285 K€	*Stakeholder judgement, SESAR common assumptions and standard references*
ATCOs' Training *(Calculated x 1 ATSU – in case of bilateral Delegation btw ATSUs the amount will be doubled)*	All the training and staff costs related to the ATCOs' Training Course to be qualified for the Delegated Airspace	508 K€	*Stakeholder judgement, SESAR common assumptions and standard references*
ATCO Supervisors' Training *(Calculated x 2 ATSUs)*	All the training and staff costs related to the ATCOs' CWP and the Supervisor Delegation Tool	306 K€	*Stakeholder judgement, SESAR common assumptions and standard references*
ATSEPs' Training *(Calculated x 2 ATSUs)*	All the training and staff costs related to the ATSEPs and the Supervisor Delegation Tool	104 K€	*Stakeholder judgement, SESAR common assumptions and standard references*
Administrative costs *(Calculated x 2 ATSUs)*	All the administrative costs related to the acquisition, installation, configuration and testing of the Supervisor Planning Tool	60 K€	*Stakeholder judgement, SESAR common assumptions and standard references*

EUROPEAN PARTNERSHIP

Co-funded by the European Union

ATC CWPs Infrastructure Installation & Commissioning *(Calculated per 6 CWPs per ATSUs – in case of bilateral Delegation btw ATSUs the amount will be doubled)*	Installation and configuration costs. Initial Test and evaluation	4,080 K€	*Stakeholder judgement,* *SESAR common assumptions and standard references*
Supervisor Planning TOOLs Infrastructure Installation & Commissioning *(Calculated x 2 ATSUs)*	Installation and configuration costs. Initial Test and evaluation	1,280 K€	*Stakeholder judgement,* *SESAR common assumptions and standard references*
TOTAL		**16,708 M€**	

Table 10: Solution 93 Implementing costs

Operating costs:

- ***Device and infrastructure replacement***.

  It is assumed that:

  - ✓ the ***ATC infrastructure equipment (HW and Communication Network)*** will be replaced on ***10-year cycle*** throughout the CBA period at the full initial implementation cost. The ***replacement will start 5 years*** after the IOC.
  - ✓ this ***periodic one-off cost includes provision of SW updates and patches*** throughout the ***yearly period*** or when it necessitates on demand.
    The *replacement/maintenance/update* of the ***SW*** for the CWPs allocated to the Delegated Airspace within the ASTU will be planned in parallel with the entire ATC System of the ATSU, that means it will be update parallelly with the other entire SW infrastructure within the ATSU, independently if the CWPs are allocated to the Delegated Airspace or to the AoR of the ATSU.
    There won't be any additional cost to update the SW and the Licences for the CWPs addressed for the Delegation of Airspace amongst ATSUs, because both the SW Maintenance and the provision of updates and patches are part of the same contract.

  The cost driver, per year after ***IOC*** (planned in ***2025*** as in Section 2.2)*, is centred on the **10%** of the initial installation costs:*

  - ***[(Cost to update HW on ATC infrastructure equipment)] + [Cost of Comms network** (Datalink)] * **1.20***, and the final value will be divided per 10, ***considering the life-cycle periods of technological infrastructure equal 10 years each***, where:
  - ***Cost of communications network** (Datalink)* = Cost of [acquisition + installation + configuration + testing and certification to applicable standards + operational deployment] ***per each life cycle***
  - ***Lifecycle of technology = 10 years &*** increase of costs estimated of ***20%*** at 2042

- ***SUPERVISOR DELEGATION TOOL***

As for the ***ATC infrastructure equipment,*** it is assumed that the same assumptions should be assessed for the ***Supervisor Delegation Tool*** too. The life cycle of this device is compatible with the other ATC infrastructure:

- ✓ the ***basic equipment*** (*HD & Computer interface*) will be replaced on ***10-year cycle*** throughout the CBA period at the full initial implementation cost. The ***replacement will start 10 years*** after the IOC.
- ✓ this ***periodic one-off cost*** includes provision of ***SW updates and patches*** throughout the ***10-year period***. The replacement will ***start 5 years*** after the IOC.

The cost driver, per year after ***IOP*** (planned in ***2025*** as in Section 2.2)*, is centred on the 10% of the initial installation costs:*

*[(**Cost of Server & SW**)] + [**Cost of Comms network** (Datalink)] * **1.20***, and the final value will be divided per 10, ***considering the life-cycle periods of technological infrastructure equal 10 years each***, where:

- ➢ ***Cost of Server & SW*** = Cost of [acquisition + installation + configuration + testing and certification to applicable standards + operational deployment] ***per each life cycle***
- ➢ ***Cost of communications network*** *(Datalink)* = Cost of [acquisition + installation + configuration + testing and certification to applicable standards + operational deployment] ***per each life cycle***
- ➢ ***Lifecycle of technology = 10 years*** & increase of costs estimated of ***20%*** at 2042

The above will be valid both for the delegating ATSU and for the Delegated ATSU and vice versa.

ATSU/ACC *– Very High & High OEs (**Source**: Stakeholder Judgement)*

Item	Low (K€)	Medium (K€)	High (K€)
ATCOs' CWPs HW & Comm (***Calculated per 6 CWPs per ATSUs –*** in case of bilateral Delegation btw ATSUs the amount will be ***doubled***)	***461***	***576*** ***(96*6)***	***691***

Co-funded by the European Union

Supervisor Delegation Tool Licenses & SW & Comm *(Quantification is calculated for **2 devices per ATSU** & then for **2 ATSUs**)*	***115***	***154*** ***(38.4*2)*2***	***192***
Total	***576***	***730***	***883***
Annual value *(#/10)*	***57.6***	***73***	***88.3***

- **Training for ATCOs & ATCO Supervisors & ATSEPs:**

  It is not envisaged that ad hoc training cycles and/or dedicated recurrent training courses are planned for ATCOs as well as for Supervisors, both new assigned and personnel already in force at the ATSU for extensions of ATC qualifications, because both the basic training program and the monthly recurrent training courses for ATCOs personnel will also include a section dedicated to updating the specifications relating to Airspace Delegation, as well as in the case of new functions of the Supervisor Delegation Tool and/or changes relating to the characteristics and / or dimensions of the Delegated Airspace.

In summary, the estimated ***Operating Costs*** per ***YEAR*** after the ***IOC*** calculated for ***Solution 93*** are shown in the following table.

Cost Item	Short description	Median Cost (K€)	Source
Replacement Infrastructure Installation & Commissioning	***10-year replacement*** Installation and configuration costs, *after the IOC*	***730 K€***	Stakeholder judgement
TOTAL	**Annual**	**73 K€**	

Table 11: Solution 93 Operating costs

5.1.2 ANSPs cost assumptions

The costs assessment includes only the differential (or delta) value implied by the solution over the reference scenario. All the costs imputable to the reference scenario and not to the solution scenario are not included.

- Costs for training ATCOs as well other costs addressed to the HP will be related to the ACE Report 2021 and the Document Standard Inputs for CBA released by Eurocontrol;
- Currency used will be Euro and the discount rate will be the standard value at 8%; other investment costs and operational costs for technology or HD & SW will be proposed based on Stakeholder judgement;
- Inflation is not considered because the model uses a Real Discount Rate; basis for prices is 2019;
- 3 different Technological Architectures has been considered for VC service ("Y" – "D" – "U"). The costs' portion of Architecture implementations to be applied for the delegation process have been evaluated considering the percentage of the needs of the services during delegation ATS process;
- There won't be any cost assessments calculated for the Continuous Training, both for ATCOs and for ATSEP too, because the planned Recurrent Training lessons will provide within their scope any update of the Delegation process and any changes/amendments/integrations to the delivered delegation Scenario;
- There will be no additional cost assessments calculated for the SW's update and the provision of any (planned or unplanned) SW's patches, because all the SW evolutions available for the provision of ATC Services within the Operational premises of the Delegated ATSU will be considered as a whole, both for their own CWPs and for the CWPs dedicated to the Delegated Airspace;
- The cost savings for the ATSU1 are considered with the benefit assessment;
- In the Operating phase the new assigned ATCO/ATSEP will receive the required training for the delegated Airspace together with initial basic training, for this reason this cost item is not considered within the operating cost section;
- The recurrent training lessons (both for ATCOs and ATSEPs) will consider the topics regarding the Delegated Airspace concept and SPT, so any update or any changes/amendments on the arguments will be inserted within one or more monthly lessons with the aim of updating the trainees about; thus, it is not necessary to plan an ad hoc recurrent training for the items and it is not considered within the Operating Cost section;
- Any changes or evolutions in the Delegation concept will not be part of the administrative costs after the implementation because they will be part of the daily and institutional activities of the ATSU structures (similar to a recurrent update of the LoA or to a bilateral operative agreement btw ATSUs);
- Any changes or evolutions in the SPT (Supervisor Planning Tool) will not be part of the Operating costs after the implementation because it is already considered within the annual cost planned and included within the SW cost's patches.

5.1.3 Number of investment instances (units)

Airport				TMA			ACC		
HC	HS	LC	LS	H	M	L	VH & H	M	L
N/A	N/A	N/A	N/A	N/A	N/A	N/A	***32***	N/A	N/A

Table 12: Number of investment instances - ANSPs

5.1.4 Cost per unit

Cost category	Airport				TMA			ACC		
	HC	HS	LC	LS	H	M	L	H	M	L
Pre-Implementation Costs	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Implementation costs	N/A	N/A	N/A	N/A	N/A	N/A	N/A	***535 M€***	N/A	N/A
Operating costs	N/A	N/A	N/A	N/A	N/A	N/A	N/A	***32 M€***	N/A	N/A

Table 13: Solution 93 Cost per unit

5.1.5 Contribution from PJ32

A strong coordination with ***PJ.32-W3*** about the Cost of the CBA for PJ10.W2 Sol 93 Delegation ATS and Virtual Centre about the cost of Rationalization of Infrastructure has been established from the beginning of the project.

The evaluation of costs obtained in the CBA have been extrapolated considering what have been done in the other structured and planned activities for the Solution/PJ, day by day.

The cooperation of these 2 projects have been covered in the ***Technical Thread*** so called *Virtual Centre technical validation infrastructure* has the target to develop and/or complement, verify and integrate the technical validation infrastructure required to support Airspace Delegation validation EXEs (both PJ10-W2-93 and PJ32-W3 ATM Thread) in the Virtual Centre context.

5.2 Airport operators costs

N/A

5.3 Network Manager costs

This section is reported in the Deliverable managed by PJ32 WP2 D3.2.180. Therefore, according to the target architecture per Exercises, the ADSP was connected with specific interface to an external ATSU (centralized Network Manager and/or Civil/Military ATSUs) which is handled by the local Flow Manager Position (FMP).

5.4 Airspace User costs

N/A

5.5 Military costs

This section is reported in the Deliverable managed by PJ32 WP2 D3.2.180. This section is reported in the Deliverable managed by PJ32 WP2 D3.2.180. Therefore, according to the target architecture per Exercises, the ADSP was connected with specific interface to an external ATSU (centralized Network Manager and/or Civil/Military ATSUs) which is handled by the local Flow Manager Position (FMP).

5.6 Other relevant stakeholders

N/A

EUROPEAN PARTNERSHIP

Co-funded by the European Union

6 CBA Model

The embedded CBA model is adapted from the SESAR Integrated CBA Model described in the SESAR 1 deliverable (D68 from P16.06.06). This model, ENAV copyright, and the associated algorithm is designed for all possible CBA scenarios, both SESAR ones as well as internal needs, and many of the sheets and calculations have not been used for this Solution CBA.

The Cost-Benefit Analysis tool is based on an input-output approach, including:

- Inputs:
    - Costs: which includes investments performed by the Stakeholders and operating costs that will incur during the Delegation;
    - Benefits: expected to be brought by the solution in terms of social, economic, environmental point of view. The source for the benefit calculation inputs is the 2020 Validation Targets assigned to PJ.10-W2-93 by PJ19.04.
- Outputs:
    - Net Present Value (NPV): the difference between the present value of cash inflows and the present value of cash outflows over a period;
    - Benefit-Cost Ratio (BCR): summarize the overall relationship between the relative costs and benefits of the Delegation;
    - Payback Period (PP): the amount of time it takes to recover the cost of the investment.

In the following figure the approach adopted is presented.

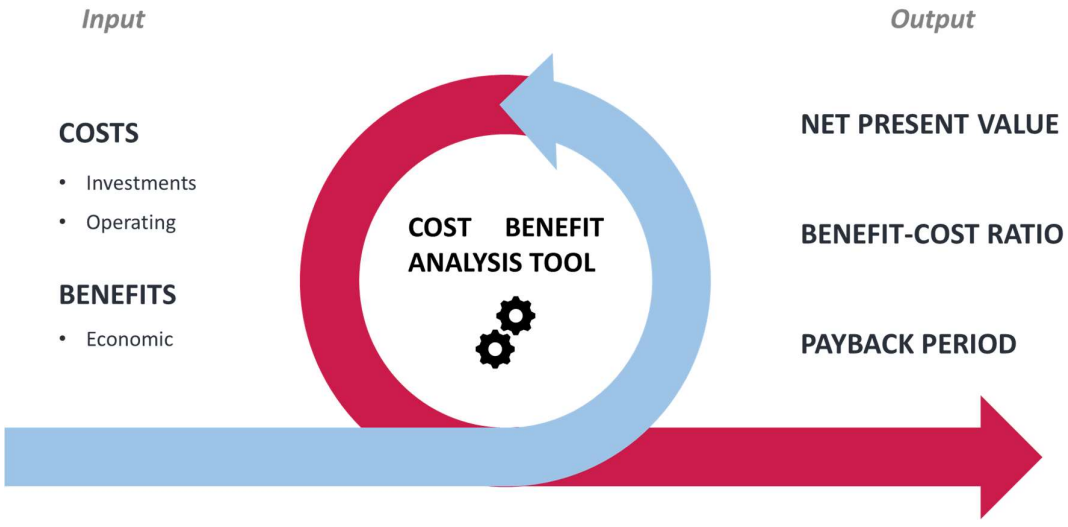

Figure 4: CBA Model

The nature of these outputs is both qualitative and quantitative. This implies an impossibility to generate an output value measurable with precision, counting also the impossibility to identify a single

Co-funded by the European Union

target value for each cost item. In fact, the excel shared with the Stakeholders concerned indicate a range of values between the minimum and maximum.

6.1 Data sources

Data Sources of information to perform the Cost Benefit Analysis are listed below:

1. Final V3 deliverables from SESAR 2020 Wave 2 & Wave 3 - PJ.10-W2-93
2. Standard Inputs used in the development of previous Cost Benefit Analyses related to ATM operational improvements
3. CBA Algorithm used for SESAR's CBA & Eurocontrol Methodology Handbooks
4. ANSP and Industry internal resources - experts from Finance, Operational & Technical departments in cooperation with industrial partner experts' contributions
5. DDR2 & STATFOR for traffic information & NM Standard Inputs for CBA for Cost value information
6. PJ.32-W3 – Virtual Centre

7 CBA Results

The analysis of the benefits that is presented in this paragraph completes the economic evaluation's framework related to the Operational Improvement of the Solution, previously validated for its operational feasibility by the RTS correlated to the Validation Exercises.

Solution OI steps are applicable for Very High/High Complexity OE (EnRoute & TMA) ATSUs in ECAC Area, since they have a similar complexity for the Operational Environment assessed by the Solution.

CBA results are aggregated at ECAC level assuming that, there are 32 (EnRoute/ #26 VHC+HC & TMA / #6 VHC+HC) Airspaces considered as eligible. According to the Airspace OE Dataset selected for this Exercise and the Use Case, the classification results based on SESAR 2020 classification scheme of OEs and Sub-OEs in ECAC States.

Benefits are realised starting from the implementation and during all the years after the deployment as detailed within the previous paragraphs. Benefits represents the positive result expected for the VTs addressed to the Solution and for which the Operational Exercise has been planned and executed, aimed to validate the feasibility of the OI addressed to the solution.

From the following graph it is possible to highlight the *Discounted Benefits*, *Discounted Costs* and *Cumulative Cash Flow* for the ATM services provided in case of Delegation of Airspace to another ATSU remotely, different from the owner of the Airspace.

These Tables shows, in details and per years, the comparations of results obtained after the determination of the Costs' assumptions by Stakeholders compared with the benefits that followed the assessment of the VTs addressed to the Solution. Having fixed the above assumptions, the following ***Cumulative Cash Flow*** was obtained.

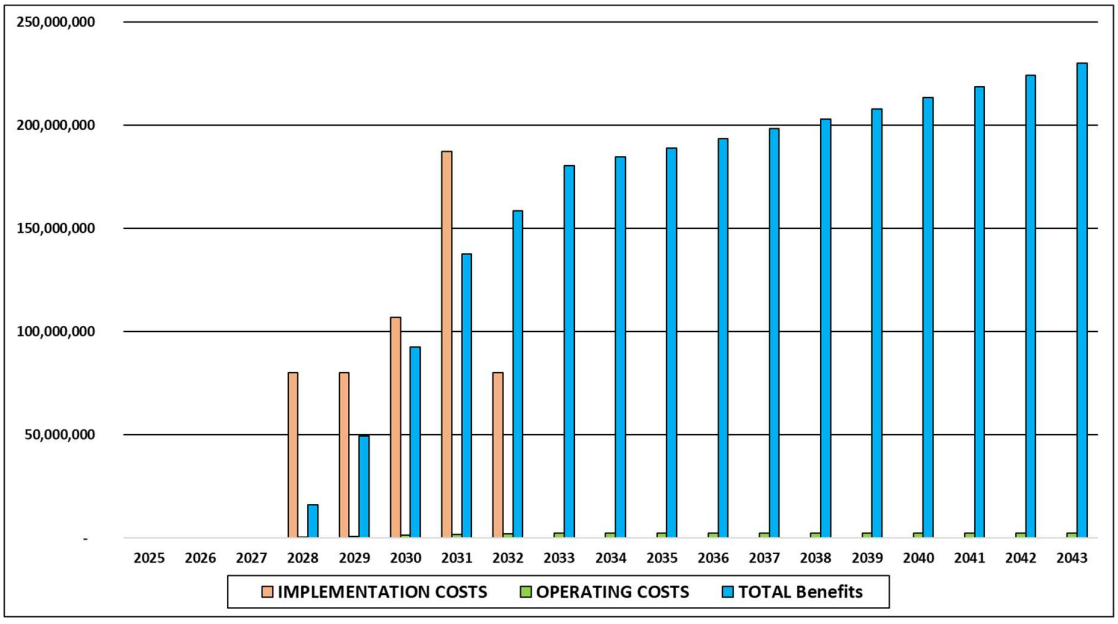

Figure 5 - CBA results - ECAC level Total costs (divided into implementation and operating costs) and benefits

EUROPEAN PARTNERSHIP

Co-funded by the European Union

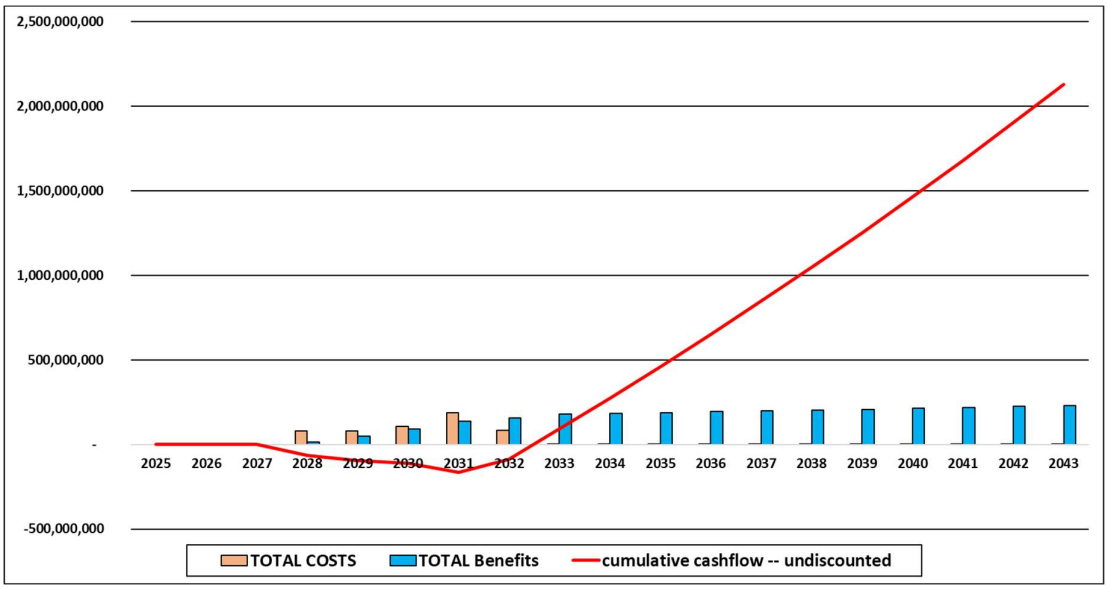

Figure 6 - CBA results - ECAC level Total (undiscounted) outputs deployment per year

A few lines to discuss about the above Tables: the first period, 2025-2032, is assumed to be investment period.
Benefits will start in 2028 (***IOC***), with the first ATSUs that implement the Delegation, and the ***RAMP-UP*** period will finish in 2033, first year after that the Delegation of Air Traffic Management services provision among ATSUs will be fully deployed and operative (***FOC***).
IOC and FOC have been defined in the implementation program of the ATM systems modernization process within the scope of the PJ10.W2 Sol 93, with the aim to ensure the efficiency of the services in order to implement the ATS Delegation.
This implementation phase timeframe (2028-2033) was an 8-years period defined as enough for the ATSUs who intend to proceed to update their ATM systems and consequently to ensure the ATS delegation services; that, irrespective of the Operational use cases defined by the Solution, are proportionate to the times required of the Stakeholders involved in the implementation.
Obviously, during the course of implementation phase, among the ATSUs that have completed the service modernization process, it will be possible to be able to bilaterally proceed with the Delegation of ATS services while waiting for the ECAC scenario to be totally accomplished with the implementations to be considered applicable at ECAC level.

Costs presented in the chart are related to the Implementation costs (CAPEX) addressed to the execution of the "Y" Architecture within the ATM system. Moreover, there are also rapresented other implementation costs related to the Training on the Delegated Airspace for new ATCOs engaged plus other complementary costs linked to the update of systems and licences or other administrative costs (see Cost Paragraph).
These costs, with the previous detailed, are additional to the same in the Reference Scenario.

From 2028 to 2032 (RAMP-UP period), economic benefits will be realized in parallel with the introduction of the Delegation process; ***Benefits*** will improve in line with the traffic growth, which is estimated looking at the Eurocontrol STATFOR forecast for the incoming years.

EUROPEAN PARTNERSHIP
Co-funded by the European Union

PJ.10-W2-93 - Delegation of ATM services among ATSUs	Benefits value at 2028	Benefits value at 2032	Benefits value at 2038	Benefits value at 2043
ALL KPIs - Economic Value - Cumulated Undiscounted	-64.348 M EUR	-86.582 M EUR	1,047.9 M EUR	2,130.0 M EUR
ALL KPIs - Economic Value - Cumulated Discounted at 8%	-29.806 M EUR	-42.252 M EUR	253,.548 M EUR	438.217 M EUR

Table 14: Yearly and cumulative Benefits of the CBA ECAC Level

Below two different Tables report the cumulative representations of the CBA's outputs. Both Tables refer to the consolidated provided Costs and Benefits obtained by assessing the post analysis of the Solution, only for the assigned VTs.
The first Table represents the ***NPV*** and the associated values of ***Benefit-Cost Ratio*** and the ***Payback period***. The second Table, instead, reports the cumulative Costs and Benefits, both ***Undiscounted*** and ***Discounted***.

The Cumulative Cash Flows discounted, as for the previous values, starts to be counted from 2025 and involves the cash-flows assumed to occur from 2028 (starting year of the deployment) to 2043, that will be the final date of the CBA's timeframe for this Project.

PJ.10-W2-93 - Delegation of ATM services among ATSUs	NPV	Benefit-Cost ratio	Payback period
	438.2 M EUR	*3.01*	*5.76 years*

Table 15: The cumulative outputs of the CBA ECAC Level outputs deployment

PJ.10-W2-93 - Delegation of ATM services among ATSUs	Costs (discounted)	Costs (undiscounted)	Benefits (discounted)	Benefits (undiscounted)
	341.1 M EUR	*566.5 M EUR*	*656.3 M EUR*	*2,130.0 M EUR*

Table 16: The inputs of the CBA – ECAC area output deployment

Therefore, we can assume that the OI addressed to the Solution will be totally implemented in operation, as well as all assessed and monetized benefits will be considered from 2033 to the final period of the economical assessment (2043).

Continuing at ECAC Level (output of the Operational Exercises) the ***Net Present Value*** has been calculated as ***438.2 M€*** over ***19*** years (from 2025 to 2043).

The overall *Cost (discounted)* corresponds to ***218.2 M €.*** A *Benefit to Cost Ratio* of ***3.01*** has been obtained, while the *Payback period* has been assumed to ***5.76*** years (calculated from the starting time of deployment).

Co-funded by the European Union

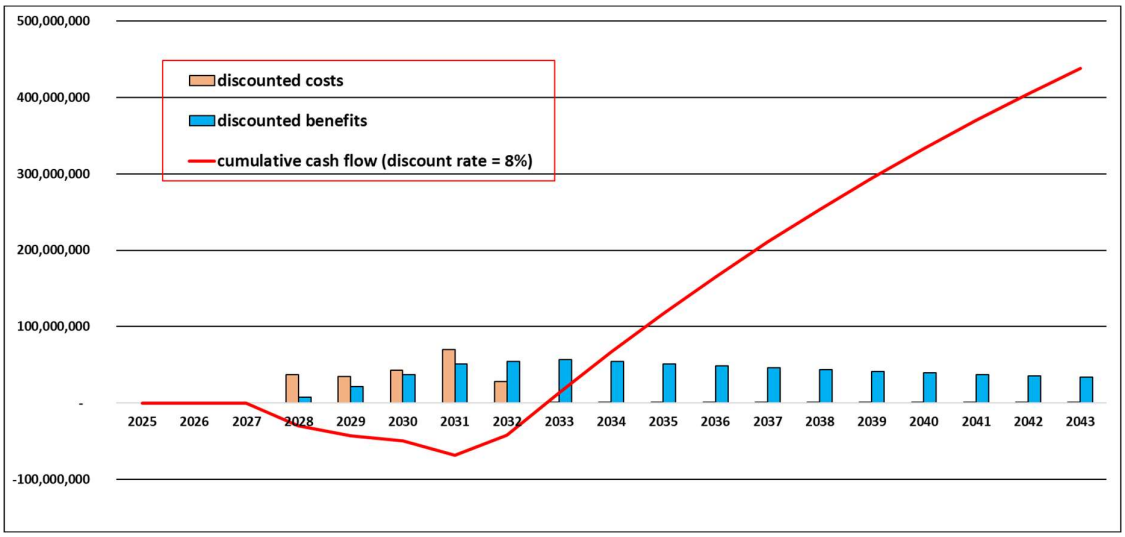

Figure 7 - CBA results 2 - ECAC level (Discounted) outputs deployment per year

The level of confidence for these outputs have been set as "*Medium to High*", due to the very specific assumptions that have been set for the reference scenario. So, the results can change +/-20% or greater.

Within the whole of the benefits reported within the PAR, one of the most observed is the KPI *Flights per ATCO Hour on Duty* (ATCO Productivity) that expresses the benefit of increasing the number of flights that an individual controller can handle safely with the same workload, even if the KPI CEF2 has not to be considered as stand alone. It is strongly linked with the other benefits related to the other counted KPIs as CAP and Op. Efficiency (PRD1 & FEFF1) also with the qualitative ones (HP-SAF), KPIs that contributed all together to satisfy the expectations correlated to the Solution.

The approach used to quantify, in post analysis, its computation is based considering the VTs assessed and the comments/suggestions received by PJ.19.4.
All the VTs assessed from the post analysis, inserts within the PAR and extrapolated from the VALR, have been determinates, extrapolated at ECAC Level, with the aim to be used for the quantification of the Benefits within this CBA and for the PAGAR scopes too.

The rationale that is behind the calculation is also described within the main lines of the OSED and the VALP as well, considering the Delegation as in process.

The extrapolation at ECAC Level has determinate as follow:

It is assumed that there are in total ***32 Airspaces (Operational Environments)*** are applicable for the Solution's scope, distributed among ECAC Area as follows:

- ✓ Applicable number of cumulative ***VHC units only =*** #9/52 ER + #2/21 TMA (SOURCE: D.19._D4_.3_S2020 Common Assumptions_00.01.00_ER & APT - September 2022 version)
- ✓ Applicable number of ***HC units*** only = ***#17/52 ER + #4/21 TMA*** (SOURCE: D.19._D4_.3_S2020 Common Assumptions_00.01.00_ER & APT - September 2022 version)

- ✓ Applicable number of TMA ***units*** only = ***6/21*** (D.19._D4_.3_S2020 Common Assumptions_00.01.00_ER & APT - September 2022 version)

Please note that in the ECAC-wide productivity improvement for ***VHC/HC Airspace (26/52) and (6/21)*** means that there is a combination of the ATSUs ***(32/73)*** that are classified in this folder. It corresponds to the percentage of more or less 44% of the ECAC Total EnRoute Operational Environments.

Moreover, also the CEF3 has been considered for the scope of the CBA in order to quantify the technology-related ANS Cost efficiency improvements that are usually expected from a reduction in operating costs resulting from SESAR-related changes to technology and systems required to deliver ANS.

Technology-related costs are considered to comprise structural ATM Systems implementations, operational engineering staff costs, system-related capital, operating costs and training costs as well.

SESAR is expected to contribute to decrease these costs both through the costs reduction in lifecycle by deploying alternative technologies greater interoperability between systems, reductions in technical staff costs and general non-staff operating costs as lower running costs and finally deploying the capabilities in a different manner as common services, obviously previously supported by the cost assessment linked with the implementation of the new ATM System so called Virtual Centre.

The assessment of these request needs specific knowledge considering the influence by the existing infrastructure, linked to local Operational ATS geography. For this reason, the extrapolation at ECAC level must be ensured by correctly choosing the Operational Environment where the related Operational Improvement can be implemented.

Solution 93 has a VT addressed to assess CEF3 – Technological Costs per flight; and the assessment has been quantified, as requested for the V3 validation activity, by extrapolating the value from the PAR/VALR.

According to PAR, it could be concluded that for the different KPA per Single validation it could be summarised as following:

Benefits contributing to CEF2:

- ENAIRE – Medium Complexity – Night (+37.5%), Fix (+25%), On-Demand (+21.4%)
- Skyguide – Very High Complexity – Night (+40%)
- COOPANS – Medium Complexity – On-Demand (+6%)

Average benefits per use case:

- Night - +38.8%
- Fix - +25%
- On-Demand - +13.7%

Extrapolation at ECAC level per use case:

- Night: 38.8% x 97.2% (VHC+HC+MC) x 29% (7 h out of 24 h corresponding to night shift) x 30% (kind of probability for having a delegation in these periods depending on resources availability) at + 3.3%

- Fix: 25% x 97.2% (VHC+HC+MC) x 25% (6 h out of 24 h corresponding to low and medium density periods) x 30% (kind of probability for having a delegation in these periods depending on resources availability) à 1.8%
- On-Demand: 13.7% x 97.2% (VHC+HC+MC) x 20.8% (5 h out of 24 h corresponding to peak traffic hours) x 30% (kind of probability for having a delegation in these periods depending on resources availability) à 0.8%
-

Aggregation of the benefits at ECAC level:

Overall benefit in CEF2 à 3.3 + 1.8 + 0.8 à + 5.9%

8 Sensitivity and risk analysis

The following sections provide an initial analysis of which impacts may have the uncertainties related to the main variables identified during the modelling of this CBA, on the outcomes of the model.

All the variables presented in this section are analysed by applying a "*ceteris paribus*" criteria (*all other circumstances being equal*), meaning that only the impacts of one variable are evaluated at each time, leaving the other variables constant facilitating the comparison between the evaluated variables.

The following assessment are based on Expert Judgement and in line with the scope of the OE of the Solution. The different relationships are related to an advanced analysis and with the aim to demonstrate that, even if some economic parameters might be "over reconsidered", the final results will be maintained in line with the scope addressed to the solution within the targets of the SESAR Master Plan.

8.1 Sensitivity analysis

Sensitivity analysis is based on the evaluation of the impacts that a set of variables have on the NPV at 2043, being evaluated separately by applying a range of variations around their initial value. The list of variables analysed the range of variation, and a brief description of the expected impacts, are reported in Table below.

Sensitivity variables	Range	Impact description
Traffic variation	±10%	This variable concerns a variation for the following KPIs: ✓ Fuel EFFiciency evaluates the changes in average of fuel burn per flight. ✓ ENV evaluates the changes in average of CO2 emissions ✓ Time EFFiciency evaluates the changes in average of flight duration per flight ✓ ATCO Productivity evaluates the average variation of CEF2 depending on the traffic variation
ATCO Productivity	±10%	This variable concerns a variation in the ATCO employment costs (productivity of ATCO on duty), generated by a variation in the sensitivity factor.
CAPEX	±10%	It evaluates the impact that a variation in CAPITAL/Investment Costs has on the NPV in 2043, generated by a variation in the sensitivity factor.
OPEX	±20%	It evaluates the impact on the expenditure of Operating of Costs, based mainly on costs of Replacement Infrastructure Installation & Commissioning, generated by a variation in the sensitivity factor.
Discount rate	±8% / ±2%	It evaluates the impacts on the NPV of a variation of Discount Rate.

Co-funded by the European Union

Sensitivity variables	Range	Impact description
Changes of ATM Architecture	+ 5 %	It evaluates the variation of the NPV that the implementation of the "D" ATM Architecture, instead of the "Y" considered within the CBA assessments, generates as a variation for the selected ATM Services able to Delegate the ATM data.
Changes of ATM Architecture	+ 15 %	It evaluates the variation of the NPV that the implementation of the "U" ATM Architecture, instead of the "Y" considered within the CBA assessments, generates as a variation for the selected ATM Services able to Delegate the ATM data.

Table 17: Solution 93 Range of variation

The 10% risk is established downstream of the increase in cost variation, defined by the Analysis listed in table 6, considered in the IOC - FOC timeframe.

Following the changes shown in the table, it is very interesting to note how the proposed variables such as Traffic, ATCO Productivity, CAPEX and OPEX do not cause large changes to the NPV value in 2043. Meanwhile, the Discount Rate has a strong impact on the NPV in 2043 considering the duration of the investment. Finally, the different ATM Infrastructures impact the implementation costs and therefore the final NPV. Therefore, according to the Operational requirements captured in the OSED and TS-IRS, they are compliant with the different Architectures in a VC environment. The proposed "Y" Architecture is a tangible example for the exchange of the services for the delegation of ATS.

The table at the following paragraph, considering the Y architecture as main scenario, highlights the differences that allow a better vision of the expected downstream benefits of the selected architecture.

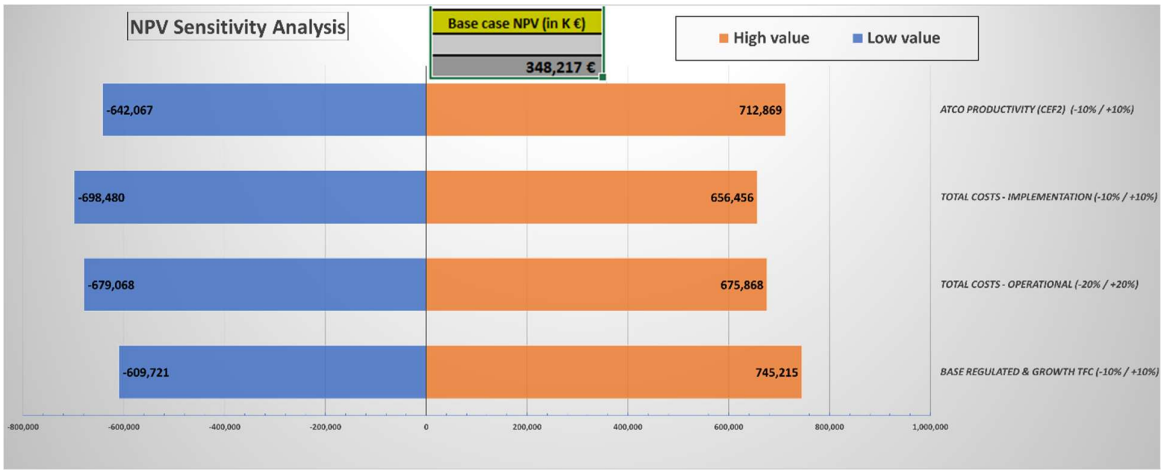

Figure 8: Solution 93 NPV Sensitive Analysis

Co-funded by the European Union

In addition to the definition of the Variation's percentages of the Costs, and the standard input from the statement defined in the CBA process, it could be highlighted that there are some uncertainness from the output of this Deliverables about the real values of the costs and the benefits. That in order to obtain a complete picture of the CBA itself, considered the different assumption from the beginning of V3 phase as a Standard Reference Scenario.

Considering what above stated, and to provide an updated vision with the aim to facilitate a more complete and real dimensions of the economic scenarios, it is opportune to add an integration within the Sensitive Analysis, a Table similar to the one related to the Discount Rate reported below, that highlights the variation of the value and costs of the money over the years within the timeline of the CBA.
The new Table will provide a vision, arranging a variation of the original NPV obtained by reducing the benefit values recovered from the PAR Document, considered as an assumption at the baseline output Scenario.

Here following, it is reported the Table that shows the Variation of the NPV when the Discount Rate changes from the standard defined as assumption for this CBA represented at 8 %.

Discount Rate	NPV in M€
8%	438.2 €
6%	642.3 €
4%	949.1 €
2%	1,415.0 €
12%	208.3 €

Table 18: Variation of the Costs with respect the Standard of the CBA

Complementing what above stated, and with the purpose of detecting and updating a new vision of the "Break-Even Point" when considering the downward % variation of the Benefits reported within the PAR, a proper and ad-hoc metric was defined.

Therefore, it will be possible to continue having a positive NPV, by maintaining the same standard assumptions considered as for the initial output (NPV), until the benefits exceed the costs by approximately 20% of the outputs reported in the PAR.

Consequently, looking at the initial value of the BCR (equal to 3.01) obtained by implementing the SDM of the Solution, when assuming a value of the benefits below 20%, the BCR will be equal to "zero" or negative and then the convenience of the implementation will have to be evaluated by investigating different parameters (for instance the opportunity to implement the SDM because of Operational needs) from the presented economic output analysis.

Co-funded by the European Union

Total values at 2043	
218,118,196	discounted costs (8%)
656,335,334	discounted benefits (8%)
438,217,138	NPV
-152,484,663	10% - Discounted Benefits
-54,034,363	25% - Discounted Benefits
110,049,471	50% - Discounted Benefits
274,133,305	75% - Discounted Benefits
438,217,138	100% - Discounted Benefits

Table 19: Total Values at 2043

8.2 Sensitivity analysis dedicated to different ATM Architectures

The present paragraph is dedicated, by introducing differences in Cost inputs quantified for the different proposed Architectures as illustrated in the POI, to obtain final different economic outputs from the one proposed by the “Y” architecture analysed in this CBA Deliverable.

The changes will impact on the NPV expected in 2043 by comparing the final value assessed from the present CBA with the possible alternatives, the “U” and/or the “D” architecture.

The scope of this section inside the entire sensitive analysis’ paragraph is to produce a different prospective that allows the final readers to better understand, depending on their own intendments and their own behaviour, the economic quantification and the differences in the final NPV by changing the implementation of the ATM Architecture. Therefore, will not be define the operational and technical characteristics contextual to each one of the other 2 ATM architectures (“D” & “U”), but only the differences in terms of implementation costs compared to the Reference one (the “Y” one) will be analyzed.

As described in detail in the OSED and TS-IRS Deliverable specifications, for the purposes above defined, it is appropriate to compare the other 2 architectures identified as possible alternatives which are the "D" Architecture and the "U" Architecture. And precisely for the purpose of avoiding a repetition of what has already been proposed and detailed in the context of the other Technical Deliverables (as also done for the "Y" architecture in the previous paragraphs of the Document), this paragraph will only refer to the economic evaluation of the infrastructure considered, respectively first the "D" and then the "U".

Then, with the aim to re-elaborate a NPV value at 2043 by inserting the new calculation of costs in the CBA algorithm, thus obtaining an economic value of NPV which will help the final reader to identify the expected benefit with respect to the implementation preferences of its ATM architecture, which in any case will always be used for the purpose, pending this analysis, of ensuring the feasibility of the Airspace Delegation between ATSUs.

Starting with Architecture "D", we can define that the costs to be considered in addition to what has already been defined for the enablers of Architecture "Y" are:

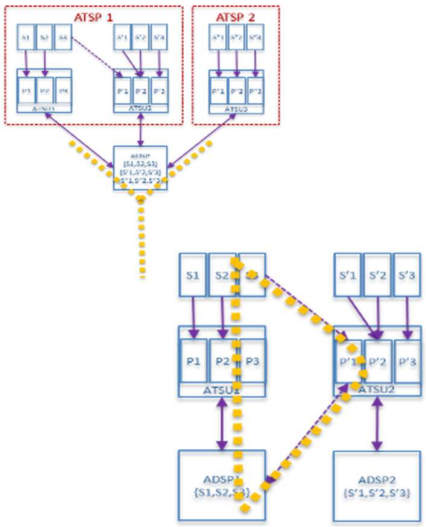

Figure 9: Comparison between Architecture Y and Architecture D

- ✓ ***CAPEX***: Costs of the interfaces/enablers that ensure the correct sharing of the Services between different ATSUs
- ✓ ***CAPEX***: Service interface costs between ADSP1 & ADSP2 in case of Contingency
- ✓ ***CAPEX***: There are no additional costs for the implementation of the ATS Services Delegation
- ***OPEX***: Operating of Costs, based mainly on costs of Replacement Infrastructure Installation & Commissioning provided by the ATSEPTs for the maintenance/monitoring of the Services

Having assessed the above assumptions, it might be assumed that the additional Costs to be considered might be quantify as follow:

- ✓ ***CAPEX***: total additional Costs: 10,590 K€
- ✓ ***OPEX***: annual Costs: 77 K €

With reference to the "U" architecture, we can instead define that the costs to be considered with respect to the "Y" architecture are:

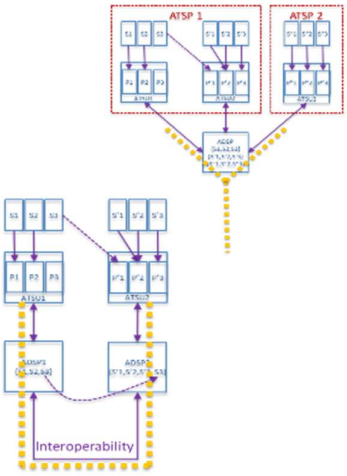

Figure 10: Comparison between Architecture Y and Architecture U

- ✓ ***CAPEX***: Interoperability costs of the 2 ADSPs for the Delegation of Services
- ✓ ***CAPEX***: Costs for synchronizing Services for live operation concurrency
- ✓ ***CAPEX***: There are no additional costs for the implementation of the ATS Services Delegation
- ✓ ***OPEX***: Operating of Costs, based mainly on costs of Replacement Infrastructure Installation & Commissioning provided by the ATSEPTs for the maintenance/monitoring of the Services

Having assessed the above assumptions, it might be assumed that the additional Costs to be considered might be quantify as follow:

- ✓ ***CAPEX***: total additional Costs: 11,600 K€
- ✓ ***OPEX***: annual Costs: 84 K€

In any case, the Level of confidence in the results must be clearly stated and the sources of uncertainty affecting the results pinpointed.

To better define the measure of the reliability of a result, it is stated a Confidence Level of 95 % (or 0.95); that means that there is a probability of at least 95 per cent that the result is reliable.

With respect to the Y Architecture, that aims to address a Centralized option, when comparing with the current scenario it offers some advanced position to assess most of the use cases (i.e. cross border operation issue or on-demand use cases) and would not proposed to a regulatory capture, with the option to intervene more independently from specific local implementation in consideration of harmonizing and seeking to ensure the most regulatory outcomes at network-wide level.

Furthermore, when comparing with the other 2 Architectures (D and U) from the economic scale and scope of the implementation, It would enable to make efficient all the resources and the ATM expertise available for the propose of the operational benefit.

The rational of the additional costs, assessed for the scope and linked to the implementation of two other alternative architectures (D and U) with respect to the Y one, is defined by the whole ATM system itself. Such additional services for the rationalization of the infrastructures will consider the equipment and the services data exchanges of the shared data between 2 ADSPs (or more - CAPEX), and, consequently, also the human capital must be re-considered for the personnel costs and indirect costs accordingly (OPEX).

The quantification of the additional costs related to the D architecture, assumed the minor interactions to allow the delegation of ATS process, have been evaluated of 5% of the services due to the low impact of the COTS, rather then, the additional human efforts to supply the Monitoring, maintenance and control of the ATM System as a whole.

Differently, but not as considered the main assumption is the U Architecture.

Considering that the U Architectures has the possibility to manage “n instances of ADSP”, itself requires some additional Costs in terms of multiple interoperable services, to be used simultaneity, in order to manage the Delegation of ATS in favor of the U Architectures that is targeting for this scope.

The additional effort is approximately quantified in about 15% with respect to the reference Architectures Y/Centralized, related to the Technological needs linked to the infrastructures and the Human performance, from the user perspectives, required to the ATSEP to manage this task, by maintain the safety efficient monitoring and managing of the ATS Services.

The following tables summarize the Sensitive Analysis’ evaluations taking in account the Input/Implementation Costs of the different Architectures ("D" & "U"), with respect to the main Architecture considered in the SOL 93 ("Y").

PJ.10-W2-93 - Delegation of ATM services among ATSUs - D architecture	NPV	Benefit-Cost ratio	Payback period
	431.428 M EUR	*2.92*	*5.87 years*

Table 20: The cumulative outputs of the CBA ECAC Level outputs deployment

PJ.10-W2-93 - Delegation of ATM services among ATSUs - D architecture	Costs (discounted)	Costs (undiscounted)	Benefits (discounted)	Benefits (undiscounted)
	224.907 M EUR	*584.450 M EUR*	*656.335 M EUR*	*2,112.1 M EUR*

Table 21: The inputs of the CBA – ECAC area output deployment

PJ.10-W2-93 - Delegation of ATM services among ATSUs - "U" architecture	NPV	Benefit-Cost ratio	Payback period
	417.959 M EUR	*2.75*	*6.11 years*

Table 22: The cumulative outputs of the CBA ECAC Level outputs deployment

PJ.10-W2-93 - Delegation of ATM services among ATSUs - "U" architecture	Costs (discounted)	Costs (undiscounted)	Benefits (discounted)	Benefits (undiscounted)
	238.376 M EUR	*619,827 M EUR*	*656.335 M EUR*	*2,076.7 M EUR*

Table 23: The inputs of the CBA – ECAC area output deployment

EUROPEAN PARTNERSHIP

Co-funded by the European Union

9 Recommendations and next steps

As widely documented in the previous paragraphs, and in line with what was previously demonstrated and validated during the V2 Maturity Gate at the end of Wave 1, the economic evaluations have clearly highlighted both the operational feasibility of the SDM assigned to the Solution and the economic feasibility of the implementation itself.

As far as operational feasibility is specified in other Deliverables such as OSED, VALR and TS-IRS which offers several opportunities of the best use of the Virtual Centre according to the different Architectures, in this Deliverable the economic conclusions have been highlighted. The Benefits related to the KPAs which were examined during the post analysis of the Performances for the Validation EXEs were obtained from the assessments showing in the PAR for the different KPAs.

Hence, therefore, the conclusions assessed can obviously confirm what was economically positive previously highlighted by the economic Benefits originate by the considered 32 ATSUs, both En-Route and Terminal, to the entire ECAC Scenario, once in terms of NPV developed, equal to approximately ***438.2 million €*** in 2043 (8% Discount rate) as well as the breakeven in 2029 (Payback Period) as ROI for defined Costs.

Furthermore, it should be focused that, even if the OEs in which the Validation EXEs have been tested refer to ECAC's VHC & HC En-Route categories only, it has also been demonstrated that the principle of the Delegation of Airspace can naturally be extended to Terminal Airspaces and to other categories of EnRoute OEs with minor complexity. However further work needs to be carried out for High to very High traffic for all Use Cases and to consider additional Services interface with the ADSP needed when delegatin Services (e.g. CDR tools) in a Virtual Centre Environment. Therefore a specific economical analysis needs to be carry out in order to carry out the benefits.

What has been demonstrated thanks to the feasibility of the Operational Concept of SOL 93 aligns with the expectations of Wave 2 of SESAR 2020, in terms of Flexibility of Operations, Data Sharing of ATS "as a Service", ATM Cost Optimization, ATC Capacity improved and Operational Efficiency of flight trajectories, while maintaining high levels of Safety and Security of Operations by increasing the availability of Resilience of ATM systems in possible events of Contingency due to both predictable events or in case of any Cyber-attacks.

Finally, the Virtual Centre concept is a key element and represents the future investment that require some Technology adoption process, The actors that also point out the benefits of these new and radical technologies to the implementation of the choice of the different Architectures that all the Stakeholders could benefits.

The principal KPAs of the CBA are CEF and Technology cost, that represent the highly fragmented structures of the European ATM system; the ambition of this Solution is to quantify these benefits up to the Architectures and therefore to defragment it based on the Delegation of ATS concept.

Results from the economic impact on the CEF2 have shown significant yearly maximum potential saving (Figure 7) especially for the specific architecture analysed with the service interface network in order to be able to connect the ADPS with a different instances during the Delegation of ATS. The potential saving depend largely on the services adopted and needed for the Delegation process and the exact Architecture choice by the ANSP.

The benefits of the Virtual Centre focus on dynamicity, scalability, flexibility, digitalization and availability “as a service”. These keyworks towards defragmenting the currents fragments structures in European ATM and reaching towards defragmenting the current fragmented structure in Europe.

According to the Different Stakeholders there is not a preferable ATM Architecture to be targeted, in this CBA they are represented by Cost index on the Delegation of ATS Services up to the entire infrastructures. This work was performed in cooperation with PJ32 WP3.

Thanks to the different options on the Architectures, the Stakeholders will have enlarged vision of choices to address their investments on the preferable architectures where the Cost-Effectiveness is a major KPA to be consider. Indeed it requires a new workforce on the standardization level based also form the outcome obtained on EURICAE WG-122.

The economic benefit of the Virtual Centre, after the initial investment mainly in the Area of Dynamic Resource Allocation (especially with the U architectures that due to the complex and geographical distribution on the system across the EUROPE) will enable also the optimization of Staff effort.

Future SESAR 3 Activities, as the Island or the Vitacy Solutions, will enable to invest on a complete Economic analysis for the D and U Architectures, when considering a complex environment with the remote training. That will enable a quick validation and training exercises to be done “location independently”. And that will allow a minimum cost in terms of rationalization.

Finally, the Level of confidence of the CBA, continues being evaluated, after several years of analysis and developments in the scope of SESAR 2020 (both Wave 1 & Wave 2), and considered as MEDIUM. The results have been assessed considering the outcome and recommendation of V2 Validation and the quantitative analysis executed in V3 exercises.

10 Discussion and Further work

Although many details have been considered since the initial beginning of the development of the Solution, it should be emphasized that there are still present some gaps, lack of assumptions missed in this CBA that must be considered in detail for the next phases.

By considering fundamental to quantify all Costs both in Real and Simulated environment, a real operational scenario have to take care of many Costs that could be add for a significant implementation by the ANSPs perspectives, e.g. the value that are reported in the Sensitive analysis about the 95%, that still has to be paid by the individual ANSPs or Regulatory.
This assumption will likely only be done at a moment when a major renewal must be carried out for other reasons anyway and this will most probably results in some ANSPs delaying implementation for many years. That the case when the Benefits can only be reaped later.

In addition, with respect to the original nature of the PJ10.W2 SOL 93, this CBA analyzed the Costs related to the ATS Delegation Service by offering advantages and Benefits from the Concept of Delegation ATS itself, and considering the unit cost for the ATSUs. , Then, from the point of view of the Rationalization of the Infrastructures based on the Different Architectures analyzed, the Costs of implementation for each service Interface of the Virtual Center were considered partially evaluated due to the roles of the ATSEPs as well.

Finally, according to the conclusion reported in the VREP of PJ10.W2 SOL 93, it could be summarized that:

- Generally, although experienced in some exercises, the delegation of ATM services would not be feasible in High to very High traffic densities but was demonstrated as feasible in Low to Medium traffic densities for all Uses Cases considered.
- About the delegation environment, it is recommended that the environment of the delegating ATSU has the same level of complexity or, if possible, lower compared to the receiving ATSU (i.e., compatible sub-OEs).
- Furthermore, the concept has been demonstrated as operationally feasible for the following use cases:
    - Night use case
    - Fixed time use case

Considering the On-Demand use case only, (Cross-border, Civil Military and ATFCM), the operational feasibility results are not as almost positive as in the previous Use cases.

In addition and with the aim to integrate what above stated, for the “cross-border scenario” the results indicate a mix between positive, neutral and negative outputs, without a well-defined conclusion; instead of, the “ATFCM scenario” has been demonstrated as non-feasible Use case due to the high traffic load and high complexity scenario.

In both cases, the quality of the ATC Service has been proven as “highly negatively impacted”.

EUROPEAN PARTNERSHIP

Co-funded by the European Union

11 References and Applicable Documents

11.1 Applicable Documents

a) SESAR 2020 Project Handbook

b) PJ19-W2: Validation Targets - Wave 2 – June 2020 – edition 00.01.00

c) SESAR 2020 Requirements and Validation Guidelines – May 2020 – edition 00.02.01

d) SESAR 16.06.06-D26_03, Methods to Assess Costs and Monetise Benefits for CBAs, Edition 00.02.02

e) SESAR 16.06.06-D26_04, Guidelines for Producing Benefit and Impact Mechanisms, Edition 03.00.01

f) ATM Cost-Effectiveness (ACE) 2018 Benchmarking Report

g) EUROCONTROL Seven-Year Forecast February 2019

11.2 Reference Documents

[1] European ATM Master Plan 2020 - SESAR Joint Undertaking, 2020

[2] AAS - A proposal for the future architecture of the European airspace - SESAR Joint Undertaking, 2019

[3] SESAR 2020 - PJ19.04 - D4.7 Performance Framework (2019) Edition 00.00.02

[4] Standard Inputs for EUROCONTROL Cost Benefit Analyses (Edition Number: 8.0, Edition date: January 2018)

[5] PJ.10-W2 PROSA: PJ.10-W2 Separation Management and Controller Tools. **Safety and Performance Requirements (SPR) and Interoperability Requirements (INTEROP). Deliverable** D3.1.030, Edition 00.00.03, 02 October 2020

[6] PJ15.09 Delegation of Airspace and Contingency - SESAR SOLUTION 15.9: COST BENEFIT ANALYSIS (CBA) FOR V1. Deliverable ID: D5.0.10, Edition 00.00.03, 25 October 2019

[7] D.19._D4_.3_S2020 Common Assumptions_00.01.00_ER & APT - September 2022 version

[8] SESAR Solution PJ.10-W2-93 SPR/INTEROP-OSED for V3 - Part V - Performance Assessment Report (PAR)

12 Appendix

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

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

EUROPEAN PARTNERSHIP

Co-funded by the European Union

ATM Master Plan SESAR Performance Ambition KPA	ATM Master Plan SESAR Performance Ambition KPI	Performance Framework KPA	Focus Area	#KPI / (#PI) / <Design goal>	KPI definition
Operational Efficiency	PA5 - Arrival predictability: 2 minute time window for 70% of flights actually arriving at gate		Variance of actual and reference business trajectories	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> see section 3.4	Total number of fatal accidents and incidents
Security	PA10 - No increase in ATM related security incidents resulting in traffic disruptions	Security	Self - Protection of the ATM System / Collaborative Support	(SEC1)	Personnel (safety) risk after mitigation
				(SEC2)	Capacity risk after mitigation
				(SEC3)	Economic risk after mitigation
				(SEC4)	Military mission effectiveness risk after mitigation

Table 24: Mapping between ATM Master Plan Performance Ambition KPAs and SESAR Performance Framework KPAs, Focus Areas and KPIs

13 Annexes

13.1 Annex 1 Contingency Use Case

Scope of the analysis for Contingency UC

One of the UCs explored by PJ10. SOL 93 is the Contingency Situation, and in particular in two specified events:

- ✓ When the contingency occurs, the delegation procedure is applied to manage the emergency;
- ✓ When the unexpected event happens, and a Delegation of ATM services is already on-going, a third partner will be involved to keep the service up.

The description of the high-level specifications that will establish the criteria for managing a Contingency situation in the context of the delegation are ad-hoc procedure that needs to be planned in advance into a bilateral agreements between involved ATSUs/ANSPs; the Contingency situation and its management are dedicated operational definition and synchronization actions that will be handled at local level between ATSUs, and if the event is addressed to supply when a delegation procedure is in progress, this requires an even more complex management and involvement of all impacted ATSUs.

The UC in case of contingency is characterized by:

- Moderate but **permanent cost** for a primary or secondary ATSU to build and hold available capacity in hot or cold stand-by;
- Huge but **very rare benefits** in the shape of avoided damages in case of the contingency situation;
- Low and **very rare cost** for managing the actual contingency case.

Perform an economic evaluation of such an uncertain and unpredictable event is extremely complex, as the number of assumption needed to identify a specific situation to assess cost and benefits, would lead to an analysis too specific, not applicable to the contingency UC as a whole. Furthermore it has to be considered that the contingency procedures (current procedures or new ones based on delegation) are usually investments that are made only for safety reason, and don't present a real benefit plan as the contingency event isn't really expected to happen.

For this reason, the main component that this paragraph will underline is a qualitative assessment of all the elements (planning, operative, procedural) that are necessary to implement the Contingency when the event happens, and how they could impact, positively or negatively, on the cost and benefit of the solution with respect to the actual system in place for contingency.

The Contingency procedure

The Contingency Procedure, analyzed as unusual and unexpected operational Situation, is aligned with the Contingency Lifecycle defined by Eurocontrol.

Considering PJ10.SOL 93 and its current version of the OSED, only ATSU failures are considered; in next V3 version, failures of ADSPs or Wide Area Networks might be considered as well.

EUROPEAN PARTNERSHIP

Co-funded by the European Union

The Contingency Lifecyle starts with an unexpected severe event that causes the failure of an ATSU; and the unusual operational situation will be handled in line with the defined permanent procedures released by each ATSU.

In the Eurocontrol documentation it is assumed that the ATSU comprises the control room and/or the equipment room.
In a non-Virtual Centre environment, as the actual operational situation, there is almost only the option to implement immediately the procedure called "*clear-the-sky*".
Depending on the nature and the effects of the failure (*Contingency*), the immediate actions that could be instantly implemented, while the research of the failure and the possible corrective actions are in progress, could range from the possibility of retaining the ATCOs in the OPS room pending the Recovery Phase up to restore the Operating Environment.
Otherwise, if the nature of the failure required to evacuate the building, it would even envisage transferring the ATCOs to the alternate premises where they could remain awaiting for the recovery phase, with a system parallel to the one presented in the main ops room.
Both these two procedures, and any other intermediate that could be envisaged depending on the different situations, will be provided and described, both in the LOAs and in the internal Operational Procedure.

The technical flexibility expected from Virtual Centre should provide improvements in operations, especially offering means for Contingency that were not existing before.
Recapping the standard definition of a Contingency Lifecycle, with the aim to define the operational situation, the unusual event consists of three major phases:

- Degraded Mode / Emergency

  This phase is characterized by the immediate countermeasures against the failure.
  In most cases the affected airspace is cleared, and ATFCM regulations are put in place.
  In a non-Virtual Centre environment, ATCOs would be relocated to contingency premises, which would need some time for travelling.

- Service Continuity

  During the Service Continuity phase flights are managed from the contingency premises.
  These premises often have a reduced capacity compared with the failing ATSU. Therefore, ATFCM regulations are expected to be in place during this phase, meaning that the traffic is significantly impacted.

- Operational Recovery

  When the failing ATSU has been restored again, Air Traffic Management will be shifted back to the original ATSU.
  During this time lapse, ATCOs are required in both premises: the original ATSU and the Contingency ATSU.
  Then ATM services provision will be delegated between these two units according to the delegation procedure. And just after the Operational Recovery will be completed, the original ATSU is back at normal Operations.

The above descripted standard is planned to be implemented in case of Contingency in a non-Virtual Centre environment. PJ10.SOL 93 aims to demonstrate the feasibility of the application of delegation

procedure in a Virtual Centre environment as a new standard to be applied in case of failure. This could be applied both in case of ordinary ATM service provision or in case of a Delegation already in place when the ATSU suffers the unpredicted event.

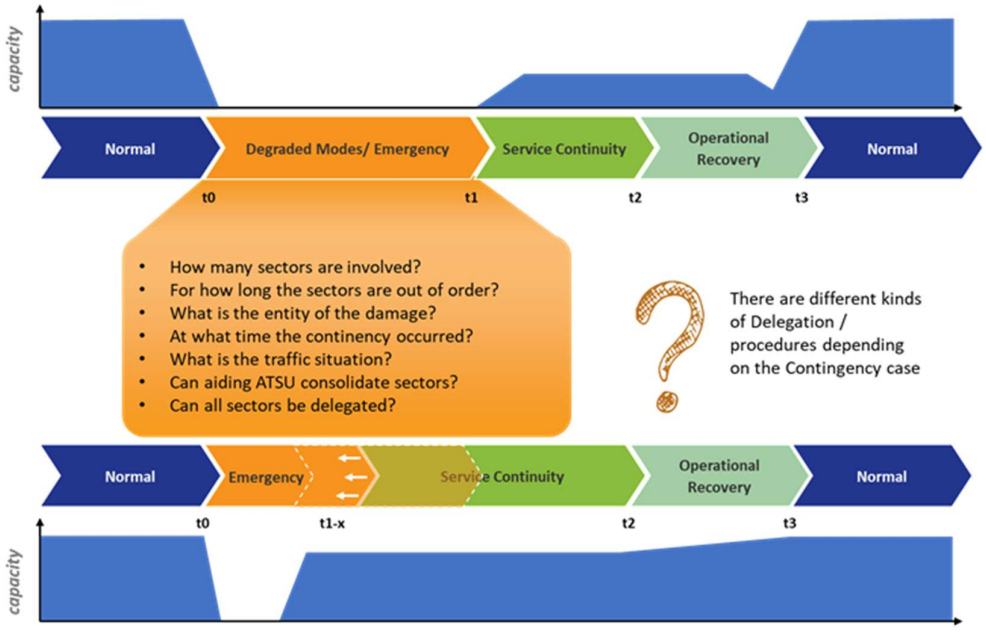

Figure 11 – Impact on the capacity lack

Delegation for contingency and qualitative economic analysis

The procedure of using delegation in case of contingency has been explored in the OSED, section 3.3.2.3.1. The procedure explains all the step to undergo in case an un-expected event results in the failure of an ATSU, given the assumption that the ADSP is not affected by the ATSU failure and thus is still able to provide data to other ATSUs that are not impacted.

The added value is to enable the opportunity to have an almost immediate Contingency Delegation of some sectors, if time permits, reducing the time needed for contingency procedures with the standard current means, allowing the continuity of AUs services without any kind of interruption.

It is very likely that the aiding ATSU is not able to provide Contingency for all sectors of the failing ATSU, but only for a few of them. On the other hand, there might be more than one aiding ATSU being able to provide Contingency service. In any case the final configuration is extremely variable and depending on the timing and severity of the contingency:

- All the sectors are delegated to another ATSU
- All the sectors are delegated to multiple ATSUs
- Some sectors are delegated, and some are closed
- Some sectors are delegated, and some are managed with a non-delegation procedure (e.g. using alternative premises for the failing ATSU)

These alternatives are applicable both in case the aiding ATSU is immediately available, or if it is needed the application of the "*clear the sky*" procedure before the ATSU receives the delegated sector/s. Furthermore, it is also feasible the possibility to delegate the sectors at different time as soon as aiding ATSUs or alternative premises can be ready.

It is worth mentioning that these activities might need from a few hours up to 48 hours, because the ATCOs need to be contacted and then go to the aiding ATSUs premises. One of the expectations from the implementation of the Virtual Centre environment is to provide a more flexible system, that will reduce to the minimum the set-up time in this kind of situations.

The most efficient solution for the aiding ATSUs, would be to consolidate the delegated sectors with the one already managed, in order to optimize the number of ATCOs and working position needed, but of course this could be possible only under certain condition of traffic. Only if the ATSUs available would not be able to handle all the sectors involved in the Contingency situation, it might be reasonable to manage part of them with the standard procedure in the failing ATSU. Finally, in case of event that foresee a very long duration of the Service Continuity phase, it could be reasonable to relocate the ATCOs in the aiding ATSUs, but this could be possible only if the aiding ATSUs have availability of enough spare working position for the requested time.

Planning the resources to be reserved to contingency is demanding, as all depends in particular on when the unexpected event occurs and for how long: How many ATCOs must be trained in advance? Do we need to install some more working position? How many ATSUs are required to cover all the sectors? What kind of agreements are needed to cover such procedures?

These questions can't find an answer without knowing when the event will occur, and in which traffic condition for all the ATSUs involved (failing and aiding). It's expected that delegation can be a very good solution in case of low traffic, for example at night time, when the sectors can be delegated almost immediately as there is a good availability of working position and ATCOs can more easily consolidate sectors. In this case the clear the sky procedure wont' be probably needed, and the overall capacity would remain the same. More difficult is to foresee what could happen in a high traffic period: in this case provide enough ATCOs/position to maintain the same capacity would be demanding, and restriction would be probably needed.

Of course, it must be considered that nowadays all the ATSUs are already organized in different way to face emergency, and before choosing an option, a careful comparison between costs of different solution, time to react and provided capacity, must be evaluated.

The following table explains the impact of all the variables on cost and benefit of the solution compared the Contingency procedure already in place.

Variables		Cost of contingency procedure			Impact on the set-up time			Impact on the capacity lack		
		Low Costs	Medium Costs	High Costs	Short set-up time	Medium set-up time	Long set-up time	Higher capacity	Unchanged capacity	Reduced capacity
Time of the day	Day			X			X		X	
	Night	X			X			X		
Type of delegation	Full		X				X	X		
	Full on multiple ATSUs			X			X	X		
	Partial with clear the sky	X				X			X	
	Partial with relocation in current contingency premises		X			X		X		
ATCO	Relocation of ATCOs		X				X	X		
	ATCOs from aiding ATSU		X				X	X		
Sectorization	Delegation with consolidation	X			X			X		
	Delegation without consolidation			X			X	X		

Contingency Cases during previous Delegation of ATM services provision

One of the possible application of the delegation is to handle a Contingency situation also when a primary delegation is already ongoing: if the receiving ATSU is not able to manage the sectors involved in the previous delegation and the delegating ATSU cannot take back the sectors, a third ATSU should be involved in order to keep the ATM services operative.

EUROPEAN PARTNERSHIP

Co-funded by the European Union

Figure 12 – Contingency during previous Delegation of ATM services provision

Normally this kind of procedure must be well defined in advance and agreed between the three parties with a previous agreement: the receiving ATSU will guarantee the prosecution of the service also in case of contingency, setting up another agreement with a third ATSU.

The procedure reflects the one already defined for the delegation in the OSED: the overall delegation is initiated by the delegating ATSU sending a delegation request to the receiving ATSU, as defined in the standard agreement signed; and the same situation needs to be defined and prepared for the Contingency receiving ATSU (the third aiding ATSU).
This is a new concept expected to be explored by PJ.10-W2-93 in V3.

So, to realize the situation above described situation, each step already defined for the receiving ATSU needs to be replied for the third one. Each action, both for ATCOs and ADSP or technicians, each expense and each investment need to be implemented in both ATSUs (e.g. training of ATCOs, preparation of working station, developments, procedures etc)

Analyzing the scenario under this point of view, in case the delegation is chosen as main to handle contingency during a planned delegation, the cost of the investment would be practically doubled, while the amount of benefits obtained are the same, as the possibility to recover in case of failure of the receiving ATSU is a necessary condition for the activation of the delegation .
No specific benefit can be measured, as the real contingency case will be likely never occurring, contingency costs must be considered like an insurance to be paid, but never expecting to be compensated or payed back.
The following table shows the impact of the Contingency delegation on UC#1 Delegation at Night

Variable	Impact on cost	Impact on benefit
Using a new delegation procedure in case of contingency while a planned delegation is on	**+++** **Double cost for all categories**	**NA** **The planned delegation cannot take place if the contingency procedure is not guaranteed. The benefit are the ones calculated in UC#1 Night delegation**

As mentioned before, it must be recognized that the contingency delegation is not the only mean to ensure continuity of service in case of failure during the planned delegation.

EUROPEAN PARTNERSHIP
Co-funded by the European Union

The receiving ATSU has the obligation to ensure to the delegating one that the service will continue in normal operation also in case of contingency, and delegation is only one of the choices that can be made, but it doesn't exclude to use other procedures (like fall back systems, shadow mode rooms, training rooms, even in degraded mode if agreed between the parties).

END OF DOCUMENT-

EUROPEAN PARTNERSHIP

Co-funded by the European Union