SESAR Solution PJ.05-W2-35: COST BENEFIT ANALYSIS (CBA) FOR V3

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Authoring & Approval

Authors of the document

Name/Beneficiary	Position/Title	Date
Enav S.p.A.	CBA Leader	11-Nov-2022
BIP S.p.A.	CBA Leader	11-Nov-2022
BIP S.p.A.	CBA Leader	11-Nov-2022

Reviewers internal to the project

Beneficiary	Position/Title	Date
DLR	EXE-2.1 Leader	11-Nov-2022
LFV-COOPANS	EXE-2.2 Leader	11-Nov-2022
INDRA	EXE-2.3 Leader	11-Nov-2022
TECHNOSKY – ENAV	EXE-2.4 Leader	11-Nov-2022
DFS	EXE-2.5 Leader	11-Nov-2022
LFV COOPANS	Solution Leader	11-Nov-2022
DLR AT-ONE	PJ05 Project Manager	11-Nov-2022

Reviewers external to the project

Beneficiary	Position/Title	Date
	PJ.19	

Approved for submission to the SJU By – Representatives of beneficiaries involved in the project

Beneficiary	Position/Title	Date
TECHNOSKY – ENAV	Project Member – POC ENAV	
LEONARDO	Project Member – POC LEONARDO	
HC	Project Member – POC HC	
DLR	Project Member – POC DLR	
Indra	Project Member – POC INDRA	
NLR (AT-One)	Project Member – POC Royal NLR	
ON (B4)	Project Member – POC ON (B4)	
NATMIG (Saab)	Project Member – POC NATMIG	

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Rejected By – Representatives of beneficiaries involved in the project

Beneficiary	Position/Title	Date

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Copyright Statement

MULTIPLE REMOTE TOWER AND REMOTE TOWER CENTRE

This Cost Benefit Analysis Deliverable is part of a project that has received funding from the SESAR Joint Undertaking under grant agreement No 731781 under European Union's Horizon 2020 research and innovation programme.

Abstract

The Remote Tower concept is changing the provision of Air Traffic Services (ATS) in a way that it is more service tailored, dynamically positioned and available when needed, enabled by digital solutions replacing the need for controllers and tower buildings being located at aerodromes.

Remotely Provided Air Traffic Service for Multiple Aerodromes and development of the Remote Tower Centre are part of this Programme, which started in SESAR 1 with the basic/initial first Single Remote Towers Project.

At the state, in SESAR 2020 Wave 2, the main driver for the Remote Tower Centre concept development, allocated to PJ05 Solution 35, is linked to keep Safety and Human Performance at the same previous levels, also supported by Human Machine Interface, and to maintain the same ATC Capacity at each of the targeted aerodromes. Moreover, secondary target, but not for importance, is addressed to optimize the Cost Efficiency by increasing the ATCO Productivity, by improving the balance of ATCO workload between different MRTMs within a Remote Tower Centre, and a flexible allocation of aerodromes to each MRTM.

To accomplish the Cost Efficiency concept, the best option is to plan any possible strategy through a flexible allocation of aerodromes with the ATCOs in the RTC and to the allocation on the MRTMs. And for the scope, cost reduction calculations will also take advantage by key elements from the validation results output from Safety and Human Performance's post analysis.

This CBA document gathers Implementation and Operating costs reported for each exercise by involved stakeholders, and monetizes benefits computed from the KPAs' assessment (both qualitative and quantitative) and stated into the PAR, with the final aim to assess, from an economic point of view, the feasibility of the Solutions. Other specifications are associated and linked with the deployment of the Operational concept as described in the OSED/VALP/VALR.

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1 Executive Summary

The document provides the Cost Benefit Analysis (CBA) related to SESAR Wave 2 Solution PJ05-W2-35 – "*Multiple Remote Tower and Remote Tower Centre*".

Since the new operational "concept" started to be defined, and the following evolutions in SESAR 1 and SESAR 2020 Wave 1, the Remote Tower concept wants to improve the provision of ATS over the airport by ATCOs in an advanced manner, first by replacing the physical presence in the Control Tower positioned on its own aerodrome and parallelly by implementing digital solutions that allow the availability of the ATC Services 24/7, associated with a dynamic allocation and an advanced service tailored to improve the concept that "one ATCO controlling one aerodrome".

The objective of the CBA for PJ05-W2-35 is to compute Cost and Benefits addressed to the Solution, with the aim to demonstrate the feasibility of the Operational Requirements.
The Operational Improvement Step addressed to this Solution is *SDM-0210 - "Highly Flexible Allocation of Aerodromes to Remote Tower Modules"* with validations at V3 maturity level.

The main objective of Solution 35 remains to increase ATCO productivity; to accomplish the target, it is essential to set a balance of ATCO workload between different MRTMs within a Remote Tower Centre and guarantee a flexible allocation of aerodromes to each MRTM.

To set the concept's definition of *Flexible Allocation of aerodromes in the MRTM*, it means that one aerodrome can be allocated in different positions within MRTMs during different time window in the day; and this flexibility will be compared with the previous fixed presentation set for 2 or 3 aerodromes always into the same MRTM.

For sure, the new operational methodology will increase the complexity, as well it will stress the situational awareness for the ATCOs on the controlled aerodromes.
A resolution, provided by Solution 35, i*s to introduce a special enabler that will be handled by the figure of the ATCO Supervisor*. The scopes and the characteristics of the enabler will be focused to handle special data as traffic volume/complexity, planned maintenance and other activities, weather conditions at the different airports, as well as ATCO endorsements and availability.

Supported by this *enabler/automation support tool*, Supervisor will be able to balance on an appropriate level the ATCO's workload avoiding any uncertainties that could affect the ATCO's ability; moreover, the traffic load will be kept at a certain amount by considering traffic complexity when providing simultaneous ATC services in a safe and efficient manner.

Having assessed the above topic, the second addressed step to Solution 35 will assume that ATCOs will be qualified to manage 4 different airports, even if each of the assigned ATCOs on duty might handle traffic for maximum 3 aerodromes at the same time (that will be the task allowed by the EXEs for the main part of the Use Cases) even if this evaluation is not a paramount requirement to implement the OI concept.

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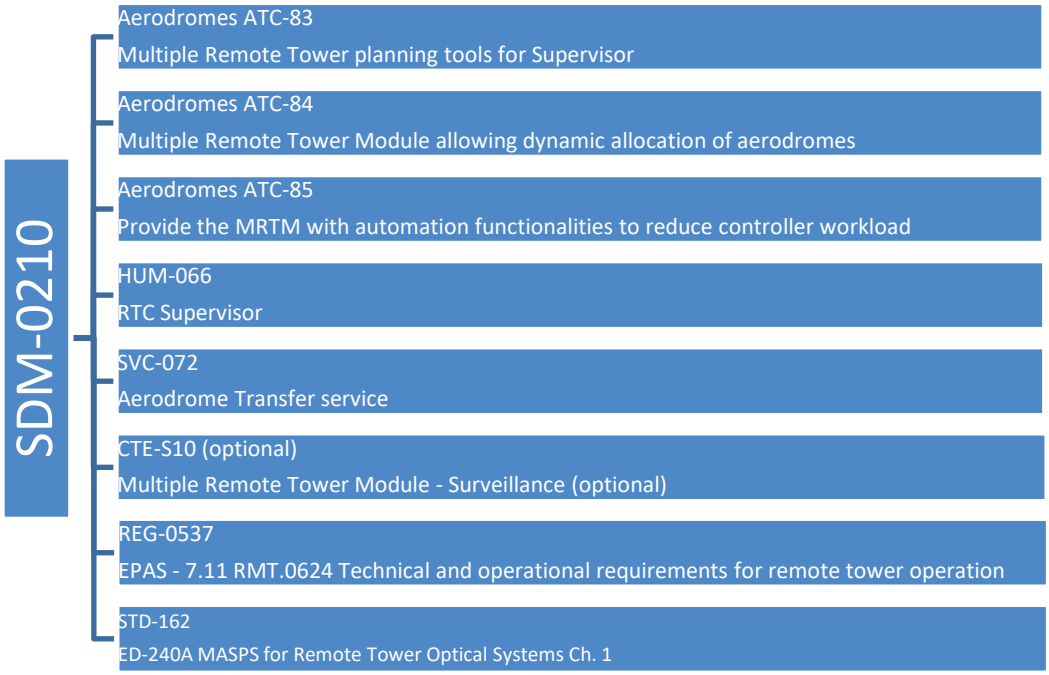

It is important to underline that the above requirement will be considered locally only, within each RTC, and depending on its own aspects such as harmonised procedures, airspace class, type of traffic involved, etc.

Furthermore, for the purpose of validating the OI of the Solution, airports can be grouped together flexibly, randomly and not in a fixed manner, in MRTMs (always based on traffic demand), in order to validate the concept that an ATCO can hold multiple endorsements according to the different types of groupings of remote airports.

Economic and technical assumptions are described in the document following, with the aim to be consistent in the analysis.

2 Introduction

2.1 Purpose of the document

This document provides the Cost Benefit Analysis (CBA) related to SESAR Solution PJ05-35 that has been validated during validation activities at a V3 level.

The CBA refers to the monetary value of the investment that is used to produce or acquire the expected performance benefit evaluated as the positive value of the return on investment (ROI) of stakeholders involved. This kind of analysis has the aim to assess the economic feasibility of solutions and to help compare different alternatives.

This CBA has been developed to identify and agree on:

- ✓ The deployment scenario approach for the Solution,
- ✓ The assumptions related to the Solutions and Reference Scenarios,
- ✓ The stakeholders impacted with the Solution, i.e., those who will support the deployment and operating costs and/or those who will benefit from the Solutions,
- ✓ The cost elements to be assessed for each stakeholder considering the operating environments where the Solutions are expected to provide benefits, as defined in the deployment scenario approach and in the final version of the SESAR Solutions PJ.05-W2-35 SPR-INTEROP/OSED for V3,
- ✓ The mechanisms to quantify the benefits, made by the expert judgement analysis, based on the main assumptions recovered both from the previous Deployed Solutions and from the expected Benefits addressed the SDM - 210.

Main focus of the CBA in V3 is to review data assessed in previous CBA Deliverables and to update mechanisms and values released at the end of Wave 1.

2.2 Scope

The CBA Deliverable aims to analyze the Use Case proposed by Solution 35 in economic terms, comparing costs incurred to implement and execute the Operational Improvement. To perform the CBA, the Reference scenarios will be examined and compared with the Solution scenarios focusing mainly on the economic aspects in the adoption of this solution.

The CBA will provide a specific assessment and evaluation of the costs and benefits derived from multiple RTSs calibrated to simulate the feasibility of the OI, addressed, to underline, to the *Highly Flexible Allocation of Aerodromes to Remote Tower Modules.*

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At the end of the RTS exercises, in the current V3 status of the Solution, the assessment will not only provide a measurement of some quantitative KPIs in Cost Efficiency, such as costs and benefits, but also other KPAs such as Safety, Security and Human Performance assessed only under the qualitative side.

The final report will include as output a first order of magnitude of benefits and the Net Present Value (NPV), with some other Sensitive Analysis to analyse the results and to offer some multiple different options to be compared.

2.2.1 Timeframe scope

The CBA for SESAR PJ05-W2-35 at V3 was calculated between 2022-2043.

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:

- **PJ05-W2.35** Solution Members
- All other **PJ05-W2** Project Members
- **SESAR JOINT UNDERTAKING (SJU)** as SESAR 2020 Program coordinator
- **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)

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

- ✓ *ANS Providers*
- ✓ *ATM infrastructure and equipment suppliers*
- ✓ *Airspace Users*
- ✓ *Network Manager*
- ✓ *Airport owners/providers*
- ✓ *Affected NSA*
- ✓ *Affected staff organisations.*

SESAR 2020 Projects/Solutions with dependencies to PJ05-W2-35:

- PJ.14 (EECNS) CNS

  (Solution PJ.14-W2-84 — New use and evolution of Cooperative and Non-Cooperative Surveillance)

SESAR 2020 Transversal Projects:

- PJ.19 W2 (CI) Content Integration PJ.20 W2 (AMPLE) Master Plan Maintenance

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

2.5 Background

The work done for Single Remote Tower, and Contingency Remote Tower, is the baseline for the Multiple Remote Tower concepts that is developed in this SESAR 2020 - Wave2, even if the concept is not developed in this document (for completeness the requirements can be found in ***PJ05-W2-35-V3 OSED*** & ***PJ.05-W2-35: Validation Plan (VALP) for V3 - Part I***).

Remote Tower Concept and flexible allocation of the aerodromes between the different MRTMs in Solution 35 can be considered as successor of *SESAR 2020 – Wave 1 - PJ05-03-V2* & V3 and for the scopes of the Wave2 will be validated at V3 maturity level.

Previous Solutions for Single Remote Tower and Contingency provided initial benefits in terms of Cost Efficiency (Single Remote Tower) and Resilience (Contingency) while providing the required level of Safety.

Additionally, Solutions regarding Remote Tower concept developed and validated under SESAR programme Projects (SESAR 1, SESAR 2020 Wave1) have delivered results determining the solution PJ05-02-V3 as reference for Solution 35 regarding Multiple Remote Tower Modules.

Preceding validated Solutions are below listed:

- ✓ Solution #71 - Single Remote Tower Services for small airports
- ✓ Solution #52 - Remote Tower Services for two low-density aerodromes
- ✓ Solution #12 - Single Remote Tower Services for medium traffic volumes
- ✓ Solution #13 - Remotely-provided air traffic services for contingency situations at aerodromes
- ✓ Solution PJ05.02-V3 - Multiple Remote Tower Module

2.6 Glossary of terms

Term	Definition	Source of the definition
ATS (Air Traffic Service)	A generic term meaning variously, Flight Information Service (FIS), Alerting Service (ALRS) and Air Traffic Control Service (ATC) (area control service, approach control service or aerodrome control service). In this document, when the term ATS is used, it is usually referring to TWR or AFIS.	ICAO, Annex 11
Aerodrome ATS	Air traffic service for aerodrome traffic, in the form of aerodrome Air Traffic Control service (ATC) or Aerodrome Flight Information Service' (AFIS).	EASA
Aerodrome Control Service (TWR)	The air traffic control (ATC) service provided by the Air Traffic Control Officer (ATCO) for aerodrome traffic.	ICAO, Annex 11
APP (Approach control service)	**T**he service for Arrival and Departing traffic (before and after they will be/have been under the TWR control. APP is provided by a single ATCO for one or more airports, either separate or in combination with TWR (TWR & APP from the Tower).	ICAO
Conventional Tower	A facility located at an aerodrome from which aerodrome ATS is provided principally through direct out-of-the-window observation of the aerodrome and its vicinity.	EASA
Multiple mode of operation	The provision of ATS from one remote tower/remote tower module for two or more aerodromes at the same time (i.e., simultaneously).	EASA
Multiple Remote Tower Module (MRTM)	A Remote Tower Module (RTM) which enables the possibility to provide ATS to two or more aerodromes at the same time (i.e., simultaneously).	PJ.05 definition
Out-of-the-window (OTW) view'	A view of the area of responsibility of the aerodrome ATS unit from a conventional tower, obtained via direct visual observation.	EASA

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Remote Tower	A geographically independent facility from which aerodrome ATS is provided principally through indirect observation of the aerodrome and its vicinity, by means of a visual surveillance system. (It is to be seen as a generic term, equivalent in level to a conventional tower).	EASA
Remote Tower Centre (RTC)	A facility housing one or more remote tower modules.	EASA
Remote Tower Module (RTM)	A combination of systems and constituents from where remote aerodrome ATS can be provided, including one or more ATCO/AFISO workstation(s) and the visual presentation. (It can be compared with the tower cabin of an aerodrome conventional tower.)	EASA
Remote Tower Centre Supervisor (RTC supervisor)	A role established in order to provide an efficient set up at all times and guarantee a flexible system by means of: performing overall supervision of all aerodromes within the RTC; managing the allocation of staff and Modules (MRTMs/RTMs); performing planning, administration, allocation of tasks and supervision of technical systems.	PJ.05 definition
Simultaneous movements	All aircraft and vehicle movements under the control of the ATCO or on the frequency at the same time.	PJ.05 definition
Single mode of operation	The provision of ATS from one remote tower/remote tower module for one aerodrome at a time.	EASA
Technical Enablers	Additional features and functions within a single or a multiple module that enable the provision of ATS using the concept. These technical features will assist in the areas of visualisation and operational performance. Further information on the requirement status of the Technical Enablers is given within this document.	EASA
Visual Presentation	A view of the area(s) of responsibility of the aerodrome ATS unit, provided by a visual display.	EASA

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Visual Surveillance System	A number of integrated elements, normally consisting of optical sensor(s), data transmission links, data processing systems and situation displays providing an electronic visual presentation of traffic and any other information necessary to maintain situational awareness at an aerodrome and its vicinity. **Note:** EUROCAE ED-240/ED-240A is using the term 'remote tower optical system' for the same.	ICAO, Doc 4444 EASA

Table 1: Glossary of terms

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List of Acronyms

Acronym	Definition
AAS	Airport Advisory Service
AC	Advisory Circular
ACC	Area Control Centre
AFISO	Aerodrome Flight Information Service Officer
ALRS	Alerting Service
ANS	Air Navigation Services
ANSP	Air Navigation Service Provider
APA	ATM Performance Assessment
APP	Approach Control Service
ATC	Air Traffic Control
ATCO	Air Traffic Control Officer
ATM	Air Traffic Management
ATS	Air Traffic Service
ATSEP	Air Traffic Safety Electronics Personnel
ATSU	Air Traffic Service Unit
AU	Airspace Users
AVF	Advance Visual Features
BCR	Benefit-Cost Ratio
CAP	Cabin Attendant Panel
CBA	Cost Benefit Analysis
CEF	Connecting Europe Facility
CI	Cost Index
CNS	Communication, Navigation, Surveillance
COOPANS	Cooperation Between Ans Providers
DDR	Demand data repository
EASA	European Aviation Safety Agency
EATMA	European ATM Architecture
ECAC	European Civil Aviation Conference
EECNS	Essential and efficient communication navigation
EUROCAE	European Organisation For Civil Aviation Equipment

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EXE	Exercise
FDP	Flight Data Processor
FOC	Full Operational Capability
HMI	Human Machine Interface
ICAO	International Civil Aviation Organization
IFATCEA	International Federation of Air Traffic Controllers Associations
ILS	Instrument Landing System
IOC	Initial Operational Capability
KPA	Key Performance Area
KPI	Key Performance Indicator
MRTM	Multiple Remote Tower Module
NM	Network Manager
NPV	Net Present Value
NSA	National Supervisory Authority
OE	Operational Environment
OI	Operational Improvement
OTW	Out-The-Window
PRU	Performance Review Unit
RBT	Reference Business Trajectory
ROI	Return of Investment
RTC	Remote Tower Centre
RTM	Remote Tower Module
RTS	Real Time Simulation
SDM	SESAR Deployment Manager
SEC	Security Officer
SESAR	Single European Sky ATM Research (Program)
SJU	SESAR Joint Undertaking (Agency of the European Commission)
STATFOR	EUROCONTROL Statistics and Forecasts Service
SW	Software
TMA	Terminal Maneuvering Area
TWR	Tower

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UC	Use Case
VALP	Validation Plan
VALR	Validation Report
VFR	Visual Flight Rules
VR	Rotation Speed
VT	Validation Target

Table 2: List of acronyms

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3 Objectives and scope of the CBA

3.1 Problem addressed by the solution

The Remote Tower concept has changed the provision of Air Traffic Services (ATS) in a way that it is more service tailored, dynamically positioned and available when and where needed, enabled by digital solutions replacing the physical presence of ATCOs and control towers at aerodromes.

Remotely provided Air Traffic Service for Multiple Aerodromes (1 ATCO controlling up to maximum 3 aerodromes) and development of the Remote Tower Centre are both part of this development which started with Single Remote Towers (1 ATCO controlling 1 aerodrome, not from a conventional tower).

This document is the cost-benefit analysis (CBA) related to the advanced development of multiple modules for remote towers within the SESAR operating concept.

3.2 SESAR Solution description

This scope of Solution 35 is addressed to increase ATCO productivity (i.e., reduce the number of ATCOs required) through a balance of workload between different MRTMs within a Remote Tower Centre, supported by a Remote Tower Centre Supervisor role (RTC supervisor) and a Supervisor Planning Tool.

The OI step addressed in this Validation Plan is:

- **SDM-0210: Highly Flexible Allocation of Aerodromes to Remote Tower Modules**
  'The provision of remote ATS service to the remote aerodromes can be dynamically assigned (over time) to any other Remote Tower Module (RTM) within a Remote Tower Centre (RTC). RTC planning tools supporting the RTC supervisor enable an efficient usage of all RTMs and staff in an RTC.'

This Flexibility should be achieved through a Flexible Allocation of Aerodromes to each MRTM, that implies the possibility for an aerodrome to be allocated in different positions within MRTMs (e.g., *aerodrome A is at the left position of the MRTM_1 in the morning and after a transfer to another MRTM_2 is received back at the right position of the MRTM_1*), even if as parallel effect the expectation might increase the Complexity as it might be more difficult for the ATCO to maintain the situational awareness on the controlled aerodromes when compared to a fixed allocation with dedicated aerodromes to a specific MRTM.

To avoid all variables that could affect the ATCO's ability to provide simultaneous Air Traffic Control (ATC) in a safe and efficient manner, the following possibilities could be taken into consideration:

- The traffic load has to be kept at a certain level, as requested in the scope of Solution 35 (aerodromes classified as Small and/or Others OE only), by monitoring that ATCO workload remains capable of provide simultaneous ATC services (e.g., backtracking vs. use of parallel taxiways, or ILS for just one RWY, are factors which impact ATCO workload).
- The ATCO workload will be balanced on an appropriate level by additional automation support.

The task of flexible allocation of grouped aerodromes to dedicated MRTMs will be supported by an ATCO with a specific role (so called ATCO Supervisor), that will be supported by a what-if tool (*Supervisor Planning Tool*) that analyses and elaborates data like traffic volume/complexity, planned

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maintenance and other activities, weather conditions at the different airports, as well as ATCO endorsements and availability.
Having in mind the requested peculiarity of the Airport Complexity of a RTC and its limited number of connected airports, the RTC Supervisor role at this stage might be, easily and without of any increased workload, carried out by one of the ATCOs on duty in the RTC.

Other validations objectives planned for the scope of Solution 35 will assume that an ATCO can hold endorsements for 4 aerodromes.
Nevertheless, having 4 endorsement is not a requirement to implement the OI and mostly it needs to be considered locally only, within each RTC and depending on aspects such as harmonised procedures, airspace class, and type of traffic.

The 4 aerodromes will be grouped inside the RTC and will be flexibly allocated to the MRTMs, validating on this manner also the concept that the ATCO can hold qualifications for a higher number than two of grouped aerodromes.

The RTSs will be addressed, for the actual scope of this Solution and this Wave 2, for a setup with two MRTMs, each providing the capability to allocate 3 aerodromes at a time and the success criteria will focus on evaluation of KPIs for Human Performance and Safety aspects only.

Solution 35 addresses any combination of Small and Others aerodrome category (OE)[1] and needs to be validated for different kinds of environments that may be composed of:

- Different levels of airport complexity (RWYs, taxiways, etc.).
- Small Airport Operating Environment: between 15,000 and 40,000 annual IFR movements
- Other Airport Operating Environment: below 15,000 annual IFR movements
- Traffic volumes and their distribution over the controlled aerodromes.
- Various conditions at the different aerodromes (weather, daylight, geographical difference).
- Variable traffic mixes (VFR-IFR-mix, rotor-fixed wing, special).

[1] EXE-PJ05-W2-35-V3-2.1.1 has been planned to test an Operational Environment with 15 Aerodromes, and a couple of them are military; so, within that EXE there is an interaction and a set of coordination need to accomplish the management of civil and military traffic. (More details are available within the OSED, the VALR & the VALP)

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SESAR Solution ID	SESAR Solution Description	Master or Contributing	Contribution to the SESAR Solution	OI Steps ref. (from EATMA)	Enablers ref. (from EATMA)
PJ05-W2-35	Remotely Provided Air Traffic Services from a Remote Tower Centre with a flexible allocation of aerodromes to Remote Tower Modules	M	Increased effectiveness on providing simultaneous ATS from a RTC to a large number of airports flexibly allocated to specific MRTMs.	SDM-0210 Highly Flexible Allocation of Aerodromes to Remote Tower Modules	AERODROME-ATC-83
					AERODROME-ATC-84
					AERODROME-ATC-85
					AERODROME-ATC-88 (Optional)
					SVC-072-Aerodrome Transfer service
					CTE-S10 Multiple Remote Tower Control Surveillance (optional)
					HUM-066 – RTC supervisor Role

Table 3: Solution #35 – Scope and related OI steps

The flexible allocation of airports to RTMs within a RTC requires the following items to be investigated:

- *Support of ATCO situational awareness*

  The RTM needs to be designed in a way that it supports ATCO situational awareness integrating all the information from the different airports. HMI guidelines need to be applied in order to find the balance between providing all information required at a certain moment while avoiding clutter of information.

  Use of automation tools supporting ATCO situational awareness needs to be addressed during the deployment.

- *Flexible allocation*

  In addition to opening a new position when splitting an aerodrome, a more flexible allocation of aerodromes, i.e., transferring one aerodrome to an already active MRTM has been validated..

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- *Supervisor Planning Tool*

  For allocating airports and ATCOs to MRTMs, the Supervisor Planning Tool should consider, at least, the following parameters:

  - ✓ traffic
  - ✓ ATCO endorsements
  - ✓ a rostering plan and shift constraints
  - ✓ weather information
  - ✓ technical constraints

  The workload calculation should be further investigated, as minimum and with some other items depending on the OE, with respect to the following:

  - ✓ The total workload of the aerodromes being allocated to one MRTM is supposed to be more than the sum of the individual workloads.
  - ✓ When airports are combined, the workload should increase a bit more than simply adding the workloads of both airports. The more airports are combined, the higher the extra workload should become.
  - ✓ A threshold for maximum task load per aerodrome and the possibility to see the number of simultaneous movements should be added

  The workload calculation needs to be fully transparent to the AUs and the other Stakeholders involved.

- *Role of the RTC Supervisor*

  The role for the ATCO Supervisor needs to be locally defined looking at this and the incoming evolutions of the Project (RTCs).

- *Automation support tools*

  Automation support tools for monitoring tasks needs to be developed in order to reduce ATCO workload, increase situational awareness, well balance the traffic scenario within the operational environment. This adds requirements on low-cost surveillance (co-operative and non-co-operative) and voice services that need to be investigated.

- *Supervisor Planning tools.*

  The Supervisor Planning Tools for planning and allocation of airports to the Remote Tower Modules need to be developed and assessed to the Operational Scenario.

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3.3 Objectives of the CBA

The purpose of this document is to develop a quantitative Cost Benefits Analysis, given the objective to reach and targeting V3 maturity level of the Solution, in order to analyse the consequences in terms of costs and benefits, related to the UC that may be enable the use of a *dynamically allocation of aerodromes between the MRTMs*.

The CBA's elaboration and the released Deliverable will be addressed to summarize and to present the affordability of the Solution by being compliant with the expected and addressed performance and economic benefits.

The expectation will be:

- Costs have to be referred to the monetary value of the investment that is "defined" to produce or acquire/quantify the benefits;
- Benefits will refer to the positive ROI (Return of Investments) for the stakeholders involved.

Solution 35 will address any recommended change compared to the baseline.
For this reason, all the prior delivered assumptions such as network quality of service, any different technical aspects and other resilience, flexibility or redundancy related issues are already in place as part of the Reference Scenario of Single Remote Tower.
The output of the Validations Exercises will be focused to assess Operational evaluation of Human Performance (HP) and Safety (SAF) aspects.

Solution 35 is addressed to validate different kinds of environments at aerodrome level such as:

- ✓ Different levels of airport complexity (RWYs, taxiways, etc.);
- ✓ Traffic volumes and their distribution over the controlled aerodromes;
- ✓ Various conditions at the different aerodromes (weather, daylight, geographical difference);
- ✓ Variable traffic mixes (VFR-IFR-mix, rotor-fixed wing, special).

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RTS will be the approach in which the operational concepts mentioned above will be tested and validated; the Operational Scenarios (Reference & Solution Scenarios) will be addressed with a setup on three or four MRTMs, each of them providing the capability to allocate 3 aerodromes at a time (Small Airport Operating Environment totalizing an amount of traffic between 15,000 and 40,000 annual IFR movements).

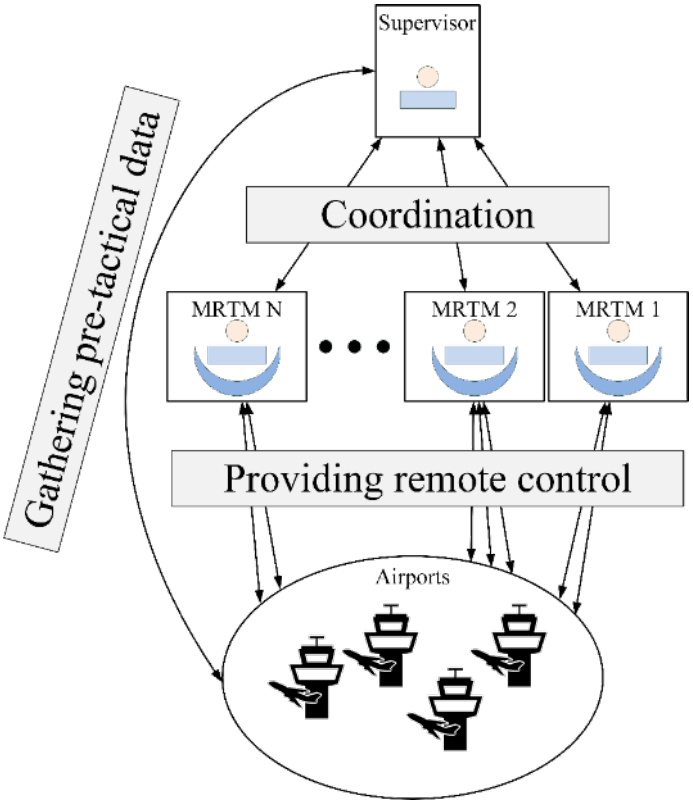

Figure 1: Management Process

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3.4 Stakeholders' identification

All the stakeholders that will be impacted by PJ05-Solution 35, directly or indirectly, are listed into the following Table, each one for the expected type of benefit, introduced by the application of the flexible allocation of the supervising planning tool.

It is important to underline, having in mind all the assumptions stated in the previous Solutions (SESAR 1 and SESAR 2020 Wave 1), that nothing will change for the quality and the standard of the ATC Services provided to the AUs (exception made for the eventual enlarged time availability/24-7).

It is possible (CBA will provide and define the quantification) that benefits in economic and performance terms will be counted by Airport Operators and Airport Authorities thanks to the improved technology, even if the maintenance and the responsibility for the fully operational status of the apparatus will be in charge to both Airport Stakeholders.

It has already been demonstrated since SESAR 1 that the ATCOs will be the main actors that will be involved by the benefits that will be introduced by the RT concept.

Stakeholder	Involvement	Why it matters to stakeholder
ANS providers	ANSPs will be able to implement the systems	ANSPs expect a reduction of cost for running local air traffic service at aerodromes
Staff union and organisations (ETF/IFATCEA)	ATCOs will be the end user of the system	Staff working in a MRTM and RTC will be affected when working with more than one aerodrome at a time. Their expectations are that the technology will ensure that daily work can be performed safe and controlled.
ATM infrastructure and equipment suppliers	The technology set new demands on a reliable system for Multiple Remote Tower	Industries are affected by new requirements on multiple remote towers and the need for stable systems
Airspace users	Airspace users fly to and from aerodromes with RTC and Multi Remote Tower	Traffic to and from airports expect to continue to traffic aerodromes without impact on scheduled traffic with a kept availability for each of the aerodromes controlled in Multiple mode
Affected NSA	NSA will issue approval for any new ANS systems	NSA expect that any new technology is safe and stable for air traffic service and that methodology is properly adapted to the technology

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Airport owners/providers	Airport owners are customers to ANS providers	Airports expect prices for ANS to be lowered with Multiple Remote Tower without a negative impact on their availability for flying customers.

Table 4: Stakeholders involved

Stakeholder impacted

1. Main stakeholders involved
2. Stakeholders that will have to make investment
3. Stakeholders that have to change the way they work
4. Stakeholders that have to establish common procedures
5. Stakeholders that have to implement common infrastructures (RTC) procedures
6. Stakeholders that will get the benefits (ANSPs – Airport Companies – AUs – NM - Customers)
7. Comparison of current facilities vs future infrastructures (Conventional Control Towers vs Remoted Control Tower's Services)

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	Airport Domain: Small & Other OEs	Investments; Enjoy benefits in operations; Support operation.	Provided inputs, Reviewed results.	Provided inputs, reviewed results
Airport Operators	N/A			
Network Manager	En-route ANS	Enjoy benefits in operations; Support operation.		
Scheduled Airlines (Mainline and Regional)	Airspace Users	Enjoy benefits in operations.		
Business Aviation	Airspace Users	Enjoy benefits in operations.		
Rotorcraft	Airspace Users	Enjoy benefits in operations.		
General Aviation IFR	Airspace Users	Enjoy benefits in operations.		
General Aviation VFR	Airspace Users	Enjoy benefits in operations.		
Military – Airborne				

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Military – Ground	Low Complexity Military Airports[2]	Investments; Enjoy benefits in operations; Support operation.	Provided inputs, Reviewed results.	Provided inputs, reviewed results
Other impacted stakeholders (ground handling, weather forecast service provider, NSA….)				

Table 5: SESAR Solution 35 CBA Stakeholders and impacts

3.5 CBA Scenarios and Assumptions

The previous work done in SESAR 2020 Wave1 has delivered results and outputs/baseline determining both the Solutions PJ05-02-V3 and PJ05-03-V2 as a reference for Solution 35 regarding Multiple Remote Tower Modules.

The objective of solution PJ05-W2-35 is to complete and to expand the scope of the Multiple Remote Tower solutions addressing Remote Tower Centre capability through a flexible allocation of grouped aerodromes to dedicated MRTMs within a Remote Tower Centre.

Such a flexible allocation allows increasing ATCO productivity by balancing the workload between different MRTMs, i.e., reducing the number of required ATCOs by allocating aerodromes to a MRTM until a maximum number of 3 aerodromes, depending by the actual traffic.

A flexible allocation of aerodromes in the MRTM implies that one aerodrome can take different positions within MRTMs compared to solution PJ05.02-V3 (no possibility to allow a flexible allocation). That allows the reduction of ATCOs on position by managing the lowered amount of actual traffic on one or more airports and by allocating them to one single MRTM and it is expected that this new method will maintain the situation awareness at the same level without any compromission of Safety of operations.

Depending on the complexity of the flexible allocation, the task of the flexible allocation of grouped aerodromes to dedicated MRTMs must be allocated to a specific role RTC supervisor and requires a support tool.

The validations assume that an ATCO can hold endorsements for 4 aerodromes. These 4 aerodromes are grouped together and can be flexibly allocated to dedicate MRTMs. As it is envisaged the provision of higher cost-effectiveness by this solution, the concept can also be valid for a higher number of grouped aerodromes if the ATCO can hold endorsements for more aerodromes. The Real time

[2] Even if the involvement of military airports (Low complexity) and therefore of a Military ANSP (Airforce) is highlighted in the cell, this finding is reported only because military airports were involved in one of the Validation EXEs.

However, it is confirmed that no involvement of military airports has been foreseen among the aims of the Solution.

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Simulations address a setup with two MRTMs, each MRTM providing the capability to allocate 3 aerodromes at time. The validations are focusing on evaluation of human performance and safety aspects.

The principles and experiences gained through the operational usage of the Single Remote Tower operations are imposed as baseline for multiple Remote Tower Operations. This New Operating Method of providing ATS from RTC that accommodates a locally determined number of MRTMs will use the outcomes from the PJ05.02-V3 validation as reference, and additionally will consider the experiences and recommendations obtained by the previous PJ05.03-V2 validation.

With the introduction of the Flexible Allocation of the aerodromes to the MRTMs (even if the figure of the *ATCO in Charge* was necessary also within the previous RTC's configuration - without the dynamic allocation - and as it is today in the traditional Control Towers; indeed, a Responsible for the shift must be always nominated), it is absolutely necessary that someone takes the decisions to manage the ATCOs during the working time. And this figure cannot be nobody else than an *ATCO Supervisor*.

The figure of the *RTC Supervisor*, as detailed and explained within the lines of the Deliverable, won't have any cost at this level of OEs involved within the RTC. Because of the nature of the TWRs that has been planned to "remotize" and so to "manage" from the RTC with the dynamical allocation of the TWRs to the MRTMs assigned within the RTC, the figure of the *Supervisor* (at the moment what proposed for this study is more than enough due to the amount of traffic) will be "nominated" from the OPS office when the daily roster will be published. And as it has been detailed within the Cost Section (training of all the ATCOs on duty to manage and to receive a qualification to operate on the SPT and as Supervisor) each one of the ATCOs on duty can be "nominated" as "*ATCO in charge*" with this scenario (OE Small & Other).

As already happens in Traditional Control TWRs classified Small and Other, this figure is not one more (as instead for TWRs classified Very Large or Large and often also in some Medium) and therefore an effort in terms of manpower/additional costs. The same assumption was used for this Solution: a sort of *first among peers* that *coordinates the management of the allocation of the TWRs to the MRTMs and manages the ATCO personnel with equal merit*.

And for the scope, in the Recommendations section, we introduced a reference to future evolutions when the number of TWRs (similar OEs) allocated in the RTC will be increased and/or an evolution of the classification of the Control Towers that will be "remotized" in the RTC will happens.

In both cases, it is more than appropriate and also paramount to provide for a new figure, additional and dedicated to the role as Supervisor (probably and possibly also supported by some coordinators), who coordinates the activities and who therefore must be quantified in terms of additional costs that will have to be considered. Therefore, obviously considering an increment in terms of performance benefits for the RTC where the number of Aerodromes will increase and/or the OEs that will be allocated in a RCT will be more complex than a Small one.

As already described, the New Operational Method will enlarge the scope of the Multiple Remote Tower solutions from fixed to flexible allocation of aerodromes between MRTMs within RTC thus provision of ATS will be more efficient.

3.5.1 Reference scenario

In current day operations, provision of simultaneous remote ATS to multiple airports by one ATCO is not yet applicable in real operational environment. Nevertheless, the previous work done in SESAR 2020 Wave1 dedicated to Multiple Remote Tower, has delivered results determining Solution PJ05-02-V3 as a reference for Solution 35 regarding Multiple Remote Tower Modules.

With the reference scenario was validated a provision of ATS to two small or three other operating environment airports by one ATCO with a fixed allocation to MRTM. A single ATCO performed different roles such as: Apron Manager, Tower Clearance Delivery Controller, Tower Ground Controller and Tower Runway Controller with maintained situational awareness. It was assumed that ATCO were able to hold endorsements for up to 3 (single) different aerodromes.

The following traffic characteristics were applied regarding simultaneous movements:

- 10-20 movements (ground and air) per hour for all airports, both IFR and VFR
- 2 small airports with up to 6 simultaneous movements
- 3 other airports with up to 4 simultaneous movements

The increased workload as result from the simultaneous ATS could be mitigated on time with help of ATCOs planning tool, delivering traffic predictions in a timely manner. During abnormal situations, under degraded-more of operations or emergency situations, increased workload could be balanced by splitting of one aerodrome to the spare MRTM.

Technical enablers, AVFs, communications, radar displays, and other features/functions assisted the controller with the provision of ATS. The traffic situation was monitored using a high-resolution panoramic display located in the remote tower control unit.

3.5.2 Solution Scenario

The objective of PJ05 Solution 35 is to increase the scope of the Multiple Remote Tower solutions within an RTC and including traffic volumes and airports simultaneously controlled by one ATCO.

A flexible allocation of aerodromes within the RTC will ensure efficiency by serving multiple aerodromes within a MRTM together with RTC supervisor functionality. The Normal conditions, Abnormal conditions and Degraded modes are described in the SESAR Safety Reference Material, where details are listed.

The flexible allocation of airports and ATCOs within an RTC adds a need for a RTC Supervisor or a similar role with planning tools to enable an efficient run of an RTC.

Figure 1 Flexible allocation of aerodromes to MRTM's in RTC below adds a view on how an RTC with a flexible allocation of aerodromes could function:

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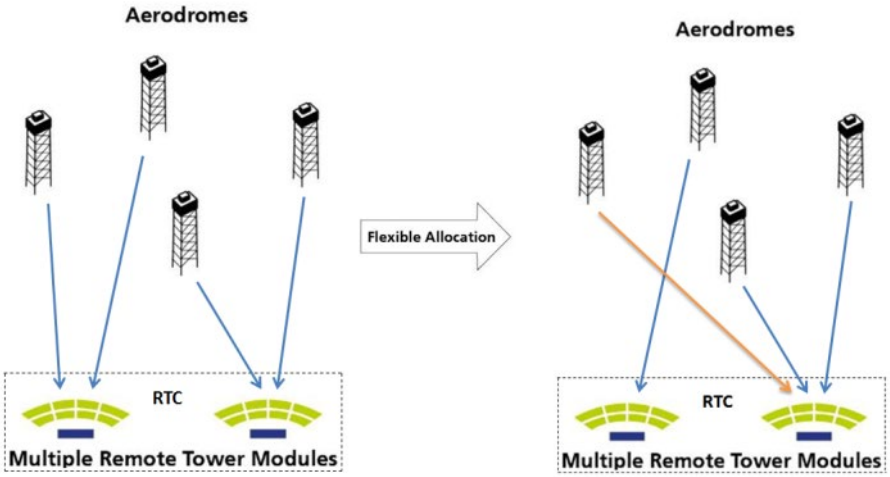

Figure 2 Flexible allocation of aerodromes to MRTM's in RTC

- Four different aerodromes are flexibly allocated between two MRTMs in the one RTC, while maximum three aerodromes can be allocated to one MRTM
- RTC supervisor should be provided with all necessary data to flexibly allocate aerodromes between the different MRTMs achieving, as much as possible, a balanced workload between the MRTMs.

The primary actors impacted by multiple remotely provided ATS are the ATCOs. Based on the single remote tower environment, the overall roles and responsibilities of the ATCO will not change, in fact they will remain responsible for the provision of the required services at the airport/airports.

The RTC, Remote Tower Centre, consists of several MRTMs, connected aerodromes, and ACTOs on duty. Staffing at the targeted aerodromes is commonly a single ATCO (spare ATCOs may be available for times with more traffic, and to ensure breaks).

Referring to the reference solution, a new role for Solution 35 is considered for the RTC Supervisor, that is responsible for the general management of activities in the Operations Room. This role may be filled by one of the ATCOs on duty or alternatively may be a distinct position with an endorsement for the task, depending on the number of Airports and Remote-Control Towers to manage. Focus on this role is balancing workload between the different ATCOs in each MRTM through the flexible allocation of aerodromes. This role is similar to an ACC and/or TWR Supervisor.

Safety and ATC management are the keys for any change of Air Traffic Management. Flexible allocation of aerodromes between MRTMs within a Remote Tower Centre has a possibility to support kept Safety levels and service, as well as the improvements in ATCFM Delay reduction and improvements in ATCO productivity and ATCO workload reduction too.

The full range of ATS should be offered in such a way that any negative impact on the AUs is reduced to a minimum, while maintaining a safe and efficient service in comparison to the single remote tower operations.

With support of Supervisor Planning Tool for the ATCO Supervisor, the traffic load balance for the ATCO can be assured for in time. This will support decision making on when to transfer airports

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between MRTMs. It will also support the decision on which airports to combine, taking into consideration e.g., suitable airport combinations and ATCO endorsements.

Providing ATS to more than one airport by one ATCO, when it is safe and practical, will add benefits to airport providers, ANSPs, airlines and eventually the flying customers through a cut in costs and/or the provision of ATC to airports earlier not served with ATC.

All the Validation EXEs have planned a Scenario where 3 or 4 different aerodromes will be tested for the Real Time Simulations, while providing simultaneous ATS for up to 3 aerodromes simultaneously from one MRTM. The VAL EXEs contain 2 MRTMs, each capable of handling up to 3 aerodromes simultaneously. For details, see at the OSED/VALP for this Solution.

The goal is to manage aerodromes in a flexible way to provide a continuous service at each aerodrome according to requested traffic levels. This will provide the ATCOs in each MRTM with a suitable level of traffic to maintain situational awareness at each aerodrome. In order to achieve as much as possible balance of the ATCOs workload caused by the traffic requests, aerodromes can be transferred between the MRTMs.

A supervisor role will be included in the scenarios. The supervisor will plan the utilization of the MRTMs based on planned traffic, weather, equipment status etc. The supervisor will also assist the ATCOs and may initiate a transfer of an aerodrome from one MRTM to another.

3.5.3 Assumptions

The main assumptions are:

- The timeframe considered for the analysis is:
  - ✓ Implementation phase: 2023 – 2027.
  - ✓ IOC: 01/01/2025 (Ramp-up period depending on the implementation).
  - ✓ FOC: 01/01/2028.
  - ✓ Shadow Mode foreseen with an effort of 5/8 weeks.
- Small and Other Airport Categories (OEs) will be involved at this first phase of implementation of the RTC.
- Implementation costs will consider installation costs of equipment (Supervisor Planning Tool) & training of ATCO's personnel. Other costs related to Technology and enablers in addition to those needed from the existing in place (RTC and MRT Modules) have already been considered within the previous SESAR Programmes and the dedicated CBAs have been assessed and released.
- The figure of the ATCO Supervisor, identified as the *ATCO in Charge*, i.e., the qualified ATCO responsible for managing the ATCO personnel and the RTC infrastructure for the operational point of view during the work shift. It is a figure that already exists in all the traditional Control Towers and in every other infrastructure/workplace where there is the necessity for a coordinator between figures who interact for the same purpose. And the same assumption was used for this Solution: a sort of *first among peers* that coordinates the management of the allocation of the TWRs to the MRTMs and manages the ATCO personnel with equal merit, without additional costs for this phase of the study.

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- Personnel cost of ATCOs and Technicians (ATSEPs) are extrapolated from the *ATM Cost-Effectiveness (ACE) 2019 Benchmarking Report edition May 2019*. Average employment costs are considered although staff working at remote centre locations may have higher costs due to additional compensation.

- The source of the implementation and operating costs related to technology implemented in the CBA (SPT) is based on stakeholder judgement plus internal experts' estimations based on standard expertise.

- In case some ATCOs will remain available, even if the extension of the availability of the ATC service from H18 to H24, following the optimization of the rostering within the RTC, succeeding the programme from the "physical" position of the Control Tower located on the airport to the Remote Tower structure, they will be immediately reabsorbed by other ANSP structures.
  By requalifying, the new ATSUs where they will be reassigned and with the aim to reorganize other ANSP's structures, for the purposes of Solution 35 and unlike the previous Wave 1's CBAs, for this V3 these benefits will be available from the RAMP-UP period and at 100% of the availability.

- It is assumed that the investment phase (implantation costs) has been established from 2023 to 2027, even if the different % of implementations will depend due to the different programs of each of the ANSPs in ECAC.

- The phase of counting the Benefits that will be obtained, following the definition of the Solution Scenario referred to in the previous paragraphs, will instead be counted on the basis of a RAMP-UP period consequent and parallel to the planned implementation phase of the investments by each of the different ANSPs of ECAC. The Benefit phase will start as a percentage as the implementation phases are concluded, starting in 2025 and up to 2027, and considering the full benefits at 100% from 2028.

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4 Benefits

The Validation Targets expected from SESAR PJ19.04 (visible into the released document, present in STELLAR, called ***D4_0_1 Validation Targets - SESAR2020 Wave 2 & Wave 3_v00_01_00_1***) 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*** and are here below reported:

- *SAF: Qualitative assessment*
- *HP: Qualitative assessment*
- *CEF2: ATCO Productivity*

The above reported Validation Targets (VT), based on a qualitative scale, apportioned to Solution PJ.05-W2-35 in the PJ19 Validation Targets 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 & Wave 3 of the SESAR 2020's expected benefits.

The colour scale indicates Impact Level 1 in green, Impact Level 2 in yellow and Impact Level 3 in orange. They are presented using the qualitative scale described in PJ19-W2: Validation Targets - Wave 2[3]

SOL. CODE	SAF	FEEF1	TEFF1	CAP3	CAP1	CAP2	PRD1	PUN1	CEF2	CEF3	HP
PJ.05-W2-35	YES	N/I	N/I	N/I	N/I	N/I	N/I	N/I	2	N/I	YES

Table 6: Validation Targets apportioned to the SESAR PJ.05-W2-35 Solution

Related to the Qualitative Post Analysis for the involved KPAs, any success criteria will be measured using questionnaires, debriefs and workshops. Answering category acceptable (or similar) will indicate success based on majority of answers for those objectives.

In other cases, it depends on the expert judgement of the feedback in questionnaires & debriefs. If a majority of the ATCOs and runs provide results of satisfactory level, or higher, results indicate success on the objective. Feedback during debriefs will support experts' judgement on the results.

[3] Results from this Solution will also be valid for airports classified as OE - Others within the PJ20 Deliverable (10.2)

Safety remains as the most important objective for Multiple Remote Tower and Remote Tower Centre. It is closely interlinked with Human Performance. Duplication of objectives and criteria that might be allocated to both KPAs was avoided emphasising human performance.

These harmonised validation objectives should be followed by all the validations and might be complemented by specific validation criteria (that should be allocated to the existing validation objectives).

The expected benefits will be quantified, both as qualitive and quantitative output, coming out from the post analysis that follows at each of the Operational Validation Exercise below listed. The role of the ATCO Supervisor, a sort of *ATCO in Charge*, won't be considered at this level of Operational Scenario (see Para 3.5 and Assumptions).

The Validation Exercises are planned both to demonstrate the feasibility as first task and to quantify the economic outputs with the aim to have a full picture of the convenience to implement the Operational concept of the Solution.

The following list provides an overview on the planned Validation Exercises

- EXE-PJ05-W2-35-V3-2.1 – DLR/FRQ/ON/PANSA
- EXE-PJ05-W2-35-V3-2.2 – COOPANS
- EXE-PJ05-W2-35-V3-2.3 – INDRA/AVINOR/HUNGAROCONTROL
- EXE-PJ05-W2-35-V3-2.4 - ENAV
- EXE-PJ05-W2-35-V3-2.5 - DFS

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5 Cost assessment

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

5.1 ANSPs costs

The CBA needs to consider the investment costs of acquiring the implementing system (***Supervisor Planning Tool***) 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 system operational).

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?

ANSPs will incur the costs. No other stakeholder will incur any costs considering the relevant 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 such as training, license, patent, program management. It is assumed that implementation will commence in 2025, 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 35 - MRTM & RTC*

Costs are categorized by the:

- ✓ deployment and on-going maintenance of the ***Supervisor Planning Tool*** and related technological infrastructure.
- ✓ deployment and on-going maintenance of the ***Supervisor Planning Tool*** functions, related to allocate Airports and ATCOs to MRTMs, that should also consider traffic allocations, ATCO endorsement, a rostering plan and shift constraints, weather information and technical constraints.
- ✓ initial training of ATCOs (all ATCOs assigned to the RTC) in the use of the devices and functions.
- ✓ update and maintenance of ATCO procedures and guidance on local use of the ***Supervisor Planning Tool*** technology and functions.

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As presented in Section 2.2, ***Solution 35*** is applicable to RTC's Operating Environment that handle more Aerodromes categorized as ***Small*** *15K - 40K* annual IFR movements or ***Others*** *<15K* annual IFR movements.

It is considered that traffic volumes of ***Small*** and ***Other*** aerodrome classification, and the related ATCO workload, are adequate to require support from the ***Supervisor Planning Tool*** to handle *MRTMs* in the *RTC*. Costs presented and assessed are, therefore, valid for ***Small/Others*** categories of aerodrome.

Implementing costs:

- ***Acquisition, installation, configuration, testing, certification and setting to work*** of the ***Supervisor Planning Tool*** equipment, comprising dedicated Data-Link interface with the NM System. It is assumed that:
  - ✓ implementation is per Control Towers and fully interoperable with the FDP Network System.
  - ✓ includes back up/failure provision.
  - ✓ is compliant to any required technical standard.
  - ✓ a single ***Supervisor Planning Tool*** infrastructure will cover the needs of all Remote Airports allocated to the RTC.

The cost driver is:

*[(**Cost of Server & SW**)] + [**Cost of Comms network** (Datalink)]*, where:

- ***Cost of Server & SW*** = Cost of [acquisition + installation + configuration + testing and certification to applicable standards + operational deployment]
- ***Cost of communications network*** *(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.

It is assumed that costs for implementation of the ***Supervisor Planning Tool*** equipment in a *Small* or *Other* aerodrome OE (RTC) have to be considered for two enablers, one operational and one for back-up (*source: Stakeholder Judgement*).

RTC *- Small - Other OEs* (***Source****: Stakeholder Judgement*)

Item	Unlikely <€K	Median €K	Unlikely >€K
Server & SW	***25***	***50***	***100***
Comms Network	***3***	***5***	***10***
Total	***28***	***55***	***110***

- ***Training for ATCOs***: the number of Tower Controllers allocated in a RTC is based on an analysis of the number of MRTMs there allocated and on the other operational positions (ATCO Supervisor and probably ATCO Coordinator position) that are necessary to manage the Operational Scenario.

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Considering a presence per shift (*Morning-Afternoon/Night*) of **5/5/3 ATCOs** (2 in operational position, 2 reliefs, 1 coordinator/ Supervisor), we can define that a *Remote Tower Center* with a similar *layout quantifies 35/40 ATCOs on average assigned and qualified to be able to operate.*

It is assumed to cover the ***Initial Training Section*** comprises ***5 days*** in the remote training facility (a theoretical session of ***2 hours for the first 3 days*** and the rest of the ***5 hours with practical exercises*** into the training facility) while the remaining ***2 days On-Job Training*** in the RTC, with 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 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 **5** (*source: Stakeholder Judgement*)
  - ✓ cost of training day, based on ***3 trainers*** (supporting theory, simulation runs and ATCO guidance) + simulation facility + materials.
  - ✓ Therefore, ***Total Cost of training course*** could be quantified between €**11*.5K*** and €***19K*** with a median value of €***15.25K***

- ***# of Courses*** *= [# ATCOs / # of ATCOs at each training session],* where***:***
  - ✓ # ATCOs is ***40*** for ***RTC*** – *Small - Other OEs* (*source: Stakeholder Judgement*)
  - ✓ # of ATCOs at each ***training course*** is ***5*** (*source: Stakeholder Judgement*)
  - ✓ Therefore, ***# of Courses*** is ***8*** for ***RTC*** – *Small - Other OEs*.

- ***Cost of an ATCO attendance*** *= **[# ATCO training days * # ATCO Hours/Day * ATCO cost/hour (=€127)],*** where:
  - ✓ # of ATCO training days is **5** (*source: Stakeholder Judgement*)
  - ✓ # of ATCO Hours/Day is **8** (*source: SESAR common assumptions*)
  - ✓ ATCO cost/hour is **€127** (*source: 2024 projection based on EUROCONTROL, ATM Cost Effectiveness benchmarking (ACE) report 2019 with 2019-2022 outlook*
  - ✓ Therefore, Cost of an ATCO attendance is **€5.1 K**

- ***# of ATCOs in RTC=*** 40 as maximum.

***RTC** - Small - Other OEs (**Source**: Stakeholder Judgement)*

Item	Unlikely <€K	Median €K	Unlikely >€K
Cost of Training Session	***92***	***122***	***153***
Cost of ATCO Attendance	***155***	***205***	***255***
Total	***247***	***327***	***408***

- Project management, update of local manuals and procedures, certification and validation and general administration in relation to the of the Supervisor Planning Tool equipment in an RTC.

Regarding ***Certification*** and ***Validation*** aspects it is estimated, based on similar activities in the past, that this would be equivalent of 2 Administrative staff over a period of 2 weeks (i.e., a total of 10 working days/person). 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 Admin staff/hour is **€64**
- ✓ # of hours/day is **8**
- ✓ # of days is **5**
- ✓ # of Admin Staff is **2**

The median cost of Certification/Validation is, therefore, between ***€8K*** and ***€12K*** with a median value of ***€10K***.

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 and general administration one-off costs. The quantified assessment amounts to ***20 working days of operational staff time*** for PM and manuals/procedures updates, equivalent of 2 Administrative staff over a period of 2 weeks (i.e., a total of 10 working days/person).

***RTC** – Small - Other OEs (**Source**: Stakeholder Judgement)*

Item	Unlikely <€K	Median €K	Unlikely >€K
PM, Documentation, Admin	***16***	***20***	***24***
Certification/Validation	***8***	***10***	***12***
Total	***24***	***30***	***36***

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In summary, the estimated One-Off costs for Solution 35 are shown in the following table.

Cost Item	Short description	Median Cost (EUR)	Source
RTC – ***Small – Other OEs***			
Training	All the training and staff costs related to the use of A/VR	327,000€	Stakeholder judgement
Administrative costs	All the administrative costs related to the acquisition, installation, configuration and testing of A/VR devices and associated functions	30,000€	Stakeholder judgement, SESAR common assumptions and standard references
Infrastructure Installation & Commissioning	Installation and configuration costs. Initial Test and evaluation	55K * 2 Supervisor Planning Tool 110,000€	Stakeholder judgement
TOTAL		**467,000€**	

Table 7: Implementing costs

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Operating costs:

- ***Device and infrastructure replacement***.
  It is assumed that:
  - ✓ the ***infrastructure equipment will be replaced on 5-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 updates and patches etc.*** throughout the ***5-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:*
*[(**Cost of Server & SW**)] + [**Cost of Comms network** (Datalink)] * [(**2 life-cycle times**) ***1.20**]*,
and the final value will be divided per 10, 2 life-cycle periods of 5 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 = 5 years &*** increasement of costs estimated of ***20%*** at 2040

RTC *– Small - Other OEs* (***Source****: Stakeholder Judgement*)

Item	Unlikely <€K	Median €K	Unlikely >€K
Server & SW	***60***	***120***	***240***
Comms Network	***7.2***	***12***	***24***
Total	***67.2***	***132***	***264***
Annual value	***6.7***	***13.2***	***26.4***

- The **Training (recurrent) covering updates to functionality etc.** It is not envisaged that ad hoc training cycles and/or dedicated recurrent training courses are planned 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 Supervisor Planning Tool.

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In summary, the estimated ***Operating Costs*** per ***YEAR*** after the ***IOC*** calculated for ***Solution 35*** are shown in the following table.

Cost Item	Short description	Median Cost (EUR)	Source
Replacement Infrastructure Installation & Commissioning	***5-year replacement*** Installation and configuration costs, *after the IOC*	13,200€	Stakeholder judgement
TOTAL	Annual ***5-year*** replace	13,200€	

Table 8: Operating costs

5.1.2 Number of investment instances (units)

Airport				TMA			ACC		
HC	HS	LC	LS	H	M	L	H	M	L
…	…	94	266[4]	N/A	N/A	N/A	N/A	N/A	N/A

Table 9: Number of investment instances – ANSPs

5.1.3 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	1,318 M EUR	3,729 M EUR	N/A	N/A	N/A	N/A	N/A	N/A
Operating costs	N/A	N/A	0,744 M EUR	2,107 M EUR	N/A	N/A	N/A	N/A	N/A	N/A

Table 10: Cost per Unit - ANSP

5.2 Other relevant stakeholders

N/A

[4] Considering those Airports that will count more than 5000 movements per year only (PJ20 OE's Classification Scheme)

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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.

For the scope of SOL 35, it is assumed that the RTC (and the MRTMs located inside to manage the traffic for the associated remoted airports) is located within the ANSP facilities. And so, for the scope of SOL 35, no further expenses are required/counted to provide for some building or facilities where to host/display the RTC in the implementation costs.

For the same reason, no additional technology costs (types of equipment, surveillance displays, update or improve the existing equipment, cost of communication infrastructure, other costs depending on local circumstances) have been evaluated or counted because they have already been considered within the previous Project of SESAR 1.

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

- Inputs:
    - Costs: which includes the Implementation investments managed by the Stakeholders before the implementation of the Solution's SDM and the Operating costs that will incur after the FOC;
    - 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 2021 Validation Targets assigned to PJ.05-SOL35 by PJ19.04.
- Outputs:
    - NPV: the difference between the present value of cash inflows and the present value of cash outflows over a reference period
    - BCR: summarize the overall relationship between the relative costs and benefits of the Solution's SDM
    - PP: the amount of time it takes to recover the cost of the investment.

In the following figure the approach adopted is presented.

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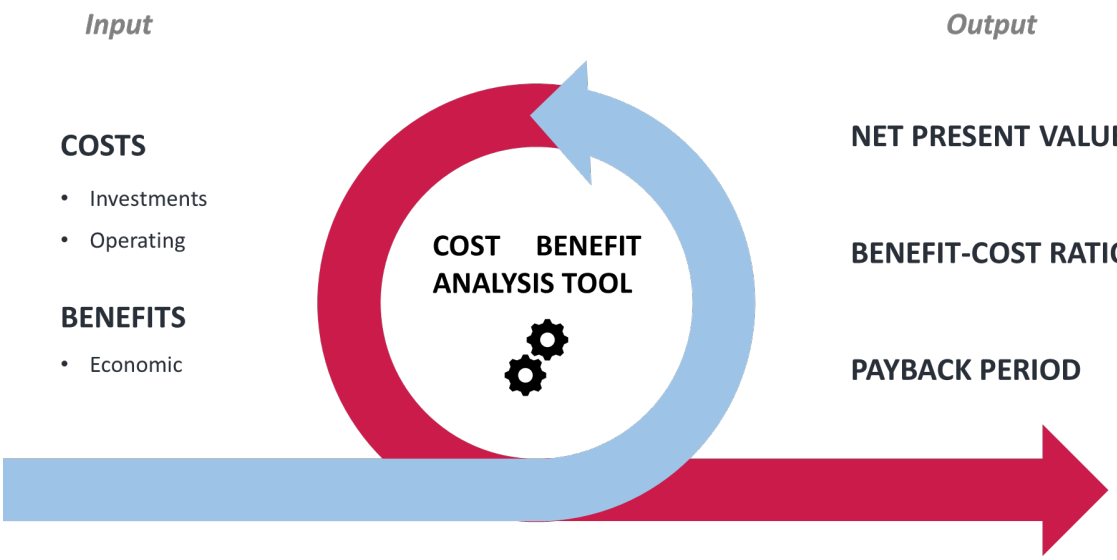

Figure 3: CBA model

The nature of the above listed outputs is both qualitative and quantitative. This implies an impossibility to generate an output value measurable with precision, also counting the impossibility to identify a single 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 deliverables from SESAR 2020-Wave 1 – PJ05.02 V3 CBA & PJ05.03 V2 CBA
2. Airport OE Dataset, PJ20
3. Standard Inputs used in the development of previous Cost Benefit Analyses related to ATM operational improvements
4. CBA Algorithm used for SESAR's CBA & Eurocontrol Methodology Handbooks
5. ANSP and Industry internal resources - experts from Finance, Operational & Technical departments in cooperation with industrial partner experts' contributions
6. DDR2 & STATFOR for traffic information & NM Standard Inputs for CBA for Cost value information

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7 CBA Results

This Section presents the financial results of the PJ.05-W2-35 CBA at V3 Level.

At the current stage, the results are based on the inputs extracted from the CBA algorithm report, from the preliminary information shown in the OSED and the final consideration listed in the VALR, taking in consideration the assumption previously stated.

This CBA leverages on main pillars, defining the main scope of the assessment:

- The impact of Solution in terms of benefits and costs have been estimated considering the implementation from the Reference to Solution Scenarios, thus excluding the implementation Costs already counted and considered in any other Solution in SESAR 1. In fact, the "economic effort" that is necessary for each ANSP in ECAC to "remote" the Control Tower have been considered in the previous Solutions. It is essential to ignore these costs in order to avoid any double counting.
- By looking at the quantified benefits related to the Cost optimization, main benefits are consequent to the new vison of the ATCOs' allocation within the RTC and the MRTMs.
  The ATCO's staff costs saving, that quantifies the reduced costs from the standard "2 ATCOs need as standard" per "physical/remoted Control Tower" to the new "needs" requested for the MRTM with the highly flexible allocation of aerodromes to MRTMs, linked with the associated increment of the Flights handled per ATCO/Hour on duty (CEF2 KPI), all those identify the quantitative economic benefit values at local/standalone deployment.
- For the scope of this CBA, other benefits have been considered as qualitative only.
  Obviously all above without any reduction and by maintaining the same high levels of Safety and Security of Operation that remain paramount, by increasing the associated and collaterally Resilience benefits in terms of avoided costs due to cancellations, diversions, delays, loss of ANS and airport charges with an extended availability of the ATC Services on the Remoted Airports from the previous H18 to H24/7.

This CBA Excel Table and the Deliverable describe the annual costs, benefits and cash flow from the perspective of the stakeholders impacted by the solution's implementation, in the specific use case the ANSP as first but AUs and Airport Authorities too.

CBA results are detailed within the following lines/paragraphs, showing the annual evolution of Costs and Benefits leading to the creation of the cumulated NPV, presenting the quantified benefits and assumed costs impacted by the solution.

Following Tables and Pictures provide an overall view of Costs and Benefits foreseen for the implementation of the OI of the Solution, in a cumulative perspective and per year too.

Starting from the following Tables, there are shown discounted benefits, discounted costs and cumulative cash flow for the remote ATS. Air Traffic Services provided for multiple aerodromes (4 aerodromes for this study) by a RTC (Remote Tower Centre) with the associated MRTMs with highly flexible allocation functionality (in case of a standalone deployment), management supported also and with the associated new enabler so called Supervisor Planning Tool.

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The Table below represents the outputs of the CBA.

PJ.05-W2.35 RTC with MRTMs and flexible allocation of aerodromes to MRTMs supported by SPT (4 aerodromes) standalone deployment	NPV	Benefit-Cost ratio	Payback period
	8,881 M EUR	3,30	4,02 years

11. Table The outputs of the CBA standalone deployment

PJ.05-W2.35 RTC with MRTMs and flexible allocation of aerodromes to MRTMs supported by SPT (4 aerodromes) standalone deployment	Costs (discounted)	Costs (undiscounted)	Benefits (discounted)	Benefits (undiscounted)
	3,857 M EUR	7,898 M EUR	12,738 M EUR	32,136 M EUR

12. Table The inputs of the CBA standalone deployment

As it is evidenced in the figure above, the cash flows are discounted back to 2022 and they involve the cash-flows assumed to occur from **2023 (start of deployment) to 2043** (end date of the CBA's timeframe for the SESAR 2020 Wave 2's specifications).

The **2023-2027** is the period of time assumed as the investment period.
The output coming from the analysis conducted with the assumptions made in the above paragraphs, considering the scope of SDM-0210 - "*Highly Flexible Allocation of Aerodromes to Remote Tower Modules and parallelly the introduction of a special enabler that will be handled by the figure of the ATCO Supervisor, so defined Supervisor Planning tool that have to support the ATCO Supervisor to allow the best option for allocating the traffic to the MRTMs, based on the actual operational scenario"*.

The benefits start to be counted **in 2024,** when the RTC and the Operational Concept of the highly flexible allocation of aerodromes to MRTMs will start to be be deployed by some ANSPs, depending on the ANSP' Implementation Programme.
The Costs presented in the Tables 8 "The inputs of the CBA standalone deployment" are related to the implementation of the technology linked to PJ.05.W2-35.

From **2024 to 2027**, Benefits are clearly visible increasing year by year, while Cost Savings decrease parallelly of the RAMP-UP over time, because not all the ANSPs will be able to implement at the same time all the "systems" especially at ECAC Level.
Then **from 2028**, it was considered that the Solution (and the operational scope associated) will be totally/fully operational, so there will be realized on total the monetized benefits to the final period (2040).

The Net Present Value of the benefits is **8,881 M€ over 22 years (from 2022 to 2043).**
The overall Cost (discounted) is 3,857 M€.

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The overall undiscounted Cost value (without considering the time value of the money, that means as considering one unit of currency spent or received in 2043 to have the same value as one unit of currency spent or received at the daily time) **has been calculated in 7,898 M€**
A benefit to cost ratio of 3,30 has been calculated, while the payback period is assumed to 4,02 years (calculated from the start of deployment).

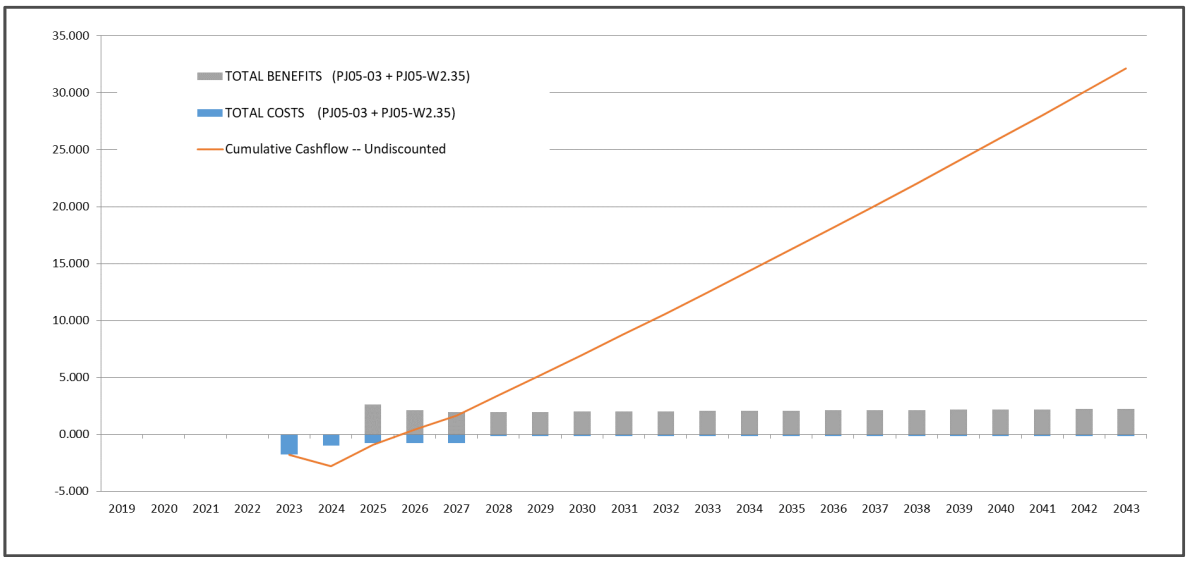

Figure 4: Remotely provided ATS for Multiple Aerodromes from RTC (undiscounted)

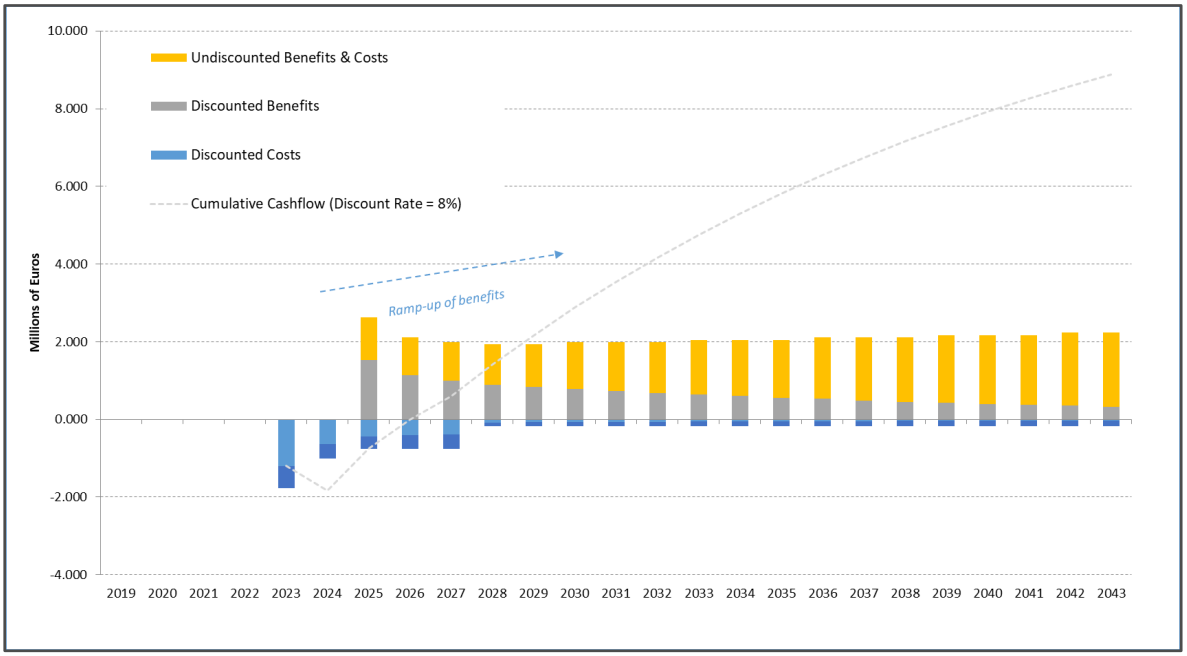

Figure 5: Remotely provided ATS for Multiple Aerodromes from RTC (discount rate= 8%)

As above introduced, we can consider, parallely with the improvement consequent of the ATCO's staff optimizzation, the ***CEF2 improvement***.

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Having assumed that the number of Airport within the RTC will remain the same, as well as the amount of traffic counted on the same OEs (Small & Others Airport categories), what we can propose (then following the details within the Sensitive Analysis' paragraph) is a quick view of the expected benefits coming from the CEF2 improvement (# of aircraft handled by ATCO/hour) consequent of the reduction of ATCOs associated with the MRTMs within the RTC, considering also the new availability of the ATS ***H24/7***.

By looking at the numbers, the ***CEF2*** can be considered increased by ***45,83%***, going from ***0,551 AC/hours to 1,018 AC/hours*** handled by one ATCO on duty within the RTC vs the Reference Scenario.

Then, completed the definition of results at Local Level, the output will be focused at ECAC level, as requested by SESAR for the scope of the Master Plan and PAGAR.

Solution OI steps have defined as applicable for Small and Other aerodromes (classification defined by "OE's categories of airports" in the PJ20 WP2.2 Operating Environment).

The Solution assumed to be applicable for airports, similar to the ones taken in account for the previous Solution of this SESAR 2020 - Wave1, with the following scenario's characteristics, considering the standards within the OSED:

- 20 to 30 movements (air and ground) per day, as peak of traffic, in total for all airports to be involved in the RTC at all (4 aerodromes)
- airports with minimum runway and taxiway system
- primarily for airports with one runway, but not exclusively
- classification at National/ECAC level as Regional (in any case, NO Large or Very Large or Medium classified Airports)

As it was set, within the above paragraphs, that only those aerodromes with current ATS service available (ATCOs physically within the Control Tower displayed at the Airport or ATCO assigned to the RT within the RTC) are considered for the scope of the current analysis.

It is assumed that 360 aerodromes are operated with ATC Services, both from Local and/or Remote, before deploying the Solution.

Considering these parameters (in particular the maximum of 20 to 30 movements per day for all airports associated within a RTC, where only four airports are assumed to be integrated because of the "assumptions" made for this Solution), it is assumed that airports over approximately 40.000 annual movements are not to be applicable for the scope of this Solution.

According to the Airport OE Dataset provided airports' classification results based on SESAR 2020 PJ20 classification scheme of OEs and Sub-OEs in ECAC Countries, as reported above, approximately 360 aerodromes[5] which may apply for multiple Remote Tower operations benefits and them are aggregated at ECAC level by assuming there will exist 90 RTC based in associated ANSP's buildings. It

[5] Based on PJ20 OE's classification scheme, 94 Small OE Aerodromes and almost 266 Other OE Aerodromes will be elected to be considered for the extrapolation from Local to ECAC Level (the ones that, in 2043, will count more that 5000 movements per year – classifies from Cluster 2 to Cluster 5).

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is also assumed, for the scope of the Solution – one more time - that there are #_6 RTC per each of the 15 Countries, each controlling 4 aerodromes as standard (due to requirements of the Solution), and so 360 aerodromes in total only.

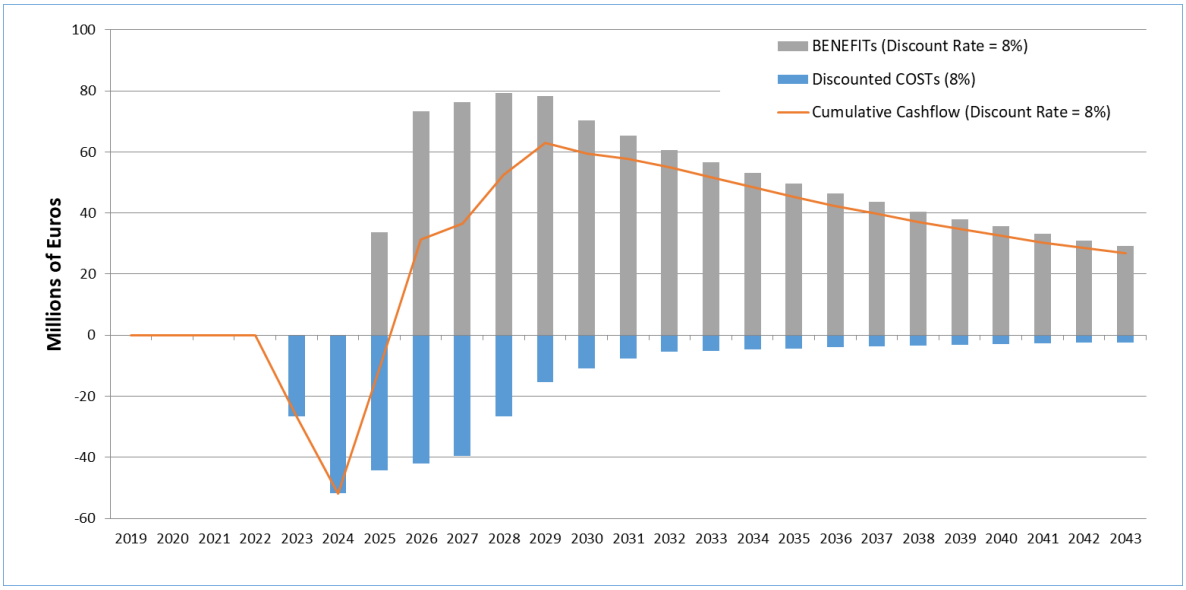
The deployment of the 90 RTC is spread over the deployment period taken from the timeline of the relevant operational improvement steps; as defined in the Assumptions, each ANSP of ECAC will define its own deployment plan.

Benefits are realised starting from the Investments done, based on their Implementation Programme, by each of the ANSPs.

The 2023-2027 timeline is assumed as the investment period also at ECAC level, as the deployment of the different ANSPs/RTC is spread over the deployment period depending on their Planning.
The starting date of the ECAC level deployment is assumed within the 2023, in accordance with the Solution's Deployment phase.

Benefits will be counted in % from the first year following the first implementation on the RTC and will be fully considered at 100% from 2028.

The following Figure shows the discounted benefits, the discounted costs and the cumulative cash flow for the provision of ATS from RTC with MRTMs and highly flexible allocation functionality considering the ECAC level deployment.



6. Figure CBA results on ECAC level deployment

The Tables below represent the outputs of the CBA on ECAC level.

Remote tower centres with highly flexible allocation of aerodromes to MRTMs – ECAC level deployment	NPV	Benefit-Cost ratio	Payback period
	684.4 M EUR	3.21	5.40 years

13. Table The outputs of the CBA ECAC level deployment

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Remote tower centres with highly flexible allocation of aerodromes to MRTMs – ECAC level deployment	Costs (discounted)	Costs (undiscounted)	Benefits (discounted)	Benefits (undiscounted)
	309.0M EUR	687.7 M EUR	993.4 M EUR	3,313.8 M EUR

14. Table The inputs of the CBA ECAC level deployment

As it can be seen in the figure above, the cash flows are discounted back to 2022 and they involve the cash-flows assumed to occur from **2023** (start of deployments) to 2043 (end date of the CBA's timeframe).

CBA 35.xlsx

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8 Sensitivity and risk analysis

Sensitivity analysis is a systematic method for examining how the outcome of cost-benefit analysis changes with the variation of inputs, assumptions, or the way the analysis is set up.

Sensitive Analysis is used to evaluate how sensitive the output variable is while changing the input in one of the variables while other input variables remain unchanged.

It is normally used in capital budgeting decisions to access how the change in such inputs will affect such outputs as Net Present Value (NPV) of the project or Discounted Payback Period and others and it also provides a better understanding of the economic and financial risks associated with a project.

The aim is to define the sensitivity of the project's economic performance compared with the variation of individual parameters to identify the most critical issues.

Once established the validity of the definition, we can observe how the relative range values change per each indicator and which will be the associated expected values linked with the maximum/minimum changes indicated into the percentage scale.

At the end, a new value with a so called "pessimistic case" will be released, recalculated considering the combination of the worst case with the highest costs and the lower benefits.

To set the scene of this Sensitive Analysis, given the assumptions made for the Solution and also the fact that the process to implement some RTs and some RTCs in ECAC are already in progress, the Risk Analysis has not been performed for this V3 CBA.

The reason is within the characteristics of that Risk Analysis itself, that is based on the Monte Carlo simulation technique to calculate the NPV results by analyzing thousands of scenarios, starting from a DO-NOTHING Scenario (that is not possible anymore for SOL 35) to the fully implementation of the process.

The results of a Sensitivity Analysis are presented both graphically and within some Tables.

Variables have been varied as follows:

- ✓ Implementation and Operating Costs has been recalculated considering a range of variation between +/-25% (assumptions),
- ✓ Discount Rate has been considered between a range from 0% to 8% as maximum, considering those % only below the reference of 8%, due to inconsistence values for the scope for higher %, also in order to present the result using the discount rate of Standard Inputs for EUROCONTROL Cost Benefit Analyses,
- ✓ in case of other variables, +/-50% for the high and low scenarios (traffic increment from the actual of 2019 – worst scenario Do Nothing – to the one forecasted by STATFOR in 2043 as 50% more of 2019 one).

The NPV for the base case is ***8,881 million of Euros***, as presented within the Tables at Para 7.

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Then, starting from that amount, some differences might be proposed with the aim to validate the economic feasibility.

The first value that is considered is the impact of the Discount Rate (the time value of the money, as considering the value of currency spent or received at the end of the reference period, for this use case it is established in 2043, compared with the actual value).

Starting from the assumption made by Eurocontrol within the Standard Inputs for EUROCONTROL Cost-Benefit Analyses, the reference value for the Discount Rate is 8% that is also the value used within the algorithm of the calculation of the NPV.

Due to the base/reference value that can be considered as the maximum for the reference timeline, only lower values of Discount Rate are considered for the sensitive analysis.

And the values are presented within the following Table.

Discount Rate	NPV in M€
8%	8,881
6%	12,024
4%	16,468
2%	22,844
0%	32,136

When modifying the other parameters, depending on the variations introduced to the input values, that will change the final ***base NPV*** as shown in the Tornado Diagram here below.

The ***NPV*** fluctuates between the range of variation (%) already defined per each of the Cost inputs; and even if the up-to-date NPV *is often more than 1 M€* when compared from the minimum to the maximum range of variation, for all the considered cases the new values obtained will validate the economic concept that the benefits provided by the implementation of the OI of the Solution (*Dynamic allocation of the aerodromes to the MRTMs, supported by the Supervisor Planning Tool*) will produce economic benefits (*ROI - Return Of Investment*) that is fully in line with the base value (*Base NPV*) of the ANSP.

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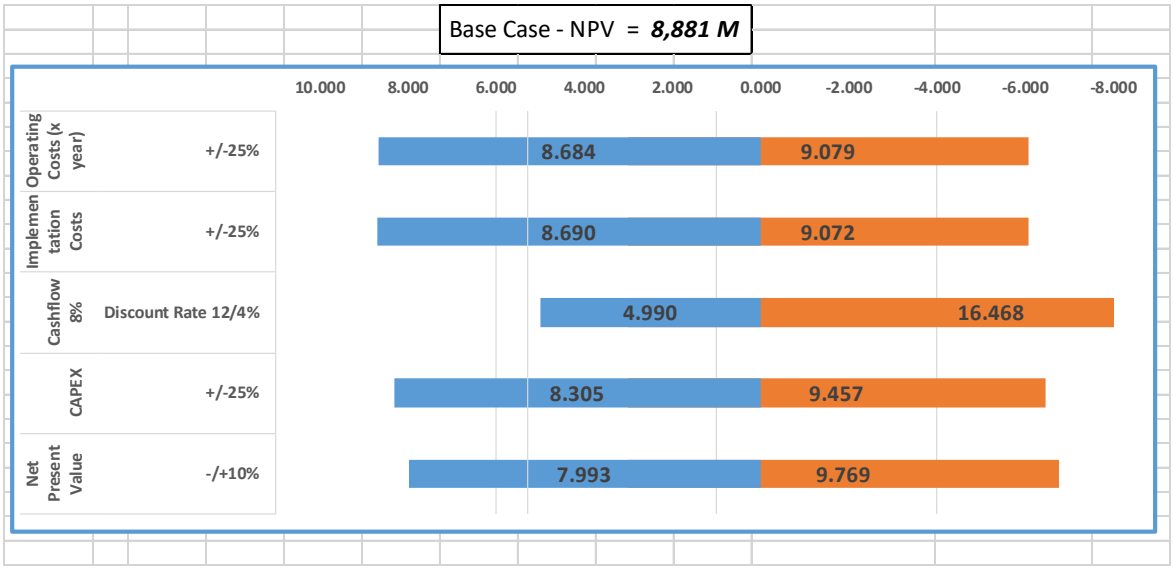

Figure 7: Net Present Value Variation

The pictures above, with the variations of the NPV, is the demonstration that the big impact in terms of economic benefits and in terms of Cost reduction is represented by the *ATCO staffing optimization,* when compared with all the other cost categories. And it presumes and represents the real very important benefit particularly looking at the representation of the benefits of the CEF2 KPI, the ATCO Productivity referred to the number of aircraft handled per ATCO/hour (see table below).

The Tables below present the CEF2 output, starting from the actual representation of the Reference Scenario (H16-18/7) compared with the evolution within the Solution Scenario (H24/7), with parallelly the forecast traffic evolution based on the STATFOR values of increment of traffic in ECAC (till 2043) and the additional aggregation of new RTs (from the actual 4 to the final 8) within the RTC.

It is possible to observe how the ATCO Productivity will increase till the 50% more than the actual situation thanks to the ATCO Staffing optimization within the RTC, operational concept based on the assumption associated to the Solution 35.

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CEF2 - #AC x ATCO/Hour (h24) - assumption based on h18

Year	4 RT	6 RT	8 RT
2019	0.476	0.476	0.476
2025	0.551	0.551	0.551
2030	0.605	0.605	0.605
2035	0.659	0.659	0.659
2040	0.713	0.713	0.713

CEF2 - Increment Rate

4 RT	6 RT	8 RT
45.83%	48.61%	50.00%

CEF2 - #AC handled x ATCO x Hour (h24)

Year	4 RT	6 RT	8 RT
2019	0.878	0.926	0.951
2025	1.018	1.073	1.102
2030	1.117	1.178	1.210
2035	1.217	1.283	1.318
2040	1.317	1.388	1.426

Figure 8: CEF2 Variation

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9 Recommendations and next steps

As widely documented in the previous paragraphs, the economic evaluations (both Costs and Benefits) that have been analyzed have highlighted both the operational feasibility of the assigned OI (Dynamic Allocations on MRTMs supported by the Supervisor Planning Tool) and the economic feasibility of the Solution realization.

With regard to the Operational Feasibility, reference can be found in the other Deliverables of the Solution such as OSED and VALR, while this Deliverable simply concretizes the Economic analysis and conclusions following the computations of the Costs which have been assessed to implement the Solution's OI and the related Benefits (in this contest by analyzing the reduction of Costs due to the implementations of the Operational and Technological Enablers).

The level of confidence for the outputs obtained by the CBA have been set as "HIGH", mainly because the main Operational and Technological concepts have both already been tested and economically evaluated by the previous Solutions and by the CBAs in Wave 1.

The concept of the reduction of the ATCO's staff on duty, as main input within the CBA Benefit Model, came from expert views by analysing the results of the Previous validations (Wave 1 Solution deployment): the PJ05-W2.35 deployment is directly linked to the increasing of the ATCO productivity by optimizing the ATCO's allocation within the new Operational Premises (RTC staffing and Workload optimization).

Reduction of the units of ATCOs on duty enables a reduction of numbers of ATCOs from a standard Control Tower to the RTC, going to 2 ATCOs per shift due to the OE where the Solution is deployed – Small/Others classification plus transitioning the Operational Activity from a H18/7 to H24/7. This implies ATCO workload increases and the number of flights that can be managed by the controller per hour on duty may vary differently.

The above assessment is applicable even if for the scope of this Solution the number of flights controlled on an airport won't be considered during the 20 years of the CBA's timeframe, neither as incremented due to the estimation of the STATFOR Long Term forecast, neither as the same number of flights "counted" on H24 timeline instead of to be concentrated in H18.

The incoming next steps following this V3 activity should confirm these performance estimations (both on Economical and Operational basis) that have been validated several times and already implemented in various operational realities in ECAC, even if not with the same "standards".

It is also necessary, as one of the first actions, to assess the quantity (numbers) of flights managed by one ATCO per hour on duty, depending on the local circumstances per airport. This action is recommended and underlined due to the concept's development of dynamical allocation of Airport's Services to the MRTM and the consideration that part of those ATC services might be delegated to different MRTM too.

This will be possible assessing a new Operational Standards supported and managed by the new figure of the ATCO Supervisor, where the new "Practices" related to the rostering and the shift management will be defined in detail also considering the Local deployment of the RTC, and in accordance with the Safety and the HP' methodology and regulations,

So, having in mind that the ATCO's staff cost savings is very sensitive in this CBA's analysis, it is mandatory that the correct balance of ATCO Productivity with the ATCO Workload and the level of Safety have to be maintained and issued as a standard within the Deployment.

Before concluding and formalizing the recommendations for the continuation of the R&D phase, stemming from the positive results described in the Solution Deliverables, it is paramount to underline and formalize that the optimization of the ATCO figure considered in the Solution is not intended to address neither the reduction of the number of ATCOs nor their possible "disposal" and therefore consequently the loss of the job.

A misleading conclusion of optimization of the number of ATCOs enabled by Remote Tower Project, could be the possibility of obtaining economic benefits from the reduction of personnel in the RT compared to traditional TWR. In addition to not being the purpose of the implementation of the RT Project, the optimization of the number of ATCOs to be used in the RTC does not respond in any way to what is described and demonstrated in the previous paragraphs, as well as analyzed for the definition of the Costs and Benefits that the SOLution.

By simply analyzing the extension of the availability of ATC services that will pass from H16/H18 to H24/7 for the airports associated with the RTC, it can be easily defined that the need for the number of ATCOs, even if reduced compared to the Reference for a single shift, will be maintained in the overall numbers for the operating personnel assigned to the RTC for the need to cover the cyclicality of the roster H24/7.

Furthermore, in the event that some of the ATCOs that were previously employed in the Control Towers located on the airport wish to be employed at an airport classified as Medium or above or at a Terminal Area or an ACC, certainly the ANSP which always needs to have both a replacement of resources and a professional advancement of its leading professionals will not deny ATCO itself to be able to move towards new perspectives (concept of reabsorption of any ATCOs at other ANSP operating structures already described in the previous paragraphs) and thus obtaining professional advancements for the benefit of both the worker and the employer.

Downstream of this, it can be stated, pending the conclusions of this study, that none of the KPIs assigned to Solution 35 have been defined to evaluate or quantify the benefits that could be obtained from the reduction of ATCO personnel.

Concluding, the results of the CBA validate from the economic point of view all developed concepts and supporting enablers (operational aspects and conditions, standards and procedures, technology, safety and human performance aspects), that can work consistently both at Local level as well as at ECAC level and be capable of delivering the required benefits with the same "metrics and methodology".

10 References and Applicable Documents

10.1Applicable Documents

1. SESAR JU, Methods to Assess Costs and Monetise Benefits for CBAs, Edition 00.02.02.
2. SESAR 2020 Cost-Benefit Analysis Model
3. Standard Inputs for EUROCONTROL Cost Benefit Analyses (Edition Number: 9.0, Edition date: December 2020)
4. ATM CBA Quality checklist, Edition 02.00.01
5. PJ19_04_D4_4 Performance Framework_ v00_00_11 (2022) Template Edition 02.00.02
6. D4_0_30-PJ19-SESAR2020_Common Assumptions_2019 (1_0)
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10.2 Reference Documents

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[2] Guidelines for Producing Benefit and Impact Mechanisms, Edition 03.00.01;

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[4] SESAR 2020 – PJ19: EATMA Guidance Material and Report (2018), Edition 01.00.02, 11 March 2019

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

[6] STELLAR SJU Coordination Group – ATM Performance Assessment (APA) [www.stellar.sesarju.eu]

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11 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

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

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

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