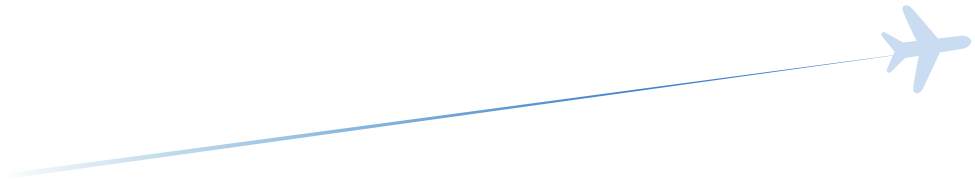

[SESAR SOLUTION XX: COST BENEFIT ANALYSIS (CBA) FOR VX]

Deliverable ID:	**D2.2.005**
Dissemination Level:	**PU**
Project Acronym:	**Multiple Remote Tower**
Grant:	**730195**
Call:	**H2020-SESAR-2015-2**
Topic:	**Remote Tower for Multiple Airports**
Consortium coordinator:	**DLR, AT-One**
Edition date:	**29 October 2019**
Edition:	**00.00.04**
Template Edition:	**02.00.01**

Founding Members

EUROPEAN UNION EUROCONTROL

SESAR JOINT UNDERTAKING

Authoring & Approval

Authors of the document

Name/Beneficiary	Position/Title	Date
Giedre Balciuniene / ans	PJ.05.02. CBA lead	2019-10-29
Adam Szollosi, HC	PJ.05-03. CBA lead	2019-10-29
László Horváth, HC	PJ.05-03. Finance expert	2019-10-29
Marcus Filipp, LFV COOPANS	Solution lead PJ.05.02	2019-10-29

Reviewers internal to the project

Name/Beneficiary	Position/Title	Date
Lindsey Martenez Hermosilla / COOPANS, LFV	Project lead, COOPANS	2019-10-31
Kirsteen Purves	Project member	2019-10-31
Sonia Pastore	Project member	2019-10-31
Tomas Tamašauskas	PJ.05.02 CBA lead	2019-10-31
Jörn Jakobi / DLR	Project Leader PJ05	25/07/2019
Marcus Fillip / COOPANS	Solution Leader PJ05.02	25/07/2019
Rainer Kaufhold / DFS	Solution Leader PJ05.03	25/07/2019
Guillaume Assire / ECTL	Project Member – POC Eurocontrol	25/07/2019
SZÖLLŐSI Ádám / Hungarocontrol	Project Member – POC Hungarocontrol	25/07/2019
Patrizia.Criscuolo / ENAV	Project Member – POC ENAV	25/07/2019
Martin Hasselknippe / INDRA	Project Member – POC INDRA	25/07/2019
Michael Ellinger / Frequentis	Project Member – POC FREQUENTIS	25/07/2019
Bengt-Arne Skoog / NATMIG (Saab)	Project Member – POC NATMIG	25/07/2019
Laszlo Horvath / Hungarocontrol	Project Member – Expert CBA	25/07/2019
Tord Pola / NATMIG(Saab)	Project Member – Expert Systems	25/07/2019
Fuentes De Frutos, Pablo / INDRA	Project Member – Expert Systems	25/07/2019

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

Name/Beneficiary	Position/Title	Date
Jörn Jakobi	Project coordinator	2019-10-31
Marcus Filipp / COOPANS (LFV)	Solution lead – 02	2019-10-31

Rainer Kaufhold / DFS	Solution lead – 03	2019-10-31
Lindsey Martenez Hermosilla / COOPANS, LFV	Project member	2019-10-31
Cristina Morales / Indra	Project member	2019-10-31
Peter Kantor / HC	Project member	2019-10-31
Vidor Czvedler / B4	Project member	2019-10-31
Mariacarmela Supino / Teknosky	Project member	2019-10-31
Giulaume Assire/Eurocontrol	Project member	2019-10-31
Marco Gibellini/Eurocontrol	Project member	2019-10-31
Laura Cafiero / ENAV	Project Member	2019-10-31
Michael Ellinger / Frequentis	Project Member	2019-10-31

Rejected By - Representatives of beneficiaries involved in the project

Name/Beneficiary	Position/Title	Date

Document History

Edition	Date	Status	Author	Justification
00.00.01	19/04/2019			First CBA draft
00.00.01	09/05/2019			Updated CBA draft
00.00.02	20/06/2019			Updated CBA draft
00.00.03	04/07/2019			Updated CBA
00.00.04	29/10/2019			Updated CBA by SJU comments

Copyright Statement

Multiple Remote Tower

This Cost Benefit Analysis is part of a project that has received funding from the SESAR Joint Undertaking under grant agreement No 730195 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 and where needed, enabled by digital solutions replacing the physical presence of controllers and control towers at aerodromes.

Remotely Provided Air Traffic Service for Multiple Aerodromes (1 ATCO controlling up to three aerodromes) and development of the Remote Tower Centre are 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) relating to the Multiple Remote Tower development of the SESAR operational concept.

The main driver for PJ.05.02 is increased cost efficiency.

The OI steps that are addressed are:

- SDM-0207: Multiple Remote Tower Module, MRTM (for up to 3 airports) for PJ.05.02 solution

Table of Contents

List of Tables

List of Figures

1 Executive Summary

This document provides the Cost Benefit Analysis (CBA) related to SESAR Solution PJ05-02 that has been validated during validation activities at a V3 level.

The CBA aims to provide results at ECAC level about the economic and financial viability of deploying PJ05 Solution 02 at European scale. Therefore, it will not provide sufficient detail to fully support individual deployment decisions that must take into account local environment/situation (e.g. lifespan of equipment, replacement timing, etc.). Rather, interested parties can take the mechanisms and inputs used at ECAC level and reference, refine and review them for their local CBAs.

The objective of the CBA for PJ.05-02 is to calculate cost and benefits of a Multiple Remote Tower Module (MRTM) that allows the Air Traffic Control Officer (ATCO) to deliver requested Air Traffic Service (ATS) for two or three airports simultaneously, taking into account that Single Remote Tower module have already been deployed at the considered ECAC locations.

The CBA is calculated for the period – 2019-2040. The period was chosen according to recommendations of the Common Assumption Document.

The CBA showed that providing ATS to two or three aerodromes simultaneously from MRTM generates a positive Net Present Value (NPV) and costs are decreasing compared with Single Remote Tower.

It has been estimated that the implementation of the Solution at ECAC level would generate a Net Present Value amounting to 60 million €, with a 12 - year payback period. Such Net Present Value is derived considering an overall investment cost of 107 million € undertaken by the involved stakeholders and benefits amounting to 172 million € over the considered period. In to Solution involved stakeholders are only ANSPs due to Airport investments for infrastructure are assumed to have already taken place for the Single Remote Tower option and therefore not included here. The main benefit is that ANSPs can handle traffic at multiple airports with fewer ATCOs.

Economic and technical assumptions are described in the document in order 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 PJ05-02 that has been validated during validation activities at a V3 level.

The CBA is assessing the affordability of the solution with respect to its expected benefits.

- Cost refers to the monetary value of the investment that is used up to produce or acquire the benefit.
- Benefit refers to the positive value of the return on investment to (some of all) stakeholders.

The focus of the CBA in V3 is to review data and update mechanisms and values. In this phase the net present value (NPV) results indicated in V2 are reviewed and updated.

2.2 Scope

The CBA for SESAR PJ05 solution 02 was calculated between 2019-2040. The period was chosen to comply with the Common Assumption Document.

The objective of the CBA for PJ.05-02 is to calculate cost and benefits of a Multiple Remote Tower Module (MRTM) that allows the ATCO to deliver requested Air Traffic Service (ATC) for 2 or 3 airports simultaneously.

The following traffic characteristics provide an indication of the traffic volumes regarding simultaneous movements (including mix of IFR and VFR):

- 2 airports with 6 simultaneous movements in total
- 3 airports with 4 simultaneous movements in total
- 10 to 20 movements (ground and air) per hour for all airports

The traffic volumes in specific situations might deviate from this indication depending on traffic complexity and other factors influencing task load for the controller.

It is assumed that an ATCO can hold endorsements for up to 3 (single) different airports.

There is a fixed allocation of airports to a set of MRTMs. However, in case of ATCO overload, due to e.g. emergency, high traffic volumes or degraded mode, the ATCO can split one or two airports into one or two spare MRTMs if required.

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

Solution OI steps are applicable for small and other airports. According to the Airport OE Dataset which provided airports' classification results based on SESAR 2020 classification scheme of OEs and Sub-OEs in ECAC countries there are 1049 aerodromes (92 small aerodromes and 957 other aerodromes), but only 360 aerodromes with current ATS service may apply for multiple remote tower module operations benefits.

2.3 Intended readership

The intended audience for this document are primarily all the partners involved in SESAR 2020 (PJ05) addressing solution 02 and solution 03.

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

- ANS providers;
- ATM infrastructure and equipment suppliers.
- Airspace users;
- Airport owners/providers;
- Affected NSA;
- Affected employee unions;

SESAR 2020 Projects/Solutions with dependencies to PJ05:

- PJ.14 (EECNS) CNS
- PJ.15 (COSER) Common Services
- PJ.16 (CWP/HMI) CWP-HMI
- PJ.18 4DTM

SESAR 2020 Transversal Projects:

- PJ.19 (CI) Content Integration
- PJ.20 (AMPLE) Master Plan Maintenance
- PJ.22 (SEabird) Validation & Demonstration Engineering

2.4 Structure of the document

This document is divided in eleven sections:

- Section 1 provides an executive summary;
- Section 2 shows the purpose of the document and scope chosen to develop the CBA;
- Section 3 presents the objectives of the CBA, the reference scenario against which to compare the solution, the stakeholders involved in and technical and economical assumptions used to develop the CBA;
- Section 4 explains the CBA benefits;

- Section 5 and 6 give the necessary information to develop a CBA: They analyse the cost categories and an approach to the benefits. These sections also provide an estimation of those costs and benefits;

- Section 7 provide the results of the economic analysis: NPV and cash flows, benefit to cost ratio, payback period;

- Section 8 presents sensitivity analysis;

- Section 9 makes an analysis of the results and provides some recommendations for future economical studies;

- Section 10 lists references and applicable documents;

- Section 11 contains mapping between ATM Master Plan Performance Ambition KPAs and SESAR 2020 Performance Framework KPAs as appendix

2.5 Background

This document considers the work done in SESAR 1 Business Case CBAs for SESAR Solutions #71 and #52 (16.06.05 D51).

The work done for single remote tower, and remote contingency, are the baseline for the multiple remote tower concepts but are not addressed further in this document. Information can be found in the data packs for the following operational improvements:

- SDM-0201 - Single Remote Tower for low density aerodromes

- SDM-0204 - Contingency solutions for aerodromes with one main RWY

- SDM-0205 - Multiple solution for two low density aerodromes simultaneously

Resulting in the following SESAR solutions:

- 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

As mentioned before, it is assumed that PJ05-02 Solution can be operational, when SESAR 1 solutions are implemented. Those elements will be part of the baseline for both the Solution Scenario and Reference Scenario.

2.6 Glossary of terms

Term	Definition	Source of the definition
Net Present Value	Net Present Value (NPV) is the sum of all discounted cash inflows and outflows during the time horizon period.	*Investopedia*
Enabler	New or modified technical system/infrastructure, human factors element, procedure, standard or regulation necessary to make (or enhance) an operational improvement.	ATM lexicon
Operational Improvement Step	The elementary level of an operational improvement.	ATM lexicon
Multiple Remote Tower Module (MRTM)	Term for the complete module including both the CWP(s) and the Visual Presentation display screens. A MRTM is defined as a workstation for one or two ATCOs able for providing ATS to more than one aerodrome simultaneously. The MRTM will enable the ATCO to maintain a view over the aerodromes including the manoeuvring area and surfaces as stipulated in regulation.	OSED
Remote Tower Module (RTM)	Remote Tower Module (RTM) is the term for the complete module including both the CWP and Visual Presentation display screens. An RTM is defined as a workstation for one or two ATCOs able for providing ATS to one single airport. The RTM will enable the remote tower operator to maintain a view over the aerodrome including the manoeuvring area and surfaces as stipulated in regulation.	EASA
Remote Tower Centre (RTC)	The Remote Tower Centre (RTC) is the centralised facility housing one or more MRTMs where the provision of a remote ATS may be provided to one or more aerodromes from each MRTM.	OSED

2.7 List of Acronyms

Acronym	Definition
ACC	Area Control Centre
ATC	Air Traffic Control
ATM	Air Traffic Management
ATS	Air Traffic Service

ATCO	Air Traffic Control Officer
CAPEX	Capital expenditure
CBA	Cost Benefit Analysis
CHMIM	Controller Human Machine Interaction Management
CWP	Controller Working Position
ECAC	European Civil Aviation Conference
FTE	Full time equivalent
HC	High complexity (airport)
HMI	Human Machine Interface
LC	Low complexity (airport)
MET	Meteorology
MRTM	Multiple Remote Tower Module
NPV	Net Present Value
OPEX	Operating and Maintenance costs
PAR	Performance Assessment Report
PIRM	Programme Information Reference Model
PTZ	Pan-Tilt-Zoom
RTC	Remote Tower Centre
RTM	Remote Tower Module
RTO	Remote Tower Operations
SESAR	Single European Sky ATM Research Programme
SJU	SESAR Joint Undertaking (Agency of the European Commission)
SWIM	System Wide Information Management
TMA	Terminal Manoeuvring Area
VCS	Voice Communications System

3 Objectives and scope of the CBA

3.1 Problem addressed by the solution

This section describes in a few words what the CBA is about, what decision it supports and what problem is addressed by the Solution.

The problem which Remote Tower is addressing is the high cost of providing ATS at small airports when the ATCOs are required to be physically present at the location.

3.2 SESAR Solution description

The solution proposes the development of a remotely provided aerodrome air traffic service by a "multiple" setting. Those settings help to combine ATS services from various aerodromes in a centralized control room independent of airport location in order to make use of the valuable ATS provider resources more efficiently.

“Remote Tower“ is changing the provision on ATS in a way that is more service tailored, dynamically positioned and available when and where needed, enabled by digital solutions replacing the physical presence of controllers and control towers at aerodromes.

SESAR PJ05 Solution is focusing on increased cost efficiency for local air traffic service at medium to small and other aerodromes with more complex environments.

More cost-efficient aerodrome ATS would allow rural, less frequented airports to work cost-efficient and to keep them in operations or even to increase the service levels for more day hours operations or even to upgrade non-controlled to controlled airports. All this would contribute to a better passenger comfort in terms of shorter travel times and better point to point connections.

The Multiple Remote Tower Concept shall contribute to the overall cost reduction of the European gate-to-gate ATM, by reducing costs for performing ATS at airports with 20 to 30 movements (air and ground) per hour in total.

“Single remote tower” solutions have already been deployed through the predecessor SESAR 1 projects, but more significant impacts in flexibility and cost-efficiency are to be expected with “multiple” remote control out of a remote tower centre.

Solution PJ.05.02 builds on results from SDM.0205 (2 low density aerodromes) and will continue to investigate multiple remote tower modules, MRTMs, for 2 small sized or 3 other aerodromes. One remaining aspect for more traffic is planning tools supporting the ATCO in his/her decision to split up aerodromes in a MRTM before workload is exceeded.

Solution 02 is focusing on increased cost efficiency for local air traffic service at small sized aerodromes.

Remotely Provided Air Traffic Service for Multiple Aerodromes shall increase cost efficiency by incorporating into the MRTM:

- a CWP, Controller Working Position, which enables ATCOs to deliver a safe continuous service to the connected aerodromes to the MRTM;

- a HMI that supports ATCOs to keep requested traffic levels at the different aerodromes in multiple mode;
- features for automation and support for operators in an environment with several connected aerodromes;
- representations of MET information for multiple airports and airports with more than one runway;
- enhanced PTZ functionality for a CWP suitable for several aerodromes;
- enhanced VCS;
- overlays to cope with several aerodromes at the same time;
- developing ATCO planning tools in the Multiple RTM (MRTM);

while:

- addressing cyber security;
- handling planning issues such as the daily operative work.

The difference between the new and previous operating method is mainly concerned with the ATCOs ability to provide ATS to more than one aerodrome simultaneously with kept safety and increased traffic. Training is also a difference, as ATCOs will not be monitoring the same aerodrome all the time and need to have knowledge of the procedures for all aerodromes in control, phraseology, etc.

SESAR Solution ID	OI Steps ref. (coming from the Integrated Roadmap)	OI Steps definition (coming from the Integrated Roadmap)	OI step coverage	Comments on the OI step title / definition
PJ.05-02	SDM-0207	Remotely provided Air Traffic Service for Multiple Aerodromes (for up to 3 aerodromes)	Fully	

Table 1. SESAR Solution PJ05 Scope and related OI steps

OI	Enabler[1] ref.	Enabler definition	Enabler coverage	Applicable

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

Steps ref.				stakeholder
SDM-0207	AERODROME-ATC-79	Provide a Multiple Remote Tower Module (MRTM) that enables one ATCO to control multiple towers simultaneously	Fully	Air Navigation Service provider
	AERODROME-ATC-81	ATCO planning tool for MRTM	Fully	Air Navigation Service provider
	AERODROME-ATC-82	Technical supervision of MRTM	Fully	Air Navigation Service provider
	CTE-C14	Advanced Voice Services for MRTM	Fully	Air Navigation Service provider

Table 2. OI steps and related Enablers

3.3 Objectives of the CBA

The main objective of the V3 CBA is to assess the economic feasibility of the PJ05-Solution 02 “Remotely Provided Air Traffic Services from a Multiple Remote Tower Module, MRTM”.

The output is a quantitative assessment of both cost and benefits of the chosen solution.

Organizations and entities who will have to pay for or will be impacted by the PJ05-Solution 02 directly or indirectly are presented in Table 4.

The airspace users are receivers of the ATS service. However, neither their role nor their responsibility will change as a result of the introduction of multiple remote ATS.

Airport owners are looking for solutions to reduce cost whilst increased technology demands for any new technology need to be balanced. Multiple Remote Tower with Single Remote Tower as baseline will use the same airport equipment which is already available for Single Remote Towers.

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

It will still be the responsibility of the airport authority / ATS service provider to ensure that the equipment is properly maintained and kept in acceptable condition. The ATCO will not be responsible for faults or failures due to lack of maintenance or design issues. These issues will be addressed by qualified engineers and technicians.

Stakeholder	The type of stakeholder and/or applicable sub-OE	Type of Impact	Involvement in the CBA task	Quantitative results available in the current CBA version
ANSP	Civil ATS Aerodrome Service Provider	Benefit: ANSPs expect a reduction of cost for running local air traffic service at aerodromes Costs: ANSPs pays for the MRTM	Only ANSPs are candidates for deployment of Remote ATS. ANSPs will be able to implement the systems	Both costs and benefits
Staff union and organisations (ETF/IFATCEA)		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 in a safe and controlled manner.	Not involved in analysis	No cost and benefit estimation
ATM infrastructure and	Technology Provider	Industries are affected by new requirements on	Not involved in analysis	No cost and benefit

equipment suppliers		multiple remote towers and the need for stable systems		estimation
Airspace users	ATS users	Benefit: Airspace users expect to continue to be served by aerodromes without impact on scheduled traffic with a kept availability for each of the aerodromes controlled in Multiple mode. Also airspace user can expect to have lower fees in long term.	Not involved in analysis	No cost and benefit estimation
Affected NSA		NSAs expect that any new technology is safe and stable for air traffic service and that the applied methodology is properly adapted to the technology	Not involved in analysis	No cost and benefit estimation
Airport owners/providers	ANS Provider	Airports expect prices for ANS to decrease with Multiple Remote Tower without a negative impact on their availability for flying customers.	Not involved in analysis	No cost and benefit estimation Airport infrastructure is assumed to already be deployed in the Reference Scenario which includes the Single Remote Tower solution

Table 3. SESAR Solution PJ05 CBA Stakeholders and impacts

3.4 CBA Scenarios and Assumptions

3.4.1 Reference Scenario

The baseline for multiple remote tower operations is the single remote tower operations, which enables the provision of remote ATS for a single aerodrome and is already available. Single Remote Tower is characterised by one ATCO providing ATS to a single aerodrome remotely from a Remote Tower Module (i.e. not a conventional tower building). ATCOs are used to providing ATS from a

single RTM, in some cases with endorsements for several airports connected to the centre. Technical enablers, communications, radar displays and other features/function assist the controller with the provision of ATS. The traffic situation is viewed using a high resolution panoramic display located in the Remote Tower Module.

3.4.2 Solution Scenario

An ATCO provides ATS operations to 2 or 3 aerodromes simultaneously. The difference between solution 02 and single Remote Towers is the increased traffic levels and increased needs of planning tools for the ATCO to enable a capability to cope with the increased complexity. The objective for PJ.05-02 is to develop and validate a MRTM that allows the ATCO to maintain situational awareness for 2 or 3 airports at a time. The following traffic characteristics are just providing an **indication of the traffic volumes** regarding simultaneous movements (including mix of IFR and VFR):

- 2 airports with 6 simultaneous movements in total
- 3 airports with 4 simultaneous movements in total
- 10 to 20 movements (ground and air) per hour for all airports

The traffic volumes in specific situations might deviate from this indication depending on traffic complexity and other factors influencing task load for the controller.

In order to be able to allow more airports and/or higher traffic volumes to be controlled simultaneously from one MRTM compared to SESAR 1 solution #52 or #12, the solution validates advanced features of the visual reproduction as well as additional voice services being integrated into the MRTM.

There is a fixed allocation of airports to a set of MRTMs (i.e. they cannot be recombined in different configurations). However, in case of ATCO overload, due to e.g. emergency, high traffic volumes or degraded mode, the ATCO can split one airport into a spare MRTM if required.

3.4.3 Assumptions

Summary of main assumptions:

Variable	Value	Source
Applied currency	EUR	
Solution period	20 years (2019-2040)	SESAR PJ19
Investment period (standalone deployment)	2023-2025	Start of implementation is 3 years before Benefits start date (IOC). In EATMA IOC is 30/06/2026 and FOC years is 30/06/2030.
Investment period (ECAC level)	2023-2030	Start of implementation is 3 years before Benefits start date (IOC). In EATMA IOC is 30/06/2026 and FOC years

		is 30/06/2030
Discount rate	8 %	SESAR PJ19
No of controlled airports per multiple remote tower module	3	Validation report
Annual costs of an ATCO	145 000 per year	Standard Inputs for EUROCONTROL Cost-Benefit Analyses [16]
No of ATCO to man 3 single (or multiple) remote tower modules without solution (i.e. one aerodrome is handled per module)	8	PJ.05-02 CBA team assumption
No of ATCO to man a multiple remote tower module with solution (i.e. three small or other aerodromes are handled per module)	6 (25% reduction)	PJ.05-02 CBA team assumption
Investment costs with solution (Investments costs for 2 controller positions including the cost of network devices and network infrastructure associated with the surveillance system, and other possible technology related costs that could be necessary to provide service for 3 aerodromes simultaneously)	1 440 000	Estimated by internal project experts + project partners judgement MRTM implementation costs can vary from 0.6 M to 2 M, it depends on integrity of independent different single remote tower solutions. The more similarities the simpler (software, hardware, ATM systems etc.) the merge of single remote tower unit into an MRTM.
Operational costs for technology with solution	65 000 per year	Estimated by internal project experts + project partners judgement

Table 4. Main Assumptions

More details on the assumptions include:

- Benefits will be realized through improved ATCO productivity (number of flights per ATCO hour) and reduced operating costs (cost savings) as an increased number of aerodromes are controlled by one ATCO while traffic at each aerodrome remains the same;
- For the investment costs, it is assumed that the Multiple Remote Tower Module is located in current ANSP facilities. Remote Tower module operational improvement investment is calculated for connection and equipment for 2 working positions (primary and backup - 2 sets of screens and interfaces linked to the same processing system);
- Each of the three aerodromes are assumed to be aerodromes that already have a staffed remote tower and where ATS service are already provided (from single remote towers).

- Based on PJ05-02 OI step SDM-0207 it is assumed that remotely provided air traffic service is served up to 3 aerodromes at a time from one MRTM position;
- Roles and responsibilities of one ATCO is assumed to be extended to (all covered by one ATCO):
  - Tower Clearance Delivery Controller
  - Tower Ground Controller
  - Tower Runway Controller
  - Apron Manager
  - Approach controller (optional)

The table below and figures present an example of the number of ATCO required:

Single RT	No of ATCO	Multi RT 2 AD	No of ATCO	Multi RT 3 AD	No of ATCO
1 AD small	2	2 AD small	2 ATCO, 1 back up ATCO		
1 AD small	2				
Total small	**4 ATCO**		**3 ATCO**		
1 AD other	1*			3 AD other	1 ATCO, 2 back up ATCO
1 AD other	1*				
1 AD other	1*				
Total small	**4 ATCO**				**3 ATCO**
Reduction			25%		25%

Table 5. ATCO reduction

Regarding the number of ATCO required in the solution scenario to man 3 different aerodromes compared to the reference scenario the following **improvements** are **assumed** (as example):

a. providing ATC from Single Remote Towers (**reference scenario**) for 3 aerodromes in total for all airports requires a ***staff of 8***. (3 such type of aerodromes need 1 ATCO per shift and aerodrome = 3 x 1 in Single RTM plus 1 spare ATCO per shift– total of 8 per shift, for overall operation is needed 2 shifts).

b. providing ATC from Multi Remote Towers (**solution PJ05.02)** for 3 aerodromes with the same traffic characteristics requires a staff of 6. The assumption is that with this solution 1 ATCO can hold endorsements for up to 3 (single) different airports.
The improvement with this solution is **reduction of** ATCO numbers that is **25%** because instead of the staff of 8 in single remote towers, a ***staff of 6*** is sufficient. This assumed reduction is in line PJ05.02 Performance Assessment Report according to which the number

of ATCO can be reduced by up to 25% for small and medium aerodromes. The calculation is based on generic approach, not limited to validation exercises. From single remote to Multi remote the reduction is in the number of 'active' ATCOs, since only **2 ATCOs** are required to **actively control 3 aerodromes** as from one MRTM (one MRTM consists of 2 CWP). Nevertheless, with solution Multi remote towers we still need 4 'spare' ATCOs considering the followings:

- firstly, each active ATCO needs a 'spare' one to switch their position during the shift as needed (2 'standby' ATCOs) according to:
  - the maximum time at a position without a fatigue break,
  - the number of night duties permitted,
  - the length of the shift cycle,
  - the policy regarding including break times as working time or not
  - other local working conditions, and
- secondly, with solution PJ05.02 it is assumed that:
  - there is a fixed allocation of airports to a set of MRTMs,
  - only possibility is to split to spare RTMs/MRTMs, in case of ATCO overload (due to e.g. emergency, high traffic volumes or degraded mode) the ATCO can split an airport into a spare RTM/MRTM if required. So there should be spare RTMs/MRTMs as backup behind each 'active' MRTMs and the remaining 2 'spare' ATCOs could take over one/more aerodromes when such a split is required.
  - Overall 18 hours of aerodrome opening hours on average, thereby continuous two-shift operation is assumed in the CBA.

User characteristics are assumed as follows:

- ATCO: The ATCO will have main responsibility for the provision of ATS.
  It is assumed that the TWR ATCO is responsible for assuring safe operations and provision of air traffic control services for the aerodrome maneuvering area and the vicinity of the aerodrome. This includes responsibility for clearance delivery, ground control, arrival management, departure management and flight data processing. Number of ATCOs are captured in details in the CBA.
- Other stakeholders: As noted in 3.4 Stakeholder identification, no quantitative results is available in the CBA for stakeholders other than ANSPs.

3.5.3.1 Assumptions on costs

Pre-implementation costs

R&D and pre-industrialisation costs are already incurred in the SESAR Development Phase and therefore not included in the cost assessment.

Implementation costs

- Capital costs and other one-off costs that are incurred during the implementation period. These include the costs of equipment & systems as well as integrations costs. Other one-off costs cover initial training, installation and administrative costs.
- It is assumed that the Multiple Remote Tower Modules are located in current ANSP facilities and no building & facilities and land & property costs are captured in the implementation costs. The housing facility will differ per location based on local circumstances.
- Costs were estimated for the enablers required in addition to those needed for the existing separate single remote towers (reference scenario) at all considered aerodromes.
- Since the underlying technological solution is very specific to the different aerodromes for which the multi-remote tower is being implemented, detailing the cost of technology was not evaluated. It is also important to point out that there are several ways (i.e. different types of equipment) to implement the solution.
- The source of the implementation costs in the CBA is stakeholder judgement plus internal experts' estimations based on experience.

Operating costs

- Personnel cost of ATCOs is estimated by annual ATCO costs input from Standard Inputs for EUROCONTROL Cost Benefit Analyses [16]. Average ATCO employment costs are considered although staff working at remote centre locations may have higher costs due to additional compensation.
- The source of ongoing operating costs related to technology implemented with the solution is stakeholder judgement plus estimations of internal experts.
- The benefits assumed above are assumed to be realized through savings in staff costs.
- Cost savings are not realized immediately but ramp-up over time.
- The actual reduction in costs will differ per location based on local circumstances.

Costs of the solution per stakeholder groups

- ANSP's will incur the costs. No other stakeholder will incur any costs. To airport, related investments are already included in the reference scenario.

3.5.3.2 Deployment assumptions

In the CBA scenario - for deployment – MRTM are installed and three aerodromes are controlled from these positions, the aerodromes were previously controlled from single remote towers. If an ANSP want to deploy MRTM from scratch they should take the CBA of Single Remote Tower [8] and this CBA and build a new model for their local characteristics based on the two.

4 Benefits

4.1 Benefits of Solution 02

The key benefit is improving Cost Efficiency through improved ATCO productivity (CEF2) and reduced operating costs. Cost Efficiency is achieved while maintaining importance of safety, capacity and human performance at the aerodromes.

A remote solution with ATCOs controlling 2 or 3 aerodromes from Multiple Remote Tower working positions in a Remote Tower Centre has a possibility to reduce costs for staff. Different rostering is possible in an environment where several controllers are controlling several aerodromes.

Cost Efficiency is achieved, however, at the same time:

- the solution **maintains safety** levels for local Air traffic services,
- aerodrome **capacity will not change** with Multiple Remote Tower Operations. The same procedures apply for providing aerodrome control service as with operations from a local tower. In general, traffic demand is expected to be below aerodrome capacity at aerodromes characterized by 10 to 20 movements (air and ground) per hour in total. In CBA the aerodrome capacity changes in demand are not considered.

4.1.1. Quantitative benefits

In the Benefit and impact mechanism (BIM) four KPAs were analysed: cost efficiency, safety, capacity and human performance.

Only one KPA could be analysed in terms of economic units: Cost efficiency (in terms of operating cost reduction).

The main driver for Remote Provision of ATS for multiple aerodromes is Cost Efficiency. However, this has not been fully proven through the validation activities.
Therefore, the reduction in ATCO numbers as CBA Model input came from expert opinions after analyzing the results of the validations. The PAR (Performance Assessment Report) has calculated the 'Absolute ANS Cost efficiency at ECAC level' (CEF 1) (0.354%) based on extrapolating the 25% 'ATCO number reduction' to ECAC level. The 0.354% value is applicable for top-down CBA approach (where the CBA model contains ECAC level parameters). However, as this CBA is built from a bottom-up approach (the CBA model focuses on a single (ANSP) deployment location before multiplying up to ECAC level), the 25% value is appropriate.

For a single deployment of the Solution (not on ECAC level) the following benefits are monetized:

Without solution (reference scenario)			**With solution**			**Ratio of benefit monetization**	**Benefit (annual) [(e2-e1)*80%]; [(g2-g1)*80%]**
Ref	**Description**	**Value**	**Ref**	**Description**	**Value**		
a1	No of airports controlled	3	a2	No of airports controlled	3		
b1	No of atco to man 3 single remote towers per shift	8	b2	No of atco for multiple remote tower modules in RTC per shift	6		*25% assumed ATCO number reduction*
c1	Number of shifts per day[1]	2	c2	Number of shifts per day[1]	2		
d1	Annual costs of an atco	145 000 EUR	d2	Annual costs of an atco	145 000 EUR		
e1	**Atco (personal) costs for 3 single remote towers (annual) [b1*c1*d1]**	**2 320 000 EUR**	**e2**	**Atco (personal) costs for multiple remote tower modules in RTC (annual) [b2*c2*d2]**	**1 740 000 EUR**	**80%**	**580 000 EUR**
Total benefit per year							**580 000 EUR**

Table 6. Results of the benefits monetisation

Based on the assumptions described in '3.5.3 Assumptions' section, benefits derived from improved ATCO productivity and reduced operating costs are monetized.

4.1.1.1 Benefit monetization on ATCO costs

Three aerodromes characterized by 20 to 30 movements (air and ground) per hour in total for all airports require a staff of 4 per shift in a Solution PJ05-02 of aerodromes to MRTMs compared to the reference scenario (without solution) that requires a staff of 6 per shift in three Single Remote Towers. It assumes an ATCO number reduction of 25% compared to the reference scenario.

- Monetization of cost of ATCOs – assuming two shifts per day - presents that:
    - Annual ATCO costs of 3 single remote towers amounts to 2.32 M€
    - Annual ATCO costs of multiple remote tower modules amounts to 1.74 M€

This results in a benefit on ATCO costs amounting to 0.58 M€ annually.

In the benefit monetisation only **20%** (80% of the 25% ATCO number reduction) is **considered for the cost saving** as ANSPs cannot immediately adjust their staff resources. The benefits monetized above (cost savings) are not realised immediately but ramp-up over time. In the investment period (assumption is 2023-2025) no benefit is realized. After the deployment it is considered that the benefit monetized will be gradually realized and is expected that the 0.46 M€ annual benefit will be reached by 2027 (2 years after the completion of investment period).

The table below presents the benefits assumed in the CBA's reference period:

Performance Framework KPA[2]	Focus Area	KPI/PI from the Performance Framework	Unit	Metric for the CBA	Unit	Year 2019	Year 2026	Year 2040
Cost Efficiency	ANS Productivity	**CEF2** Flights per ATCO-Hour on duty	Nb	ATCO employment Cost savings (2 or 3 aerodromes)	M€/year	n.a	*0.23*	*0.46*
		CEF3 Technology cost per flight	EUR / flight	Technology cost change	€/year	-	-	-

Table 7. Results of the benefits monetisation per KPA

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

5 Cost assessment

5.1 Cost assessment for Solution 02

Cost assessment provided below includes only the delta value implied by the solution over the reference scenario. All the costs imputable to the reference scenario and not to the solution scenario are not included.

5.1.1 ANSPs costs

Cost descriptions

It can be considered three cost groups:

- Pre-implementation costs: R&D and pre-industrialization costs are already incurred in the SESAR Development Phase and therefore not included in the cost assessment.
- Implementation costs:
    - Capital costs of implementation: Cost incurred to implement the project. Mainly these are cost of equipment & systems and integrations costs related to the enablers listed in 3.2 SESAR solution description.
    - One-off implementation costs: one-off implementation costs incurred during the implementation period, such as training, program management.

Although the manpower has planned training every year (refresh of procedures, new systems, etc), CBA considers that the trainings associated to the solution will be additional to the standard one.

- Operating costs:
    - ATCOs in OPS (personal) costs: this category consists only of ATCOs working in Operations. Full-time equivalent (FTE) ATCOs are defined as participating in an activity that is either directly related to the control of traffic or a necessary requirement for ATCOs to be able to control traffic. One Full Time Equivalent (FTE) is assumed to be the hours worked by one person on a full-time basis. This working time is converted into Employment Costs. Employment costs comprise gross wages, salaries and contributions to social security schemes, taxes, pension contributions and other staff-related costs. Usually this category benefits from a higher salary than other staff categories and has a direct impact on productivity.
    - Operating costs for technology: this category is related to maintenance, technical supervision, data transmission services and other technology related services.

Quantitative costs

- Pre-implementation costs:

As already noted, this type of costs is not included in the cost assessment.

- Implementation costs:

Cost quantification provided below for implementation costs is based on CBA's the assumption that a MRTM provides remote ATS for two or three aerodromes. These costs are extrapolated to ECAC level in section 7.2 is assumed (not on ECAC level).

Distribution of implementation costs is presented in the chart below. It is expected that about 83 % of the implementation costs is related to ANS infrastructure development, multi TWR CWPs and voice communication infrastructure. Other considerable part of the costs is training for the solution. Training costs assumed in the CBA is on the premise that it covers additional costs to be incurred on ATCO certification or regulatory approval associated with ATCO licensing to have unit endorsements for more airports at the same time.

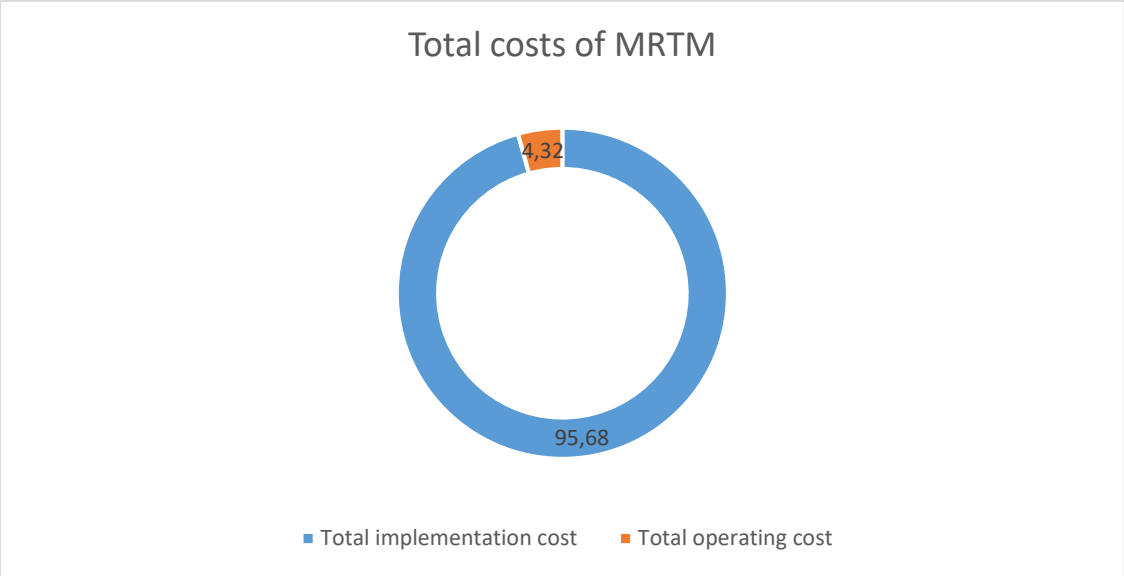

Figure 1: Overall implementation costs of MTRM

Readers are reminded in respect of implementation costs that, we assume prior implementation of the Single remote tower solution, and thus we assume that airportside installation of cameras and related the airportside network infrastructure are already implemented. Implementation costs is expected to be incurred over 3 years for standalone deployment and 7 years for ECAC level.

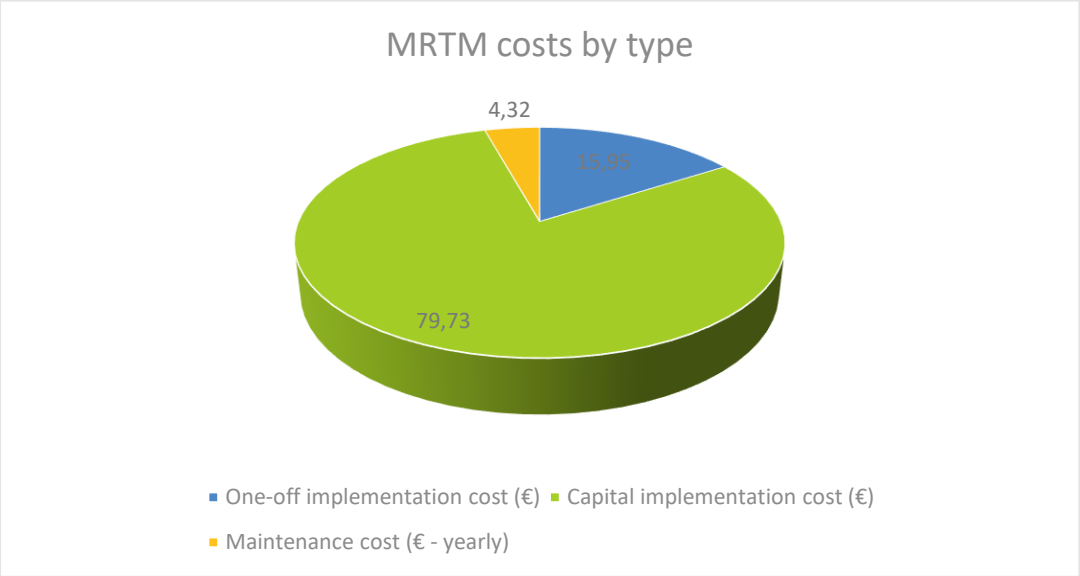

Figure 2: MRTM implemetation costs per Unit -ANSP

Implementation costs over the three years of investment period is assumed to be distributed in the CBA as follows until the complete rollout. In case of ECAC level deployment the CBA considers a longer investment period (5 years) as the deployment of the MTRM is spread over the deployment period.

The following table includes the investment costs for “solution scenario”:

Enabler	Description	One-off implementation cost (€)	Capital implementation cost (€)	Maintenance cost (€ - yearly)	Administration cost (€ - yearly)	Total implementation cost	Total operating cost
Aerodrome ATC-79 -Multiple Remote Tower Module	Provide a Multiple Remote Tower Module (MRTM) that enables one ATCO to control multiple towers simultaneously	90 000	650 000	30 000		740 000	30 000
		ATCO training cost	Out The Window, CHMIM Aerodrome ATC, G/G Communication ATC	Hardware and software maintenance and repair			
Aerodrome ATC-81-ATCO planning tool for MRTM	ATCO planning tool for MRTM	-	200 000	15 000		200 000	15 000
		-	Multiple Remote Aerodromes Management	Hardware and software maintenance and repair			
Aerodrome ATC-82-Technical supervision of MRTM	Technical supervision of MRTM	90 000	-	-		90 000	
		ATSEP training					
CTE –C14-Advanced Voice Service	Advanced Voice Services for MRTM	60 000	350 000	20 000	-	410 000	20 000
		-	A/G Voice Communication / ATCO & Crew	Hardware and software maintenance and repair	-		
Total	Overall cost value	*240 000,00*	*1 200 000,00*	*65 000,00*		*1 440 000,00*	*65 000,00*

Table 8. Enablers cost

6 CBA Model

The following figure shows the CBA model, that includes cost and benefit mechanisms as inputs and NPV, benefit-cost ratio and payback period as outputs.

The calculation of NPV, benefit-cost ratio and payback period is not straightforward, because the exact values of costs and benefits are not known. For this reason, the impact of low, base and high values of inputs to the NPV are estimated (sensitivity analysis) in section 8.

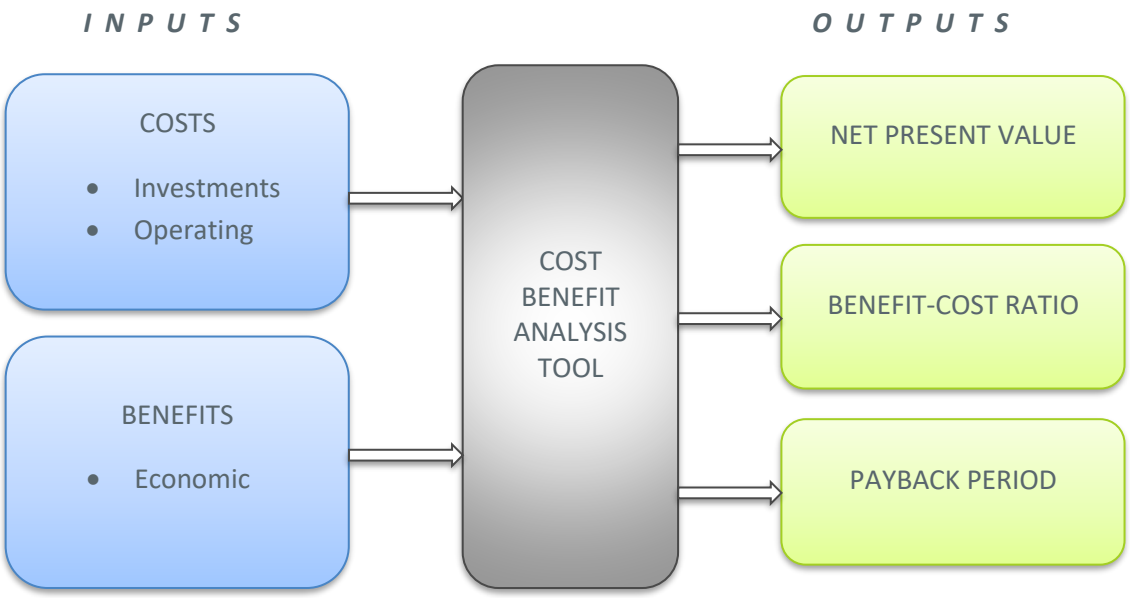

Figure 3: CBA Model

SESAR Solution
PJ05.02 V3 CBA.xlsm

6.1 Data sources

The data required to perform the Cost Benefit Analysis for Solution PJ.05 has been obtained from varying sources.

Sources of information are:

• Data from other studies (SESAR 1 Solution #71, PJ.05-03)

• ANSP (SE “Oro navigacija”) internal resources (experts from Technical, Operational and Finance departments)

• ANSP industrial partner’s recommendations

• Methodology for the Performance Planning and Master Plan Maintenance, PJ20

• Airport OE Dataset, PJ20

• Standard Inputs used in the development of previous Cost Benefit Analyses related to ATM operational improvements

7 CBA Results

7.1 Deploying solution

The Figure below shows discounted benefits, discounted costs and cumulative cash flow for remotely provided ATS for multiple aerodromes (2 or 3 aerodromes).

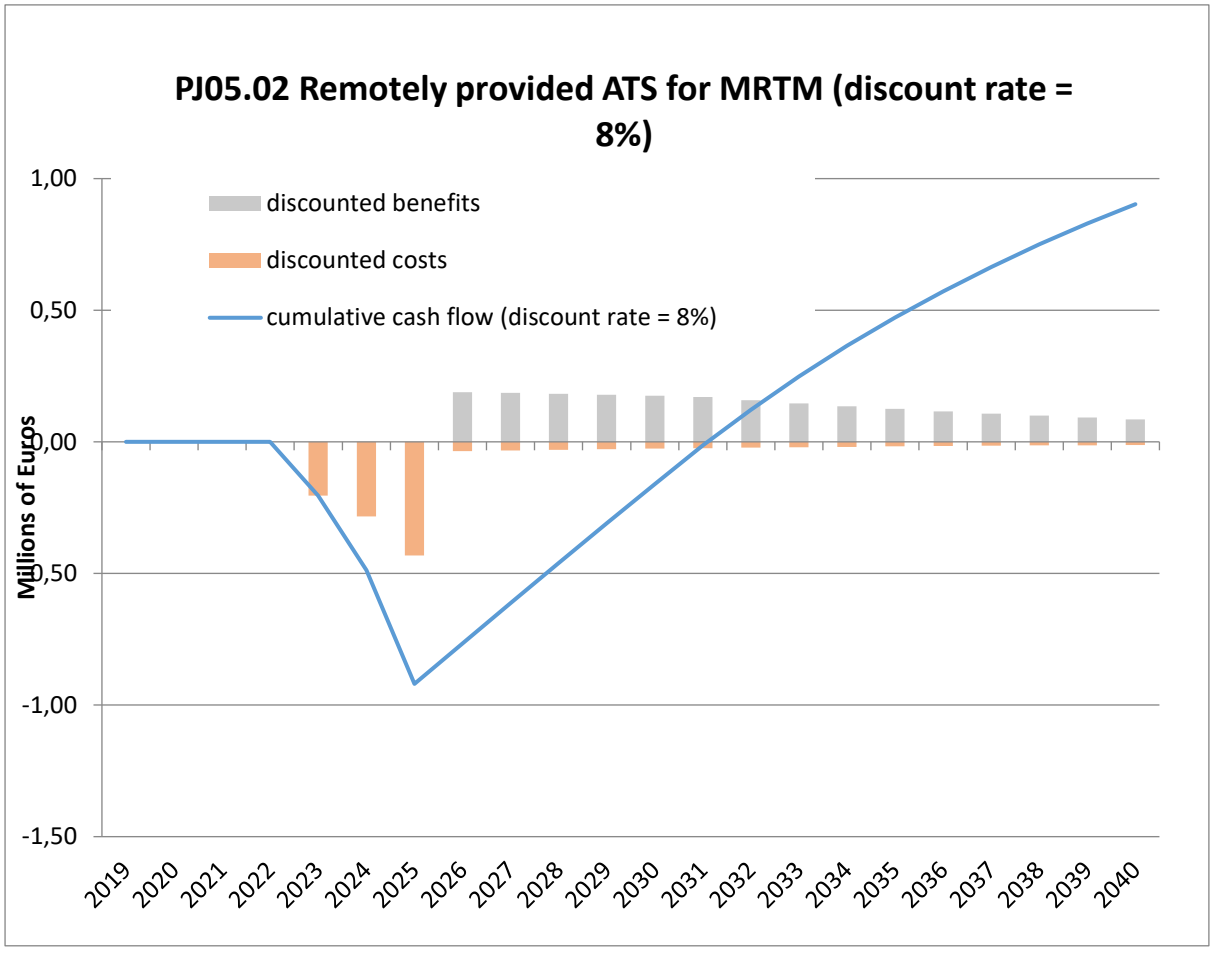

Figure 4: The outputs of the CBA of MRTM deployment for 2 or 3 ADs

The Table below represents the outputs of the CBA.

One Multiple Remote Tower Module (for 2 or 3 small aerodromes)	NPV	Benefit-Cost ratio	Payback period	Costs (discounted)	Benefits (discounted)
	0.9 M EUR	1.7	13.1	**1.2 M EUR**	**2.1 M EUR**

Table 9. The outputs of the CBA (for 2 or 3 small aerodromes)

The CBA shows that the implementation of the Solution compared with a scenario "without Solution" in which such investments would not be undertaken, would generate a Net Present Value amounting to 0.9 million €, with a 13.1 - year payback period. Such Net Present Value is derived considering an overall cost is 1.2 M €.

7.2 Solution in ECAC level

Solution OI steps are applicable for small and other airports. According to the Airport OE Dataset provided airports' classification results based on SESAR 2020 classification scheme of OEs and Sub-OEs in ECAC countries are 1049 civil aerodromes, which may apply for multiple remote tower operations benefits, but in analysis is assumed that only aerodromes with current ATS service are applicable for the solution. In ECAC countries is considered that 360 aerodromes may apply for multiple remote tower operations benefits. If an ANSP want to deploy MRTM from scratch they should take the CBA of Single Remote Tower [8] and this CBA and build a new model for their local characteristics based on the two.

CBA results are aggregated to ECAC level assuming there are 120 MTRM based in existing ANSP buildings. This includes 8 MRTM in 15 countries each controlling 3 aerodromes in order to cover all 360 aerodromes.

The Figure below shows discounted benefits, discounted costs and cumulative cash flow for remotely provided ATS for multiple aerodromes with MRTMs in case of ECAC level:

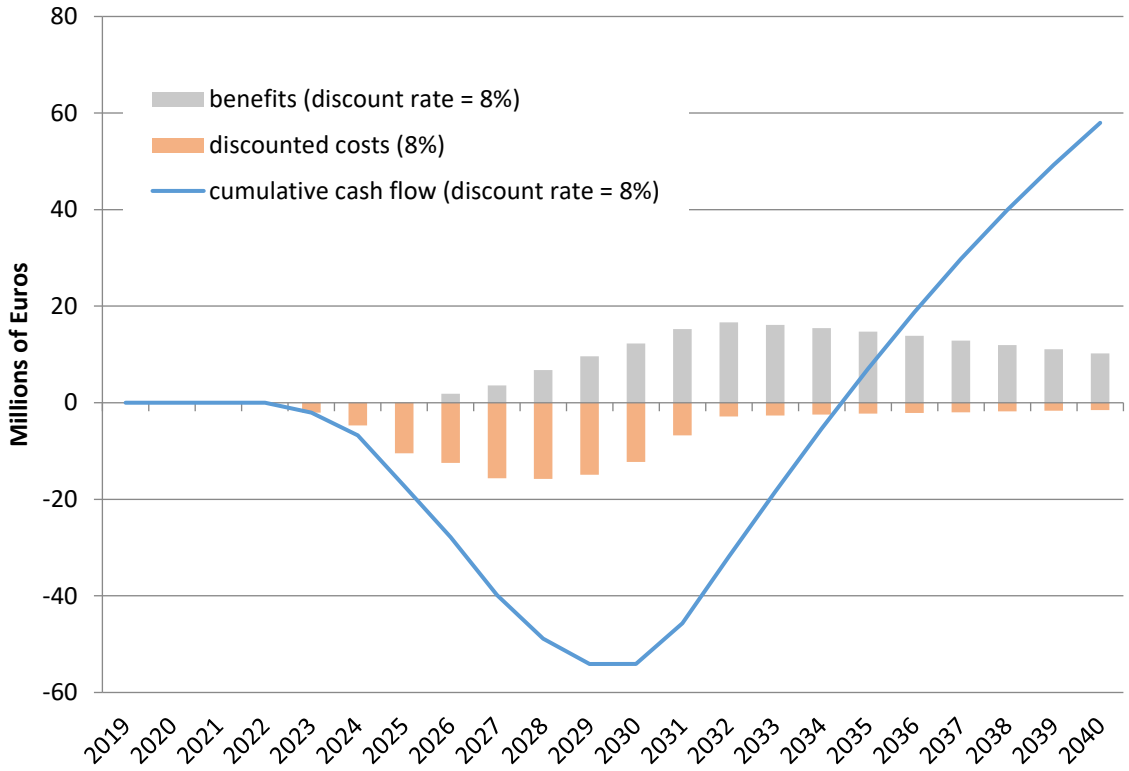

Figure 5: CBA results on ECAC level

The Table below represents the outputs of the CBA.

One Multiple Remote	NPV	Benefit-Cost	Payback	Costs	Benefits

Tower Module (for 2 or 3 small aerodromes)		**ratio**	**period**	**(discounted)**	**(discounted)**
	60 M EUR	1.5	12.3	**107.8 M EUR**	**172.3 M EUR**

Table 10. The outputs of the CBA (ECAC level)

At ECAC level solution investment period start from 2023 and end date of investment period is 2030, the benefits are assumed to firstly starts in 2026.

8 Sensitivity and risk analysis

Risk assessment of the project included the following steps: 1) sensitivity analysis, including break-even point analysis; 2) risk values calculation and risk-adjusted NPV calculation, and; 3) Monte Carlo analysis. Since detailed calculations are provided in the spreadsheet, only the main results are presented in this document.

Sensitivity

Among the direct variables (CFs) having impact on return indicators, ATCO staff cost savings are assessed to be critical variable for NPV change, i.e. percentage change of this variable effects greater (>1) percentage change of NPV. However, in comparison with investment cost variables, much stronger attention should be paid to means of helping to manage both operating and infrastructure maintenance cost savings.

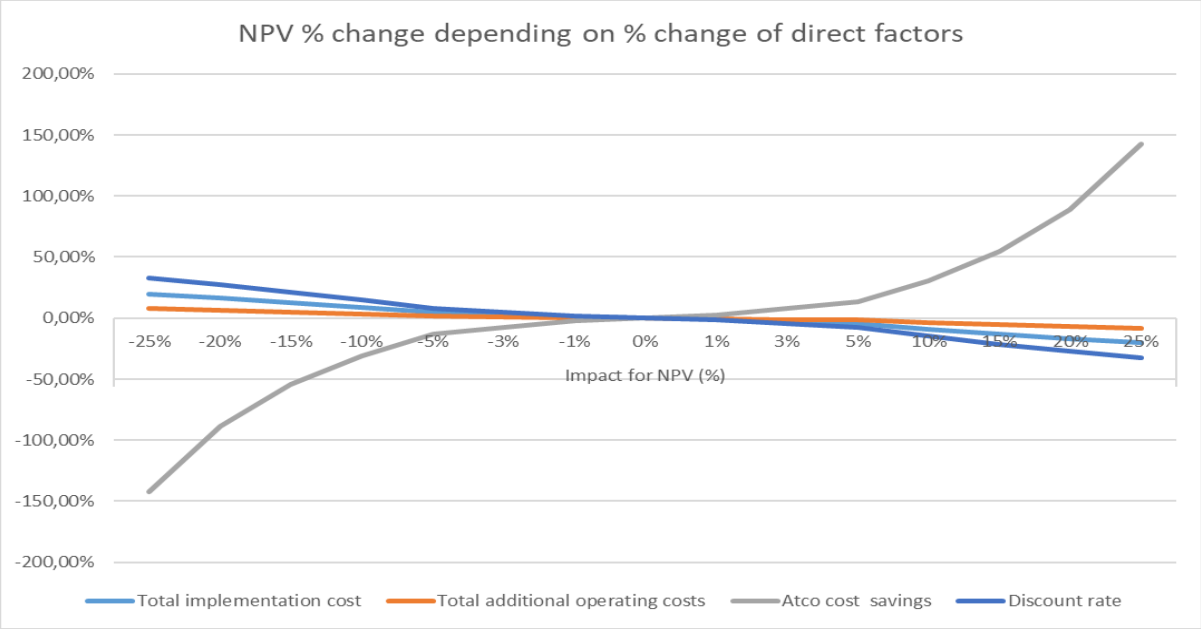

Figure 6: NPV % change depending on % change of direct factors

	Impact for NPV (%)														
	-25%	-20%	-15%	-10%	-5%	-3%	-1%	0%	1%	3%	5%	10%	15%	20%	25%
Total implementation cost	-0,80	-0,83	-0,87	-0,91	-0,95	-0,97	-0,99	0,00%	-0,99	-0,97	-0,95	-0,91	-0,87	-0,83	-0,80
Total additional operating costs	-0,33	-0,33	-0,34	-0,34	-0,35	-0,35	-0,35	0,00%	-0,35	-0,35	-0,35	-0,34	-0,34	-0,33	-0,33
Atco cost savings	5,70	4,44	3,63	3,07	2,66	2,53	2,41	0,00%	2,41	2,53	2,66	3,07	3,63	4,44	5,70
Discount rate	-1,31	-1,37	-1,43	-1,49	-1,56	-1,59	-1,62	0,00%	-1,62	-1,59	-1,56	-1,49	-1,43	-1,37	-1,31

Table 11. Critical and non-critical variables

Break-even points analysis disclosed that there are big reserves in respect of all variables to absorb their changes regarding profitability of the project. Depending on variable, the changes can be greater from nearly one to several times. These results show that this project is quite save to recover investments and earn a prefer benefit (discount rate 8%)

Variable	Change	Value of CF
Total implementation cost	98.29%	2.95
Total additional operating costs	278.1%	3.686
Atco cost savings	-42%	3.832
Discount rate	138.3%	19.07%

Table 12. Break-even points

Risk-adjusted NPV calculation

Risk-adjusted NPV was calculated by using the probability distributions (PDs), which, based on their characteristics, are most suitable and typically apply for risk assessment of appropriate CFs of investment projects.

To assess investment cost overrun risk, loglogistics (3 parameters) PD was used, of which parameters (α = 2.7906, β = 0.28554, γ= 0.72694, mode = 0.94519) are based on the empirical research, the parameters used reflect the observed tendencies of planned cost overrun risk related to investments into equipment and other similar long-term asset.

For risk assessment of additional operating costs and savings, the triangular PD was used assuming that values of CFs can vary in a range between 70% (parameter *a*) and 200% (parameter *b*) of the most likely value (parameter *c* – mode).

To calculate risk-adjusted CFs, investment costs and operating costs were increased by risk values. While, savings were decreased by risk values. Risk values for a 70% confidence interval were calculated.

Considering the risk-adjusted CFs, investment costs with the preferable discount rate (8%) is not recovered. This shows that in this case, that is considered the worst-case scenario, the solution remains unbenefit (NPV <0).

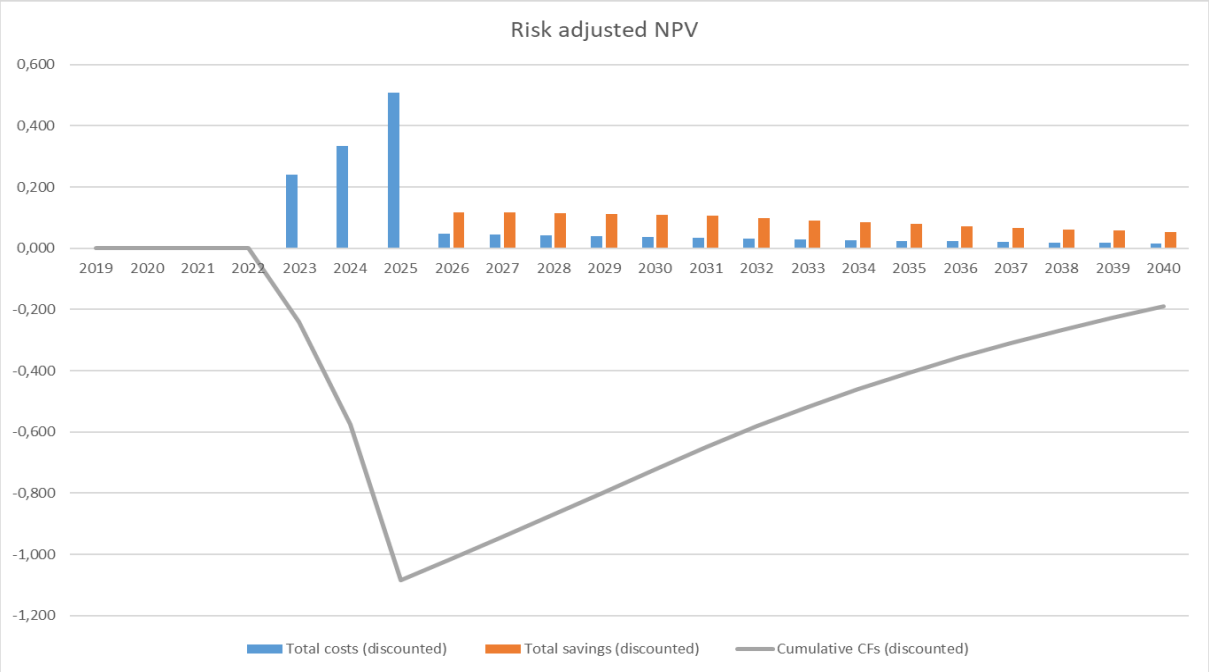

Figure 7: Risk-adjusted NPV of MTRM deployment

Monte Carlo simulation

The results of simulation of 1 000 iterations show probabilities to get the appropriate NPVs, which were calculated considering the previously mentioned risk assumptions.

There is a probability that the solution will not provide financial return due to NPV is negative. While, the most likely value of NPV falls in a range between 0.41 and 1.29 million Eur. the results disclose that the solution is relatively low-risk and worth to implement.

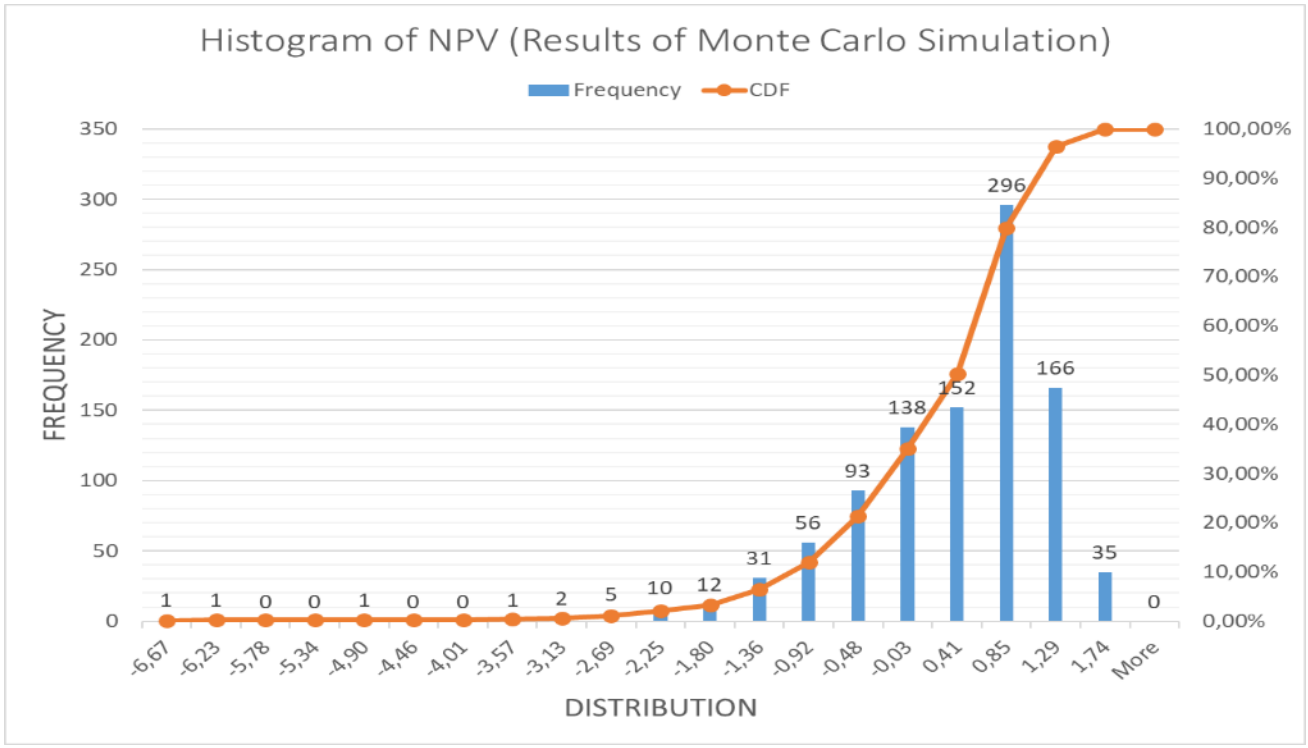

Figure 8: Histogram of NPV (results of Monte Carlo simulation / 1 000 iterations

9 Recommendations and next steps

The purpose of next steps is transition from research to deployment in an operational environment, by further development of operational concepts and supporting enablers.

The analysis has identified that implementation of PJ.05-02 solution scenario might have a significant positive impact at ECAC level (discounted benefits 172 M).

PJ.05-02 solution (standalone) estimated deployment cost is 1.4 M and may vary from 0.6 M to 2 M, depending on integrity of different single remote tower solutions. The more similarities (software, hardware, ATM systems etc.) the simpler the merge of single remote tower units into an MRTM.

MRTM solution deployment directly rely on ATCO productivity. Due to reduction in ATCO numbers, ATCO workload increases and the number of flights that can be managed by the controller per hour on duty may vary differently. In cases were flight numbers (managed by controller per hour on duty) stay the same, switching between airports itself might create additional workload and reduce ATCO capacity. As ATCO staff cost savings are very sensitive in this analysis, further ATCO productivity research in different scenarios is needed.

Nevertheless, CBA shows that solution generated positive NPV, sensitivity and risk analysis shows that the worst-case scenario the solution NPV is negative.

10 References and Applicable Documents

10.1 Applicable Documents

[1] SESAR 2020 Project Handbook

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

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

10.2Reference Documents

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

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

[6] B.05 D86 Guidance on KPIs and Data Collection support to SESAR 2020 transition.

[7] 16.06.06-D68 Part 1 –SESAR Cost Benefit Analysis – Integrated Model

[8] 16.06.06-D51-SESAR_1 Business Case Consolidated_Deliverable-00.01.00 and CBA

[9] Method to assess cost of European ATM improvements and technologies, EUROCONTROL (2014)

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

[11] 16.06.06_D26-08 ATM CBA Quality Checklist

[12] 16.06.06_D26_04_Guidelines_for_Producing_Benefit_and_Impact_Mechanisms

11 Appendix

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

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

ATM Master Plan SESAR Performance Ambition KPA	ATM Master Plan SESAR Performance Ambition KPI	Performance Framework KPA	Focus Area	#KPI / (#PI) / <Design goal>	KPI definition
				(SEC4)	Military mission effectiveness risk after mitigation

[13] **Table 6: Mapping between ATM Master Plan Performance Ambition KPAs and SESAR 2020 Performance Framework KPAs, Focus Areas and KPIs**

-END OF DOCUMENT-