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Abstract

This document provides the Cost Benefit Analysis (CBA) for SESAR Project PJ.05 - Solution 05 – Advanced Automated MET System. The CBA forms part of the data pack supporting the TRL4 maturity gate session. This document was developed to:

* identify impacted stakeholders groups and propose a possible deployment scenario approach with different options according to airport needs;
* identify and agree on which of the Solution benefits will be monetised;
* provide an initial estimate of the potential costs of the Solution for MET Service provider.

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# Executive Summary

This document provides the Cost Benefit Analysis (CBA) for SESAR Project PJ.05 - Solution 05 – Advanced Automated MET System. The CBA forms part of the data pack supporting the TRL4 maturity gate session.

Two modes of the solution were analysed from Net Present Value (NPV) point of view to assess expected monetary benefits. Non-monetary benefits are elaborated based on related KPAs and stakeholders.

NPV calculated for year 2040 in today’s value is:

* Fully-automated mode 1 546 K EUR, payback year 0.
* Semi-automated mode 93.1 K EUR, payback year 4;

To calculate these values several variables and assumptions needed to be considered and therefore sensitivity analysis in relation to specific values was calculated later in the document.

The Final TRL4 CBA will present the available cost data and a qualified assessment of the benefits. Solution presented is being developed under technological solution PJ.05-05. It needs to be noted that the essence of technological solution is to develop technological enabler which supports ATM operational improvement (OI) of whole PJ.05 in later stages. Therefore this TRL4 CBA is produced with the aim to assess the benefits of proposed Solution in TRL4, which main focus is on feasibility assessment, but full picture of CBA will be achieved in TRL6 after further development and testing of the concept is completed with special focus on:

* remote MET service provided simultaneously for more than one aerodrome;
* improved methodology for statistical evaluation with larger dataset available;
* eliminating technical constraints.

This needs to be taken into the consideration when reading the document. Results shall output recommendations for the Solution PJ.05-05 about any changes which could decrease the costs and thus highlight benefits.

# Introduction

## Purpose of the document

This document provides the Cost Benefit Analysis (CBA) for SESAR Project PJ.05 - Solution 05 – Advanced Automated MET System.

This version is the final TRL4 CBA and it is developed to identify and agree on:

* the stakeholders who will incur costs related to the Solution which is driven by the Enablers (AERODROME-ATC-92, METEO-03c, METEO-04c) linked to the Solution OI Step (POI-0001-MET);
* which, if any, of the Solution benefits will be monetised in the TRL4 CBA model (developed in attached MS Excel in Chapter 6).

The CBA will cover the period from start of deployment of the Solution Enablers to 2040 (in line with PJ.19 recommendation). Any Net Present Values will be calculated back to 2019 (the end of Wave 1)

The stakeholder who needs to invest is:

* MET Service Provider.

The benefits are received by:

* Airport Operator;
* ANSP;
* Airspace Users.

## Scope

This document develops the scope of the TRL4 CBA for one OI Step included in **SESAR Project PJ.05 - Solution 05 – Advanced Automated MET System;** see section [3.2](#_SESAR_Solution_description) for details.

## Intended readership

This TRL4 CBA for Solution PJ.05-05 is written to provide useful information to the following audience:

* PJ.05 (Remote Tower) to ensure consistency within the project
* PJ.18 4DTM (4D Trajectory Management) for MET data acquisition
* PJ.19 CI (Content Integration) responsible for managing the content integration process to ensure the needed coherency between the different SESAR 2020 projects
* PJ.20 AMPLE (Master Plan Maintenance) responsible for ATM Master Plan maintenance
* PJ.22 SEABIRD (SE-DMF support).

## Structure of the document

The following sections of this document cover:

* Section [3](#_Objectives_and_scope) describes the scope and objectives of the TRL4 CBA
* Sections [4](#_Benefits) and [5](#_Cost_assessment) detail, respectively, the benefits and the costs
* Sections [6](#_CBA_Model), [7](#_CBA_Results) and [8](#_Sensitivity_and_risk) contain, respectively, details of the CBA model, the CBA results and sensitivity analysis
* Section [9](#_Recommendations_and_next) currently provides recommendations and next steps for the development of the Solution PJ.05-05.

## Background

Small/Other airports are typical candidates for application of Remote Tower, as it is difficult or economically inefficient to implement and staff a conventional manned facility. In SESAR programme, remote provision of air traffic control was examined, but no special attention has been given to provision of MET data remotely yet. At Small/Other airports, a 24/7 MET service is usually missing and is fully or partially replaced by automated MET reporting, simplified in several regards. Remote provision of MET service can serve to local air traffic stakeholders at the airport of provision, but all aeronautical users in-flight, during take-off and landing or in planning phase can benefit from more comprehensive weather reports originated at these Small/Other airports.

Several members of the project team had previously solved partial problems concerning the remote met service provision (activities outside SESAR):

* Experimentation with cloud observation by static camera with fisheye lens in visible light;
* Proof-of-concept of visibility recognition in industrial areas and in road traffic.

Moreover, one of the project linked third party is a producer of standard automated AWOS system that is utilized by more than 300 airports in many countries [10]. That AWOS was reused as technological base, upon which the new Remote Observer MET system was built within Solution PJ.05-05.

Remote provision and monitoring of full MET information (in comparison to human MET observations) was subject of validation exercise which aims to bring this technological solution to TRL4 maturity level.

## 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* |
| Cost Benefit Analysis | A Cost Benefit Analysis is a process of quantifying in economic terms the costs and benefits of a project or a program over a certain period, and those of its alternatives (within the same period), in order to have a single scale of comparison for unbiased evaluation. | *SESAR 1 [11]* |
| Business Case | A CBA is a neutral financial tool that helps decision makers to compare an investment with other possible investments and/or to make a choice between different options / scenarios and to select the one that offers the best value for money while considering all the key criteria for the decision. | *SESAR 1 [11]* |
| Advanced Automated MET System | Advanced weather observing system, which is capable to observe automatically all-weather elements contained in METAR/SPECI including that one, where state-of-the-art AWOS systems fail (e.g. visibility, present weather, clouds) and subsequently produces AUTO-METAR/AUTO-SPECI without solidi. | SESAR Solution PJ.05-05 TVALP for TRL4 [14] |
| AUTO-METAR  AUTO-SPECI | The optional code word AUTO shall be inserted before the wind group when a report contains fully automated observations without human intervention. The ICAO requirement is that all of the specified elements shall be reported. However, if any element cannot be observed, the group in which it would have been encoded shall be replaced by the appropriate number of solidi. The number of solidi depends on the number of symbolic letters for the specific group which is not able to be reported; i.e. four for the visibility group, two for the present weather group and three or six for the cloud group, as appropriate. | WMO 306, Vol I. [15] |
| AWOS | Automated Weather Observing System (AWOS) is a fully configurable airport weather system that provides continuous, real time information and reports on airport weather conditions. | ICAO Doc 9837 [13] |
| METAR  SPECI | Current aerodrome routine meteorological report (METAR) and aerodrome special meteorological reports (SPECI), which shall contain following elements:  a) identification of the type of report;  b) location indicator;  c) time of the observation;  d) identification of an automated or missing report, when applicable;  e) surface wind direction and speed;  f) visibility;  g) runway visual range, when applicable;  h) present weather;  i) cloud amount, cloud type (only for cumulonimbus and towering cumulus clouds) and height of cloud base or, where measured, vertical visibility;  j) air temperature and dew-point temperature; and  k) QNH and, when applicable, QFE (QFE included only in local routine and special reports). | ICAO Annex 3 [12] |
| Prevailing visibility | The greatest visibility value, observed in accordance with the definition of “visibility”, which is reached within at least half the horizon circle or within at least half of the surface of the aerodrome. These areas could comprise contiguous or non-contiguous sectors. | ICAO Annex 3 [12]  ICAO Doc 9837 [13] |
| Small/Other airports | Sub-operational environment (airport) with certain Annual airport's movements (range). For small airports: (40 000; 15 000]; Other airports: < 15 000. | Airports Dataset compiled by SESAR 2020 PJ20 WP2.2 WG [16] |
| Visibility | Visibility for aeronautical purposes is the greater of:  a) the greatest distance at which a black object of suitable dimensions, situated near the ground, can be seen and recognized when observed against a bright background;  b) the greatest distance at which lights in the vicinity of 1 000 candelas can be seen and identified against an unlit background. | ICAO Annex 3 [12]  ICAO Doc 9837 [13] |

## List of Acronyms

|  |  |
| --- | --- |
| Acronym | Definition |
| **ACC** | Area Control Centre |
| **ATM** | Air Traffic Management |
| **AWOS** | Automated Weather Observing System |
| **CBA** | Cost Benefit Analysis |
| **F-AM** | Fully-automated mode |
| **HC** | High complexity (airport) |
| **HW** | Hardware |
| **LC** | Low complexity (airport) |
| **METAR** | Meteorological Terminal Air Report |
| **NPV** | Net Present Value |
| **OI** | Operational Improvement |
| **PIRM** | Programme Information Reference Model |
| **PAR** | Performance Assessment Report |
| **SESAR** | Single European Sky ATM Research Programme |
| **S-AM** | Semi-automated mode |
| **SJU** | SESAR Joint Undertaking (Agency of the European Commission) |
| **SW** | Software |
| **TMA** | Terminal Manoeuvring Area |
| **TVALP** | Technical Validation Plan |

# Objectives and scope of the CBA

## Problem addressed by the solution

Adverse weather brings unwelcome disruptions into aviation industry. The impact of adverse weather on Airport Operations, Airspace User Operations and ATS Operations can be mitigated by the timely sharing of high quality, precise, trustworthy and best available meteorological information. Many airports utilize automated weather observation instead of full meteorological observation. However, automated observations, especially of visibility, significant weather phenomena or clouds can fail (e.g. standard sensors do not capture inhomogeneous visibility conditions or cloud cover situation correctly).

Solution PJ.05-05 (Advanced Automated MET System for Remote Airport) provides two options (modes), how to cope with the current disadvantages. Both rely on visible light and infrared cameras and multiple sensor analysis. At the core of the first option is processing by artificial intelligence algorithms, the second one includes concept of remotely located human MET Observer.

## SESAR Solution description

Adverse weather brings unwelcome disruption to flight schedules and is the cause of approximately 13 % [9] of Europe’s primary delays. Yet the impact can be mitigated by the timely sharing of high quality, precise, trustworthy and best available meteorological information so that effective planning and actual decision making can be put in place. More precise MET information can assist flight planning, resource planning and route planning, and can help to avoid unnecessary delay.

Solution PJ.05-05 develops and validates a system which significantly enhances current scope of automated weather observation (AUTOMETAR) in conditions where it is difficult or too expensive to implement and staff a conventional manned facility. AUTOMETAR from such locations currently contains some weather elements reported in simplified form only and some are omitted completely.

The simplified and/or omitted (please see examples of simplification and omission below) weather elements are prevailing visibility, aeronautically significant weather phenomena and clouds, despite their significance:

* Low clouds can create low ceilings, deteriorate visibility and can change rapidly, thereby influencing flight planning. VFR traffic is significant at small airports and low clouds can make VFR flight impossible. Clouds with extensive vertical development cause range of adverse effects ranging from turbulence, wind gusts to wind shear, lightning and variety of significant weather phenomena
* Prevailing visibility enables or disables VFR and special VFR flights
* Significant weather phenomena encompass liquid, solid and freezing precipitation, thunderstorms, tornadoes and other.

Examples of simplifications and omissions in current AWOS (Automated Weather Observing System at aerodrome) systems, and where we identified the possibilities for improvement:

* CLOUD AMOUNT is calculated from observation of single point in the sky (by laser ceilometer)[[1]](#footnote-2). Calculations use simplified assumption of homogenous cloud coverage all over the sky, which is not always valid. In our proposed solution the whole sky is captured by VIS+IR camera, interpreted a) fully automatically by software, b) by remotely located observer.
* CLOUD TYPE – TOWERING CUMULUS (TCU) is omitted. In proposed solution it is reported when recognized by remotely located observer.
* CLOUD TYPE – CUMULONIMBUS CLOUD (CB) is omitted at some airports, or reported from a single lightning sensor at others. In proposed solution it is reported when recognized by remotely located observer.
* PREVAILING VISIBILITY is simplified. Reported visibility sensor value is measured in one point.[[2]](#footnote-3) In proposed solution the PREVAILING VISIBILITY is reported from examination of horizontal visibility taken by camera 360 degrees around the airport, using analysis of camera images by a) software, b) remotely located observer.
* PREVAILING VISIBILITY – DIRECTIONAL VARIATIONS are omitted. In proposed solution the DIRECTIONAL VARIATIONS are reported from examination of horizontal visibility taken by camera 360 degrees around the airport, using analysis of camera images by a) software, b) remotely located observer.
* FOG TYPES. Recognition of horizontally inhomogeneous fog types (partial fog PRFG, fog patches BCFG) was improved using camera imagery.
* Special phenomena like SHOWERS IN VICINTY of the airport (VCSH) are omitted from AUTOMETARS, because current automatic systems cannot report these phenomena. In our research, images captured by VIS+IR camera were analysed by remotely located observer, in order to identify these phenomena.

Thereby SESAR Solution PJ.05-05 addresses following key needs by collecting and analysing of images from dual visible/infrared camera:

* enhance possibilities of automatic measurement of visibility/prevailing visibility (automatic recognition of pictures by AI methods/HMI for manual processing of pictures)
* enhance possibilities of automatic measurement of clouds - evaluation of cloud cover (automatic recognition of pictures by AI methods/HMI for manual processing of pictures) and height (and significant cloud type in manual processing = human in the loop concept)
* enhance possibilities of enhanced automatic / remote human-in-the-loop detection of aeronautically significant MET phenomena

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 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.05-05 | POI-0001-MET | Improved Weather Awareness through Enhanced Automated MET observation | Fully |  |

Table : SESAR Solution PJ.05-05 Scope and related OI steps

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| OI Steps ref. | Enabler[[3]](#footnote-4) ref. | Enabler definition | Enabler coverage | Applicable stakeholder | Comments on the Enabler / definition |
| POI-0001-MET | AERODROME-ATC-92 | Real-time airport weather observation service with AI algorithms | Fully | All stakeholders using MET information for their operation (airspace users, airports and air navigation service providers) |  |

Table : OI steps and related Enablers

## Objectives of the CBA

The CBA is required to assess the affordability of a Solution with respect to its expected benefits for each SESAR Solution under the responsibility of Solution projects. [1]

In V2, the feasibility phase, the CBA assesses the economic feasibility of the solution(s) and can help to compare different alternatives e.g. a system implemented with a centralised or local backups or whether a solution is deployed everywhere or only in most complex environments. In this phase there is a quantitative assessment of both costs and benefits (i.e. the performance assessment) of SESAR Solutions. In areas such as safety, security, environment and human performance the benefits are assessed only qualitatively but the costs (e.g. to implement associated requirements) need to be monetised. Critical variables to the economic value of the solution(s) are identified and recommendations for further research to reduce critical uncertainties and improve quality of inputs are made for V3. In V2, the output should already include a first order of magnitude of benefits and net present value (NPV) of the different options being compared. [1]

Specific to this document is that this CBA is prepared for technological solution and therefore the maturity level is measured as technology readiness level (TRL). V2 level equals to TRL4, in which the Solution PJ.05-05 is currently assessed.

Main objective of this TRL4 CBA is to provide benefits that can be expected after implementation of the Solution as well as costs which are related to its implementation and operation. Benefits related to KPAs are not monetised in this stage. Costs values are subject of further assessment, calculating NPV for solution scenarios. Sensitivity analysis is developed as well, to identify the most critical variables to the economic value of the scenarios and presented in tornado diagram.

Solution options analysed in this TRL4 CBA:

* Fully-automated mode – MET service provided without intervention of human element;
* Semi-automated mode – remotely provided MET service with intervention of human element.

Several assumptions were made to provide missing information for calculations and these needs to be taken into consideration when reading the document.

Finally at the end of the document recommendations and next steps for TRL6 phase are provided.

## Stakeholders[[4]](#footnote-5) identification

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 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 |  | Benefits from improved weather information using the solution outputs | Not involved | no cost estimation |
| Airport Operators |  | Benefits from improved weather information using the solution outputs | Not involved | no cost estimation |
| Network Manager |  |  |  |  |
| Scheduled Airlines (Mainline and Regional) |  | Benefits from improved weather information using the solution outputs | Not involved | no cost estimation |
| Business Aviation |  |  |  |  |
| Rotorcraft |  |  |  |  |
| General Aviation IFR |  | Benefits from improved weather information using the solution outputs | Not involved | no cost estimation |
| General Aviation VFR |  | Benefits from improved weather information using the solution outputs | Not involved | no cost estimation |
| Military – Airborne |  |  |  |  |
| Military – Ground |  |  |  |  |
| Other impacted stakeholders (ground handling, weather forecast service provider, NSA….) | MET service provision at the airport | Enhanced tools for (automatic) weather observation of clouds, visibility and phenomena  Remote MET service provision | Involvement in both reference and solution scenario (Semi-automated mode of Advanced Automatic MET System) | costs and benefits estimations provided |

Table : SESAR Solution PJ.05-05 CBA Stakeholders and impacts

## CBA Scenarios and Assumptions

This section describes the scenarios that have been compared in the CBA. The minimum is a CBA scenario that reflects the delta (difference) between the Reference scenario (where the Solution is not deployed) and the Solution scenarios (reflecting the proposed deployment of the Solution at applicable locations). The scenario is based on the common assumptions and scenarios of the Solution (two different modes of the Solution).

### Reference Scenario

The Reference Scenario considers the future situation but without the deployment of the Solution. The CBA takes a ‘delta’ approach so the aspects that are monetised are the differences between the Reference and Solution scenarios. The Reference Scenario will not be quantified.

METAR message reported locally at the airport by professional aeronautical MET Observer, serves as source of the true weather information.

### Solution Scenarios

*Fully–automated mode:* observations of weather, including clouds, visibility and significant phenomena by new system containing camera imagery processed by AI algorithms.

Deployment of Advanced Automated MET System in Fully-automated mode requires installation of visible and infrared cameras in order to take images of whole sky and horizon regularly in sufficient quality for automatic picture recognition. Moreover integration of high level software modules for picture recognition and assessment of clouds and visibility is necessary.

*Semi-automated mode* of Advanced Automatic MET System enables remote human observer interaction with automatic observation of clouds, visibility and significant MET phenomena via dedicated HMI.

Deployment of Advanced Automated MET System in Semi-automated mode requires installation of visible and infrared cameras in order to take images of whole sky and horizon regularly in sufficient quality and respective software for their processing. Dedicated HMI for Human Observer is necessary to allow processing of images from cameras to ease and support his job in observation of clouds and prevailing visibility. While this mode of Solution enables human observation from remote location, it has potential to optimize human resources.

### Assumptions

The table below reports the main parameters affecting the CBA results. Local assumptions, made by PJ.05-05 CBA team and internal experts, were added on the top of common assumptions.

|  |  |  |
| --- | --- | --- |
| **Variable** | **Value** | **Source** |
| Applied currency | EUR |  |
| Reference period | 13 years (2028-2040) | SESAR PJ.19 |
| Investment period | 2028-2032 |  |
| Discount rate | 6 % | EUROCONTROL CBA team advise |
| AWOS (or similar technology on the aerodrome) | installed | PJ.05-05 CBA team assumption |
| No. of airports with installed solution | 1 | Validation report |
| Annual MET observer costs | 30 000 per year | PJ.05-05 CBA team assumption |
| Overhead costs for provision of MET service for single airport  (The value includes only costs for renting dedicated room MET office on local airport where MET observer executes his duty. Other costs (energies, internet) are considered to be the same at remote location.) | 3 600 | PJ.05-05 CBA team assumption |
| No. of MET observers remotely providing continuous service 24/7 for single aerodrome after installation of Semi-automated solution | 5.5 | PJ.05-05 CBA team assumption |
| No. of MET observers providing continuous service 24/7 for single aerodrome after installation of Fully-automated solution | 0 (100% reduction) | PJ.05-05 CBA team assumption |
| Investment costs for solution (Investments costs for one airport includes HW procurement and installation, SW development, initial test and evaluation, technical documentation and training of MET personnel) | 55 700 Semi-automated mode  66 300 Fully-automated mode | Estimated by internal experts |
| Operational costs for solution (HW and SW maintenance, training of new personnel) | 2 150 per year for Semi-automated mode  1 900 per year for Fully-automated mode | Estimated by internal experts |

Table : SESAR Solution PJ.05-05 CBA Solution Scenario

# Benefits

This section should describe the monetised benefits derived from the implementation of the Solution PJ.05-05, based on the CBA Scenarios illustrated in the previous section. Since the aim of the TRL4 maturity level is to ensure SESAR operational feasibility, CBA prepared in this level will be building on current level of concept maturity considering only initial feasibility assessment of proposed technological solution. As technological solution should stand as enabler for future SESAR ATM Solutions and support or enable ATM Performance Improvements achieved after its implementation [1], KPAs affected by this Solution can be either enhanced or diminished when fully mature PJ.05 ATM Solution is applied.

Provision of extended MET information remotely as described in this PJ.05-05, for airport where no human MET observer is present (at all or partially, e.g. in night time) impacts all users of MET data (e.g. Airspace Users (Pilots), airports and TMA Controllers) in positive way (in terms of safety, capacity), because current capacities of automatic MET information provision does not contain all aeronautically significant data. Therefore usability of such airport will be enhanced by improved quality of MET information provided.

This improved weather information, once properly integrated within air traffic management decision-making process, facilitates the advantage of staying up to date with the latest weather situation for airspace users, airports and air navigation service providers.

Usefulness of HMI for remote observations was assessed positively by the remote MET Observer. HMI allowed inserting their own assessment of remotely observed weather situation. For observation of clouds, prevailing visibility and phenomena prototype (Advanced Automated MET System) was available instead of manual (visual) observation on-site. The HMI of the system enabled remote MET Observers:

* to mark, if the visibility point is visible or not (for prevailing visibility calculation),
* to assess the amount and various layers of clouds (overlaid over the composed image of sky),
* to preview video from camera and enter recognized phenomena.

From Human Performance perspective the most important result is, that proposed solution enables MET Observer to be located at remote site (e.g. some central MET office) and carry out his/her tasks with acceptable level of workload, adequate accuracy and timelines of information, not decreasing the quality of provided service.

Improvements that Solution brings should have direct impact on Safety. With improved aerodrome weather information the AU should be able to better prepare and plan for intended flight and streamline the decision making process. It will limit the number of unexpected situations and the need of ad hoc decisions and provide more time to decide about diverting to other airport, returning or cancelling the flight.

As far as Capacity is concerned, it needs to be mentioned that the most probable operating environment where this solution will be implemented are Small/Other airports [16] (small regional airport with very low traffic) with unevenly distributed traffic. These aerodromes are therefore not dealing with capacity problems that are facing Large or Medium [16] sized airports. Benefits that PJ.05-05 brings for AO are more precise weather information which can reduce the time of the airport unavailability due to the adverse weather.

All of the abovementioned elements should contribute to improve Cost Efficiency as primary as well as secondary aspect. Primarily as showed with calculations of NPV investment into proposed solution should decrease the costs of MET service provision on specific airport and therefore should be reflected in the related charges billed by ATS to the user. Secondly the cumulative effect of increased traffic on the aerodrome should increase the airport revenues and therefore can decrease the unit price for airspace user.

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| Performance Framework KPA[[5]](#footnote-6) | Focus Area | KPI/PI from the  Performance Framework | Unit | Metric for the CBA | Unit | Year 2019 | Fully -automated | Semi-automated |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Cost Efficiency | ANS Cost efficiency | **CEF2**  Flights per ATCO-Hour on duty | No. | ATCO employment Cost change | €/year | *N/A* | *N/A* | *N/A* |
| Support Staff Employment Cost Change | €/year | *180000* | *0* | *165 000* |
| Non-staff Operating Costs Change | €/year | *3600* | *1900* | *2150* |
| **CEF3** Technology cost per flight | EUR / flight | G2G ANS cost changes related to technology and equipment | €/year | *N/A* | *N/A* | *N/A* |
| Airspace User Cost efficiency | **AUC3**  Direct operating costs for an airspace user | EUR / flight | Impact on direct costs related to the aeroplane and passengers. Examples: fuel, staff expenses, passenger service costs, maintenance and repairs, navigation charges, strategic delay, landing fees, catering | €/year | *N/A* | *N/A* | *N/A* |
| **AUC4**  Indirect operating costs for an airspace user | EUR / flight | Impact on operating costs that don’t relate to a specific flight. Examples: parking charges, crew and cabin salary, handling prices at Base Stations | €/year |  | *Expected benefit thanks to reduced costs of MET provision* | *Expected benefit thanks to reduced costs of MET provision* |
| **AUC5**  Overhead costs for an airspace user | EUR / flight | Impact on overhead costs. Examples: dispatchers, training, IT infrastructure, sales. | €/year | *N/A* | *N/A* | *N/A* |
| Capacity | Airspace capacity | **CAP1**  TMA throughput, in challenging airspace, per unit time | % and *#* movements | Tactical delay cost (avoided-; additional +) | €/year | *N/A* | *N/A* | *N/A* |
| % and *#* movements | Strategic delay cost (avoided-; additional +) | €/year | *N/A* | *N/A* | *N/A* |
| **CAP2**  En-route throughput, in challenging airspace, per unit time | % and *#* movements | Tactical delay cost (avoided-; additional +) | €/year | *N/A* | *N/A* | *N/A* |
| % and *#* movements | Strategic delay cost (avoided-; additional +) | €/year | *N/A* | *N/A* | *N/A* |
| Airport capacity | **CAP3**  Peak Runway Throughput  (Mixed mode) | % and *#* movements | Value of additional flights | €/year |  | *Expected benefit thanks to more precise weather information* | *Expected benefit thanks to more precise weather information* |
|  | Resilience | **RES4a**  Minutes of delays | Minutes | Tactical delay cost (avoided-; additional +) | €/year | *N/A* | *N/A* | *N/A* |
|  |  | **RES4b**  Cancellations | % and *#* movements | Cost of cancellations | €/year | *N/A* | *N/A* | *N/A* |
|  |  | Diversions | % and *#* movements | Cost of diversions | €/year | *N/A* | *N/A* | *N/A* |
| Predictability and punctuality | Predictability | **PRD1**  Variance of Difference in actual & Flight Plan or RBT durations | Minutes^2 | Strategic delay cost (avoided-; additional +) | €/year | *N/A* | *N/A* | *N/A* |
| Punctuality | **PUN1**  % Departures < +/- 3 mins vs. schedule due to ATM causes | % (and *#* movements) | Tactical delay cost (avoided-; additional +) | €/year | *N/A* | *N/A* | *N/A* |
| Flexibility | ATM System & Airport ability to respond to changes in planned flights and mission | **FLX1**  Average delay for scheduled civil/military flights with change request and non-scheduled / late flight plan request | Minutes | Tactical delay cost (avoided-; additional +) | €/year | *N/A* | *N/A* | *N/A* |
|  |  |  |  |
| Environment | Time Efficiency | **FEFF3**  Reduction in average flight duration | % and minutes | Strategic delay: airborne: direct cost to an airline excl. Fuel (avoided-; additional +) | €/year | N/A | *N/A* | *N/A* |
|  | Fuel Efficiency | **FEFF1**  Average fuel burn per flight | Kg fuel per movement | Fuel Costs | €/year | N/A | *N/A* | *N/A* |
|  | Fuel Efficiency | **FEFF2**  CO2 Emissions | Kg CO2 per movement | CO2 Costs | €/year | N/A | *N/A* | *N/A* |
| Civil-Military Cooperation & Coordination | Civil-Military Cooperation & Coordination | **CMC2.1a**  Fuel saving (for GAT operations) | Kg fuel per movement | Fuel Costs | €/year | N/A | *N/A* | *N/A* |
| **CMC2.1b**  Distance saving (for GAT operations) | NM per movement | Time Costs | €/year | N/A | *N/A* | *N/A* |

Table : Results of the benefits monetisation per KPA

# Cost assessment

For the purposes of this chapter we assume that provision of MET service is not part of ANSP services.

## ANSPs costs

As mentioned in previous chapters we expect that costs of ANSP will be reduced due to expected decrease of MET service costs. More detailed explanation of this decrease is provided in chapter 5.2 Other relevant stakeholders.

## Other relevant stakeholders

The technological solution PJ.05-05 proposes enabler that should contribute to the ATM Performance Improvement. Costs described in this chapter are derived mostly from expert judgment of CBA development team, available literature [17] and own research. Further research in TRL6 is needed to achieve more specific figures and therefore more accurate and credible results.

During TRL4 new Enabler AERODROME-ATC-92 — Real-time Airport Weather Observation service with Artificial Intelligence algorithms was created. This enabler is currently supported by another two enablers METEO-03c and METEO-04c (DS18 Dataset) [18], however there is currently ongoing discussion with PJ.18 and PJ.19 about reshuffling them and bringing new “order” to MET related enablers and supporting elements.

### MET service provider cost approach

Primary methods used for obtaining cost figures were expert judgement combined with dedicated analysis. Slovak Hydrometeorological Institute (SHMI) which stands for MET service provider in Slovak republic together with MicroStep-MIS provided estimated values. Local values valid only for Slovak region were in the next step recalculated to achieve ECAC average levels, to allow wider applicability of proposed solution.

PJ.05-05 is working with only one main enabler AERODROME-ATC-92 which is supported by two other, more generic meteorological enablers. All figures and calculations are built on AERODROME-ATC-92 level. As mentioned in previous chapter, change in organisation of these enablers after DS18 dataset is possible.

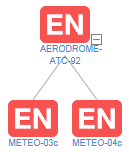


Figure 1: Enablers used in PJ.05-05

To receive more credibility for the figures and calculations, this document will be submitted for internal as well as external review. This review should be performed by experts from the field analysed in this solution and therefore their feedback will be valuable contribution to the document.

### MET service provider cost assumptions

All assumptions are provided in chapter 3.5.3 Assumptions and are related to MET service provider costs.

Table below summarises costs assumptions made by PJ.05-05 CBA team.

|  |  |  |
| --- | --- | --- |
| **Variable** | **Value** | **Source** |
| Annual MET observer costs | 30 000 per year | PJ.05-05 CBA team assumption |
| Overhead costs for provision of MET service for single airport  (The value includes only costs for renting dedicated room MET office on local airport where MET observer executes his duty. Other costs (energies, internet) are considered to be the same at remote location.) | 3 600 | PJ.05-05 CBA team assumption |
| Investment costs for solution (Investments costs for one airport includes HW procurement and installation, SW development, initial test and evaluation, technical documentation and training of MET personnel) | 55 700 Semi-automated mode  66 300 Fully-automated mode | Estimated by internal experts |
| Operational costs for solution (HW and SW maintenance, training of new personnel) | 2 150 per year for Semi-automated mode  1 900 per year for Fully-automated mode | Estimated by internal experts |
| No. of MET observers providing remotely continuous service 24/7 for single aerodrome | 5.5 | PJ.05-05 CBA team assumption |

Table : MET service provider cost assumption

The annual MET observer costs assumption is based on average annual MET observer costs in Slovakia, which was adjusted based on average annual wage ratio between Slovakia and all ECAC countries (Slovak average wage is 61% of ECAC average)

The overhead costs for provision of MET service for single airport assumption as explained in the table contains only figures that will be reduced when MET service is provided from remote central MET office. Costs for energies and internet connection are considered for both locations to be on the same price level. Cost reduction in this case will then consist from savings on rental costs which MET office needs to pay when it is located directly at the airport tower or at specific aerodrome.

The investment costs for solution assumption were prepared by MicroStep-MIS experts who took advantage of their vast commercial expertise with product pricing in this discipline.

The operational costs for solution assumption were determined by MicroStep-MIS experts based on experience with operational costs of similar solutions operated through whole ECAC area. The difference between Fully and Semi-automated mode is caused by the need of training for newcoming remote MET observer.

Number of MET observers providing continuous service 24/7 for single aerodrome was estimated to 5.5 and means decrease of 0.5 personnel in comparison to local provision of service by MET observers. It is expected that the service provided remotely will be centralised into MET office and offered for more airports in the country/ region. In such case the supervisor will be able to cover more personnel on duty and that means decrease in total number of personnel for one airport.

All assumptions provided in this chapter, related to MET service provider costs have substantial impact on calculation of NVP and therefore on whole rentability of proposed Solution from monetary point of view. The assessment of the impact of specific items on NPV is described in chapter 8 Sensitivity and risk analysis.

### Number of investment instances (units)

Based on the categorisation of Sub-Operating Environment performed by PJ.20 sWP2.2 WG in SESAR 2020 [19] there are 862 airports categorised as Other and 88 aerodromes categorised as Small in ECAC area. Significant characteristic of these airports is low and irregularly distributed traffic during the year. These airports are primary target group for Remote Tower concept due to inefficiency of keeping them manned all year long. To enhance Remote Tower concept, the Solution PJ.05-05 is focusing on improving the quality of automated meteorological information and offering ability to be provided from remote location. Since manned provision of meteorological service can be significant part of the budget, this can be centralised and provided remotely for several Small/Other airports from one central MET office in country, which can significantly reduce “unit” cost of MET service. Therefore PJ.05-05 concept is not limited only for aerodromes where remote tower is installed and in use but can bring benefits in terms of costs saving to all other conventional towers.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Number of Airports according to SESAR 2020 Airports' Classification Scheme in ECAC area | | | | | |
| Very Large | Large | Medium | Small | Other | Not classified |
| 12 | 19 | 77 | 88 | 862 | 98 |

Table : ECAC airport distribution according SESAR 2020 classification [19]

### Cost per unit

The following table includes the investment and operating costs that are expected for each solution scenario.

|  |  |  |  |
| --- | --- | --- | --- |
| Cost category | | MET service provider | |
| **Fully-automated mode** | **Semi-automated mode** |
| Pre-Implementation Costs | | | |
|  |  | SESAR R&D costs (up to V3) are not included as costs in CBA. This CBA is focusing on deployment, i.e. what the stakeholders will pay to put the solution in place [3] and operation. Assumptions made about solution prerequisites need to be taken into consideration. | |
| Implementation costs (€) | | | |
|  | One-off Costs | 7 000 | 7 000 |
|  | Capital Costs | 59 300 | 47 200 |
|  | Transition Costs | 0 | 1 500 |
| Operating costs (€) | | | |
|  | Personal | 0 | 165 000 |
|  | Training | 0 | 250 |
|  | Maintenance & Repair | 1 900 | 1 900 |

Table 8: Cost per category

# 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 assumptions were used and sensitivity analysis calculated which displays sensitivity of the model on each category of the variable.

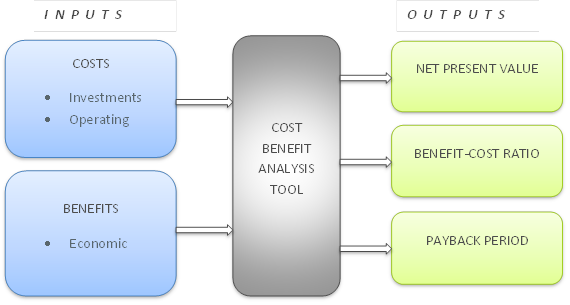


Figure 2: CBA model



## Data sources

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

Sources of information are:

• Data from other studies;

• Historical data and forecasts;

• ANSP (LPS SR) internal resources (experts from Technical, Operational and Finance departments);

• ANSP industrial partner’s (MicroStep-MIS) recommendations (experts from Technical, Operational and Finance departments);

• 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.

# CBA Results

## Deploying Fully-automated mode

The Figure below shows discounted benefits, discounted costs and cumulative cash flow for remotely provided MET service for single remote airport implementing Fully-automated mode solution.

**The Investments costs – 66.3 K EUR; Operating costs – 1.9 K EUR.**

Figure 3: Fully-automated mode

The Table below represents the outputs of the CBA.

|  |  |  |  |
| --- | --- | --- | --- |
| Fully-automated mode (single remote airport) | NPV | Benefit-Cost ratio | Payback period |
| 1 546 K EUR | 2.7:1 | 0 |

Table 9: The outputs of the CBA (Fully-automated mode)

In comparison to Semi-automated mode in this scenario it is expected that with implementation of Fully-automated mode no intervention from MET observer (remote or local) is neccessary. Therefore from the year one significant reduction in costs is achieved, since amount of personnnel costs makes substantial share on total costs compared to investment costs and operational costs.

Furthermore non monetary aspect is applicable here as well. Provision of extended MET information automatically for airport where no human MET observer is present (at all or partially, e.g. in night time) impacts all users of MET data (e.g. Airspace Users (Pilots), airports and TMA Controllers) in positive way (in terms of safety, capacity), because current capacities of automatic MET information provision does not contain all aeronautically significant data. Therefore usability of such airport will be enhanced by improved quality of MET information provided. However, enhancement of MET information is not as significant as for Semi-automated mode.

This improved weather information, once properly integrated within air traffic management decision-making process, facilitates the advantage of staying up to date with the latest weather situation for airspace users, airports and air navigation service providers.

It is expected that main benefits of remote provisioning of MET service will be appreciated in locations where it is already difficult to find qualified personnel, or it is difficult to motivate them to relocate.

## Deploying Semi-automated mode

The Figure below shows discounted benefits, discounted costs and cumulative cash flow for remotely provided MET service for single remote airport implementing Semi-automated mode solution.

**The Investments costs – 55.7 K EUR; Operating costs – 2.15 K EUR.**

Figure 4: Semi-automated mode

The Table below represents the outputs of the CBA.

|  |  |  |  |
| --- | --- | --- | --- |
| Semi-automated mode (single remote airport) | NPV | Benefit-Cost ratio | Payback period |
| 93.1 K EUR | 1:3.5 | 4 years |

Table 10: The outputs of the CBA (Semi-automated mode)

In this table the benefit of implemeting Semi-automated mode for provision of MET service for single airport seems to have positive results in fourth year of operations. As was already indicated in previous chapters this Solution is currently in TRL4 maturity level. Even though it is not expected that financial figures will significantly change in TRL6, one of the elements for further research would be abbility of MET observer to handle provisioning of remote MET service simultaneously for more than one aerodrome. In such case there will be remarkable change in financial benefits due to reduction in the number of MET observers per single aerodrome.

There is also non monetary aspect of this solution. Provision of extended MET information remotely for airport where no human MET observer is present (at all or partially, e.g. in night time) impacts all users of MET data (e.g. Airspace Users (Pilots), airports and TMA Controllers) in positive way (in terms of safety, capacity), because current capacities of automatic MET information provision does not contain all aeronautically significant data. Therefore usability of such airport will be enhanced by improved quality of MET information provided.

This improved weather information, once properly integrated within air traffic management decision-making process, facilitates the advantage of staying up to date with the latest weather situation for airspace users, airports and air navigation service providers.

It is expected that main benefits of remote provisioning of MET service will be appreciated in locations where it is already difficult to find qualified personnel, or it is difficult to motivate them to relocate.

## Deploying solution in ECAC

Project PJ.05 Remote Tower is focusing and expected to bring benefits to airports classified as Small and Other. The essence of the Solution PJ.05-05 is provisioning of MET service remotely and it is not limited to the size or complexity of the aerodrome. However from economic point of view, most interesting results when it comes to costs savings and benefits it brings for Small and Other airports because for these aerodromes the presence of MET personnel makes significant share of costs compared to its total costs. For these and other reasons mentioned in section 4 Benefits, it is expected that main benefit after considering all aspects it would have for these (Small and Other) groups of airports. In ECAC area there is currently 88 airports categorised as Small and 862 categorised as Other.

As mentioned in chapters through this document the current level of maturity is TRL4. For fully mature Semi-automated mode solution it is expected that it will be offered from central MET office covering more than one airport to multiply the benefit. The validation of this option is expected to be performed in TRL6. It was not calculated how many airports could be possibly handled by one MET observer and therefore it is not known what would be the costs of such solution. Applicability to ECAC level is hence provided in relation to D2.1.007 PJ05 CBA document for Fully-automated mode (30 installations). For Semi-automated mode assumption of 60 installations was made, however these numbers are very modest when considering the number of investment instances. All calculations are provided in CBA model embedded in chapter 6.

Figure 5: ECAC deployment Fully-automated mode

Figure 6: ECAC deployment Semi-automated mode

# Sensitivity and risk analysis

Sensitivity analysis tests the effect of changes in variable values. Different NPV values are calculated by varying one given input between its low and high value, while keeping all other inputs at their base values.

The values for low and high margins (+/- 33.33%) were chosen to provide evidence of sensitivity of NPV on change in cost type. The discount rates for low and high margin was selected based on advice from EUROCONTROL CBA team.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Variable tested | Low | | Base | | High | |
| **F-AM** | **S-AM** | **F-AM** | **S-AM** | **F-AM** | **S-AM** |
| Investment costs (thous. €) | 44.2 | 37.14 | 66.3 | 55.7 | 88.4 | 74.26 |
| Operational costs (thous. €) | 1.27 | 1.43 | 1.9 | 2.15 | 2.53 | 2.87 |
| Discount rate | 4% | | 6% | | 8% | |

Table 11: The outputs of the CBA (Full and Semi-automated mode) (ECAC)

Figures below illustrates the relative sensitivity of the variables of the model in case of Fully and Semi-automated mode. In case of Fully-automated mode NPV is most sensitive on changes in the level of discount rate due to rather low amount of investment and operational costs in comparison with expected benefits.

Figure 7: Sensitivity analysis Fully-automated mode

Also in case of Semi-automated mode highest influence on NPV has discount rate. The sensitivity to other variables is more significant here due to the fact that change in these values largely influence resulting NPV.

Figure 8: Sensitivity analysis Semi-automated mode

The PJ.05-05 Solution is currently aiming to achieve TRL4 maturity level and after discussion with EUROCONTROL CBA team it was agreed that NPV risk analysis does not need to be calculated in this stage of the project.

# Recommendations and next steps

As mentioned in chapters through this document the current level of maturity is TRL4. Therefore this TRL4 CBA is produced with the aim to assess the benefits of proposed Solution in TRL4, which main focus is on feasibility assessment. CBA prepared in this level will be building on current level of concept maturity considering only initial feasibility assessment of proposed technological solution. Full picture of CBA will be achieved in TRL6 after further development and testing of the concept is completed. It implies also recommendations and next steps.

One of the elements for further research would be ability of MET observer to handle provisioning of remote MET service simultaneously for more than one aerodrome from a central MET office. The validation of this option is expected to be performed in TRL6. It was not tested how many airports could be possibly handled by one MET observer and therefore it is not known what would be the costs of such solution. Nevertheless, in such case there will be remarkable change in financial benefits not only due to reduction of overhead costs (see Section 5.2.2), but also in the number of MET observers per single aerodrome.

Based on the results obtained during validation exercise for Advanced Automated MET System summarized in the TRL4 TVALR [20] the following recommendations for next development of the system appeared in order to further enhance quality of MET information from airport without MET observer representing non-monetary benefits of the Solution:

* Improve methodology for statistical evaluation of results to eliminate human factor (subjective assessment, sometime not for exactly the same time). More observers would create METAR message on-site in exact time point and also more remote observers would create AUTOMETAR message using the system and camera images from exactly the same time.
* Address the wiper problems
* Increase frequency of observations and extent to 24 hours
* Statistical evaluation of all concerned MET parameters at larger dataset.

# References and Applicable Documents

## Applicable Documents

1. SESAR 2020 Project Handbook, Edition 01.00.01 FINAL 27th April 2017
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 Monetise Benefits for CBAs, Edition 00.02.02

## Reference Documents

1. 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)
2. European ATM Master Plan Portal <https://www.atmmasterplan.eu/>
3. SESAR C.02-D110, Updated D02 after MP Campaign, Edition 00.01.00
4. SESAR 2020 D108, Transition Performance Framework, Edition 00.06.00
5. SESAR 2020 D86, Guidance on KPIs and Data Collection – Support to SESAR2020 transition
6. <http://www.eurocontrol.int/news/weather-resilience-forum-2015>

1. [https://www.microstep-mis.sk/web/references/list-of-references]( https://www.microstep-mis.sk/web/references/list-of-references )
2. SESAR 16.06.06, D48, SESAR Business Case Example – Remote Tower, Edition 00.01.02
3. Meteorological Service for International Air Navigation – ICAO Annex 3 – 16th Edition –2007.
4. Manual on Automatic Meteorological Observing Systems at Aerodromes – ICAO Doc 9837 – 2nd Edition – 2011
5. SESAR Solution PJ.05-05 TVALP for TRL4
6. Manual on Codes Volume I.1 – WMO - No. 306 – 2011 edition (updated in 2016)
7. Airports Dataset compiled by SESAR 2020 PJ20 WP2.2 WG
8. Standard Inputs for EUROCONTROL Cost-Benefit Analyses, Edition Number: 8.0 January 2018
9. Master Plan Dataset 18
10. Airport OE dataset; December 2017; Version (1\_0)
11. SESAR Solution PJ.05-05 TVALR for TRL4

# Appendix

Mapping between ATM Master Plan Performance Ambition KPAs and SESAR 2020 Performance Framework KPAs, Focus Areas and KPIs, source reference *[7]*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **ATM Master Plan SESAR Performance Ambition KPA** | **ATM Master Plan SESAR Performance Ambition KPI** | **Performance Framework KPA** | **Focus Area** | **#KPI / (#PI) / <Design goal>** | **KPI definition** |
| Cost efficiency | PA1 - 30-40% reduction in ANS costs per flight | Cost efficiency | ANS Cost efficiency | CEF2 | Flights per ATCO hour on duty |
| CEF3 | Technology Cost per flight |
| Capacity | PA7 - System able to handle 80-100% more traffic | Capacity | Airspace capacity | CAP1 | TMA throughput, in challenging airspace, per unit time |
| CAP2 | En-route throughput, in challenging airspace, per unit time |
| PA6 - 5-10% additional flights at congested airports | Airport capacity | CAP3 | Peak Runway Throughput (Mixed Mode) |
| Capacity resilience | <RES1> | % Loss of airport capacity avoided |
| <RES2> | % Loss of airspace capacity avoided |
| PA4 - 10-30% reduction in departure delays | Predictability and punctuality | Departure punctuality | PUN1 | % of Flights departing (Actual Off-Block Time) within +/- 3 minutes of Scheduled Off-Block Time after accounting for ATM and weather related delay causes |
| Operational Efficiency | PA5 - Arrival predictability: 2 minute time window for 70% of flights actually arriving at gate | Variance of actual and reference business trajectories | PRD1 | Variance of differences between actual and flight plan or Reference Business Trajectory (RBT) durations |
| PA2 - 3-6% reduction in flight time | Environment | Fuel efficiency | (FEFF3) | Reduction in average flight duration |
| PA3 - 5-10% reduction in fuel burn | FEFF1 | Average fuel burn per flight |
| Environment | PA8 - 5-10% reduction in CO2 emissions | (FEFF2) | CO2 Emissions |
| Safety | PA9 - Safety improvement by a factor 3-4 | Safety | Accidents/incidents with ATM contribution | <SAF1>  see section 3.4 | Total number of fatal accidents and incidents |
| Security | PA10 - No increase in ATM related security incidents resulting in traffic disruptions | Security | Self- Protection of the ATM System / Collaborative Support | (SEC1) | Personnel (safety) risk after mitigation |
| (SEC2) | Capacity risk after mitigation |
| (SEC3) | Economic risk after mitigation |
| (SEC4) | Military mission effectiveness risk after mitigation |

Table 12: Mapping between ATM Master Plan Performance Ambition KPAs and SESAR 2020 Performance Framework KPAs, Focus Areas and KPIs

-END OF DOCUMENT-

1. Sometimes 2 - 4 points are used, when 2 - 4 ceilometers are available, which is not the case of small airports. Still, few points are directly measured, not the whole sky. [↑](#footnote-ref-2)
2. Sometimes several points are used to estimate prevailing visibility and directional variations when several sensors are available, which is not the case of small airports. Still, few point measurements are taken into account, not whole airport surrounding. [↑](#footnote-ref-3)
3. This includes System, Procedural, Human, Standardisation and Regulation Enablers [↑](#footnote-ref-4)
4. Note that the terminology used to describe AU stakeholders in the CBA differs from that associated with Enablers in the dataset. This is due to costing being provided for different types of aircraft regardless of the operations they perform. [↑](#footnote-ref-5)
5. For information, the mapping to the Performance Ambition KPAs (used in the ATM Master Plan) is available in the Appendix. [↑](#footnote-ref-6)