INDUSTRIAL RESEARCH

SESAR SOLUTION PJ.02-03: COST BENEFIT ANALYSIS (CBA) FOR V3

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PJ.02 EARTH

INCREASED RUNWAY AND AIRPORT THROUGHPUT

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

Abstract

This document provides the Cost Benefit Analysis (CBA) at V3 level of **SESAR PJ.02-03 – Minimum Pair Separation Based on required Surveillance Performance (RSP)**. It includes quantification and monetisation of costs and benefits, NPV calculation, sensitivity analysis and the CBA model.

Solution PJ.02-03 aims to reduce the in-trail Minimum Radar Separation Up to 2NM on final approach so as to provide a direct positive impact on runway throughput (Capacity/Resilience, Fuel and Time Efficiency).

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1 Executive Summary

This report[1] provides the Cost Benefit Analysis (CBA) for **SESAR PJ.02-03 - Minimum Pair Separations Based on Required Surveillance Performance (RSP)**.

SESAR Solution PJ.02-03 aims to develop and validate the concept of Minimum Pair Separation Based on Required Surveillance Performance (RSP)-using an Optimal Runway Delivery (ORD) Separation tool- in support of a reduction of the in-trail Minimum Radar Separation down to 2 NM on final approach so as to provide a direct positive impact on runway throughput (Airport Capacity/Resilience, Fuel and Time Efficiency).

The solution will deliver the separation either through a category-based approach, where the new surveillance minima will only be allowed behind a leader aircraft category with a shorter Runway Occupancy Time (ROT), or, through a separation tool (such as time based separation part of solution PJ.02-01), which will propose the minimum separation being the higher value of runway occupancy time (ROT), wake or the new surveillance minima.

PJ.02-03 enables a more efficient non-wake turbulence separation to be established between each lead and follower pair. This will facilitate a further improvement in runway capacity/resilience.

SESAR Solution PJ.02-03 is part of the High Performing Airport Operations PJ02.

The in-trail MRS constraint on final approach is currently typically 3 NM, or can be 2.5 NM under certain conditions as prescribed by international and local regulations. The resilience benefits that can be gained from the wake turbulence separation optimisation concepts for arrivals including, Time Based Separation (TBS), Static Pair Wise Separation (S-PWS) and Time Based Static Pairwise Separation (TB S-PWS), are limited by the in-trail 2.5 NM MRS on final approach. This solution aims to address this issue by facilitating a reduction of the in-trail MRS on final approach down to 2 NM.

The expected benefits are an **increase in runway capacity/resilience** (with no detrimental impact on safety), an **increase in efficiency** (increase in the runway throughput resulting in the more efficient use of the runway) and an **increase in fuel and time efficiency** (reduction of airborne delay e.g. in case of holding). Resilience has not been directly addressed in this CBA due to limitations of wind conditions reproduction in the Fast Time Simulation stemming from the lack of wind measurements in specific runways across the airports. FTS results used for the CBA contain no wind effect and thus do not address the moderate, strong and very strong headwind conditions on the straight-in approach track where the reduction of the MRS from 2.5 NM to 2NM provides the runway throughput resilience benefits. This CBA has therefore been a conservative approach to the potential benefits the reduction of the MRS from 2.5 NM to 2 NM and if it would be more representative of the potential benefits to add also the runway throughput resilience benefits in moderate, strong and very strong conditions, and then the net benefits of the CBA would potentially be significantly increased.

[1] The opinions expressed herein reflect the authors view only. Under no circumstances shall the SESAR Joint Undertaking be responsible for any use that may be made of the information contained herein.

Benefits from Human Performance are not part of this CBA as these have not been measured.

CBA is presented at ECAC level following an extrapolation of local benefits. The local analysis is conducted for capacity constrained Very Large and Large airports (following SESAR Classification Scheme) operating in segregated mode, using Fast Time Simulation exercise. The number of airports identified as candidate for this solution is 7. However this has excluded the five airports that currently employ the 2.5 NM MRS on the straight-in approach track that would benefit from the runway throughput resilience to moderate, strong and very strong headwind condition on the straight-in approach track; including Heathrow and Vienna, which is a significant limitation of this CBA. The deployment of PJ.02-03 will require only ANSPs[2] to invest.

The CBA results are discounted at 8% between 2019 and 2040, with PJ.02-03 being deployed between 2025 and 2035 and with benefits starting to be realised in 2028. PJ.02-03 would achieve a Net Present Value of **387M€** by 2040 (1 535M€ undiscounted value) with overall costs of 140 M€ (undiscounted value). Different scenarios of sensitivity analysis are included in this CBA.

Although the CBA may seem negative from an ANSP point of view, delivering better services to airports and airspace users is a key benefit.

There is a strong link between minimum radar separation, wake vortex, runway occupancy and enhanced approach procedure. Combining these concepts will optimise the approach sequence. By improving wake separation, reducing surveillance minima and predicting accurate runway occupancy, it will be possible to deliver an enhanced sequence with reduced separation distances, optimising runway throughput.

It is recommended to present this CBA to ANSPs who may be interested in pursuing the concept solution, or similar, and to the airspace users and airports who might benefit highly from it.

[2] A simplifying assumption that airport systems are owned by the ANSPs has been taken; ANSPs are incurring also all the relevant upgrade costs of these systems.

2 Introduction

2.1 Purpose of the document

This document provides the Cost Benefit Analysis (CBA) for **SESAR PJ.02-03 – Minimum Pair Separations Based on Required Surveillance Performance (RSP)** that has been validated during validation exercises at v3 level. The CBA is required to assess the **affordability of the solution PJ.02-03** with respect to its expected benefits.

According to SESAR Handbook, the final R&D CBA developed in **V3** should include all the evidence gathered in terms of impacts, benefits and costs of a solution. By V3, the CBA should provide the NPV overall and per stakeholder group, a sensitivity analysis identifying most critical variables to the value of the project, the CBA model, report and recommendations.

2.2 Scope

The scope of this document is the V3 CBA for PJ.02-03. This CBA should have included all of the costs and benefits generated by the OI Steps of the Solution and the associated list of required enablers. However due to the limitations this CBA does not include the runway throughput resilience benefits in moderate, strong and very strong headwind conditions on the straight-in approach track.

The DS19 EATM Dataset was used as a Reference [10].

The CBA provides the costs and benefits of the PJ.02-03 Solution as if it would be deployed as a standalone Solution, independently from any other S2020 Solution. However it is questionable whether the full cost of the ORD tool support should be attributed to the cost profiling for OI AO-0309 as the ORD tool will be deployed to support Time Based Separation for Arrivals and Static Pairwise Separation for Arrivals and it only requires a minor additional change to the ORD tool to support an in-trail 2 NM MRS instead of a 2.5 NM MRS and to support an in-trail Spacing Minimum that can reduce to 2 NM rather being restricted to 2.5 NM.

The stakeholders involved in the Solution are: ANSPs, Airspace Users and Airports.

2.2.1 Geographical Scope

According to the Operational Service and Environment Definition report (OSED)[14] and the Performance Assessment Report (PAR)[15] the solution is applicable to **Very Large, Large and Medium airports which are capacity constrained during peak hours** and where the runway throughput is impacted by moderate, strong and very strong wind condition on the straight-in approach track resulting in the build-up of arrival delays and the potential need for flight cancelations. The PAR assesses the achievement of the solution target at ECAC level based on the PJ19.04 common assumptions. Looking more specifically into EUROCONTROL NM arrival data for August 2018 (busiest August in terms of IFR movements ever), only very large and some large airports seem to be capacity constrained during the day.

Although the approach followed remains the same as per the PAR this CBA enters in more depth considering traffic data for each single airport allowing a local assessment of the benefits if the solution is being put in place. The CBA is then conducted at ECAC level following an extrapolation of local benefits. This practically represents the effect of diluting specific locations' benefits into the network.

The extensive list of airports (local assumptions) considered for the purpose of this cost benefit analysis can be found in the List of PJ.02-03 targeted Airports of this document.

The solution is not considered to be attractive for non-capacity constrained airports therefore some very large, some large and all medium airports will be excluded from the current analysis as-from the NM data- traffic peaks leading to capacity constraints were not identified. Nevertheless, airports that are not included in the current local assumptions (i.e. not capacity constrained during August peaks) have the possibility of requesting a local CBA assessment based on the collection of relevant data and expected forecast growth.

Full set of candidate airport results per peak and per location are not disclosed for the purpose of this CBA due to sensitive data used and processed for this analysis.

2.2.2 CBA Timeline

The Solution and Reference Scenarios consider a **22-year period** for the analysis of all potential costs and benefits, **from 2019 to 2040**. Deployment of most of the Operational Improvements of the Solution is not expected before **2028**.

Any Net Present Values will be calculated back to 2019 (the end of Wave 1).

2.3 Intended readership

The intended readership for this document includes:

- PJ.02-03 project members
- PJ.02 Increased Runway and Airport Throughput – Other Solution partners
- PJ.01 Enhanced Arrivals and Departures – Related Solutions' partners
- PJ.04 Total Airport Management – Related Solutions' partners
- PJ.09 Advanced Demand & Capacity Balancing – Related Solutions' partners
- PJ.19 – who provides inputs such as the assumptions and who will consolidate the CBA results (where required by PJ20).
- PJ.20, in its role of Master Plan Maintenance project
- PJ.22 - System Engineering Data Management Framework (SE-DMF)
- SESAR Programme Management
- Stakeholders (ANSPs and airports) interested in deploying this solution
- Airspace Users mainly benefitting from this solution

2.4 Structure of the document

This report is structured as follows:

- Section 1 provides the executive summary;
- Section 2 provides the overall scope, time horizon, intended audience, structure of the document, background, glossary of terms and acronyms;
- Section 3 presents the objectives and scope of this CBA, provides a description of the PJ.02-03 Solution and the problem addressed by this Solution, identifies the main stakeholders impacted and describes the different scenarios compared in the CBA;
- Section 4 provides a view on the overall contribution to Key Performance Indicators (KPIs) and the monetisation of the benefits
- Section 5 describes the cost approach and the main assumptions taken when assessing the cost elements of the Solution and presents the results of the cost assessment;
- Section 6 provides a description of the CBA model and the sources of data used to build the CBA Model; the CBA Model will be provided as a supporting document.
- Section 7 provides the CBA results;
- Section 8 includes sensitivity analysis;
- Section 9 includes recommendations and next steps;
- Section 10 includes the references and applicable documents.
- The appendices provide the list of very large and large airports identified as target airports, the rationale of the use of 8% discount rate and the mapping between ATM Master Plan Performance Ambition KPAs (Key Performance Areas) and SESAR 2020 Performance Framework KPAs, Focus Areas and KPIs.

2.5 Background

This section provides information on previous activities related to the solution concepts. This background information covers mainly technical and regulatory aspects of the current operational improvements rather than providing cost assessment or economic appraisals related information.

1. An impact assessment of RECAT EU[3] (Non-SESAR R&D Solution) has been performed for Charles de Gaulle airport one year after RECAT EU Deployment at the airport. Results were presented in the Runway Throughput Symposium October 2018 at EUROCONTROL Experimental Centre.

   http://recat-project.eu/activities/runway-throughput-symposium-2018

2. Time Based Separation was introduced into full operational service at Heathrow Airport on 24 March 2015. To counteract the effect of wind on the landing rate and provide resilience for airport operations, Time Based Separation (TBS) replaces distance separations with time separations. Whilst TBS doesn't directly reduce the cost of ATM its introduction has delivered major benefits to Heathrow Airport, the airlines and the flying public at no additional cost. TBS is delivering a reduction in wind related ATFM delay of over 60%. This is achieved by an

[3] European Wake Turbulence Categorisation and Separation Minima on Approach and Departure https://www.eurocontrol.int/publication/european-wake-turbulence-categorisation-and-separation-minima-approach-and-departure

average increase in the landing rate of 1.2 arrivals per hour over distance-based separations across all wind conditions, increasing to an average of 2.9 arrivals per hour in winds over 20kts. As a result of this, there has been a marked reduction in weather related flight cancellations. TBS is mandated to be in operation at Europe's busiest airports by 2024.

https://ec.europa.eu/transport/modes/air/ses/ses-award-2016/projects/time-based-separation-heathrow_en

3. In the context of SESAR Project 6.8.1 "Optimization of Runway Throughput", EUROCONTROL investigated concepts for flexible and dynamic use of wake turbulence separations Study on separation delivery at six major European airports (Barcelona El Prat, London Gatwick, London Heathrow, Milan Malpensa, Paris Charles de Gaulle, and Vienna Schwechat). The results of this study were used by SESAR and EUROCONTROL in the development of a new ATC tool to predict aircraft speed performance. This Leading Optimised Runway Delivery (LORD) tool supports Air Traffic Controllers to optimize the separation buffer and more efficiently and easily deal with the compression effect on the last part of the final approach.

   http://www.atmseminarus.org/seminarContent/seminar11/papers/466-Van%20Baren_0126150311-Final-Paper-5-7-15.pdf

2.6 Glossary of terms

Term	Definition	Source of the definition
Benefit	A Benefit is the positive value of the return on investment to (some or all) stakeholders.	SESAR 16.06.06 - Methods to Assess Costs and Monetise Benefits for CBAs (D26, Edition 00.02.02, July 2016)
Benefit and Impact Mechanism	A Benefit and Impact Mechanisms a cause-effect description of the positive and negative impacts of the Solution proposed by the project	SESAR 16.06.06 – Guidelines for Producing benefit and Impact Mechanisms (D26_04, Edition 03.00.00)
Business Case	A Business Case 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. A Business Case has a wider scope than a CBA.	SESAR 1
Cash Flow	Cash flow is the difference between the cash inflows and outflows related to the project during the time horizon in which they occur.	SESAR 16.06.06 - ATM CBA for Beginners, D26-01, October 2014

Cost	A Cost is the monetary value of an investment used up to produce or acquire the benefit.	SESAR 16.06.06 - Methods to Assess Costs and Monetise Benefits for CBAs (D26, Edition 00.02.02, July 2016)
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. 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
Cost mechanisms	Cost mechanisms are a description of the potential costs of the project broken down into relevant cost categories (e.g. investment, operating).	SESAR 16.06.06, ATM CBA for Beginners, D26-01, October 2014
Discount Rate	Discount Rate is a way to capture the time value of money. This is a percentage that represents the increase in the amount of money needed or estimated to keep the same value as one year ago.	SESAR 16.06.06, ATM CBA for Beginners, D26-01, October 2014
Initial Operational Capability	Initial Operational Capability is the state archives when a capability is available in its minimum usefully deployable form. In other words, it identifies the start of benefits and the benefit ramp-up period.	16.06.06-D68-New CBA Model and Method 2015-Part1 of 2
Inflation	Inflation is a rise in the general level of prices of goods and services in an economy over a period of time.	SESAR 16.06.06, ATM CBA for Beginners, D26-01, October 2014
Net Present Value (NPV)	Net Present Value (NPV) is the sum of all discounted cash inflows and outflows during the time horizon period.	SESAR 16.06.06, ATM CBA for Beginners, D26-01, October 2014
Sensitivity Analysis	Sensitivity refers to the impact one given input to the model has on the overall NPV.	SESAR 16.06.06, ATM CBA for Beginners, D26-01, October 2014

Stakeholder	Stakeholders are organizations and entities who will have to pay for or will be impacted by the project directly or indirectly.	SESAR 16.06.06, ATM CBA for Beginners, D26-01, October 2014
Time Horizon	Time horizon refers to a definite time period during which all cost and benefits related to a given project occur.	SESAR 16.06.06, ATM CBA for Beginners, D26-01, October 2014
Time Value of Money	Time Value of Money means that the same (nominal) amount of money received at different points in time has different value	SESAR 16.06.06, ATM CBA for Beginners, D26-01, October 2014
Wake Turbulence	Wake turbulence is a function of an aircraft producing lift, resulting in the formation of two counter-rotating vortices trailing behind the aircraft. Wake turbulence from generating aircraft can affect encountering aircraft due to the strength, duration, and direction of the vortices.	PJ.02-03 partners
Wake Vortex	Wake vortex is a circular pattern of rotating air left behind a wing as it generates lift.	PJ.02-03 partners

2.7 List of Acronyms

Acronym	Definition
ACC	Area Control Centre
A-IGS	Adaptive Increased Glide Slope
ATM	Air Traffic Management
ANS	Air navigation services
ANSP	Air Navigation Service Provider
APT	Airport
ATC	Air Traffic Control
ATCO	Air Traffic Controller
ATM	Air Traffic Management
AU	Airspace User
CAP	Capacity

CAPEX[4]	Capital Expenditure
CBA	Cost Benefit Analysis
CCDF	Complementary Cumulative Distribution Function
CDG	Charles de Gaulle Airport
DS	Data Set
EAP	Enhanced Arrival Procedures
EATM	European ATM (Portal, database, dataset)
EATMA	European ATM Architecture
EC	European Commission
ECAC	European Civil Aviation Conference
EN	Enabler
ER	En-route
EU	European Union
EUROCONTROL	European Organisation for the Safety of Air Navigation
FEFF	Fuel Efficiency
FOC	Final Operating Capability
FTS	Fast Time Simulation
HC	High complexity (airport)
HP	Human Performance
ICAO	International Civil Aviation Organization
IGS	Increased Glide Slope
INTEROP	Interoperability
IOC	Initial Operating Capability
KPA	Key Performance Area
KPI	Key Performance Indicator
LC	Low complexity (airport)
LHR	London Heathrow airport
LiDAR	Light Detection And Ranging (or laser detection and ranging)

[4] Note that the term CAPEX has been used in the CBA Report to indicate all the investments (pre-implementation and implementation costs).

MRAP	Multi Runway Aiming Points
MRS	Minimum radar separation
MTOM	Maximum Take Off Mass
MTOW	Maximum Take Off Weight
NM	Network Manager
NPV	Net Present Value
OE	Operating Environment
OI	Operational Improvement
OPEX	Operating Expenditure (Considers Changes in Operating Costs)
ORD	Optimised Runway Delivery (Tool)
OSED	Operational Service and Environment Definition
PAGAR	Performance Assessment And Gap Analysis Report
PANS-ATM 4	Procedures for Air Navigation Services — Air Traffic Management
PAR	Performance Assessment Report
PCP	Pilot Common Project
PJ	Project
PMP	Project Management Plan
PRD	Predictability
PWS	Pair Wise Separation
R&D	Research and Development
RECAT	Wake Turbulence Re-categorisation
RES	Resilience
ROT	Runway Occupancy Time
RSP	Required Surveillance Performance
RTS	Real Time Simulation
RTS5	Real Time Simulation 5th Run (LHR Heathrow)
RWY	Runway
SAF	Safety
SDM	SESAR Deployment Manager
SESAR	Single European Sky ATM Research Programme
SJU	SESAR Joint Undertaking (Agency of the European Commission)
SOL	Solution

SPR	Safety and Performance Requirements
S-PWS	Static Pair Wise Separation
SRAP	Second Runway Aiming Point (SRAP)
TBS	Time Based Separation (Wake Turbulence)
TDIs	Target Distance Indicators
TMA	Terminal Manoeuvring Area
VT	Validation Target
VLD	Very Large Demonstration
WDS	Weather Dependent Separation
WP	Work Package

3 Objectives and scope of the CBA

3.1 Problem addressed by the solution

As airports remain one of the most significant bottlenecks in the ATM system, the reduction of the in-trail Minimum Radar Separation down to 2 NM on final approach represents great potential for system wide improvements.

3.2 SESAR Solution description

The in-trail MRS constraint on final approach is currently typically 3 NM, or can be 2.5 NM under certain conditions as prescribed by international and local regulations. The runway throughput resilience benefits that can be gained from the wake turbulence separation optimisation concepts for arrivals, including Time Based Separation (TBS), Static Pair Wise Separation (S-PWS) and Time Based Static Pairwise Separation (TB S-PWS), are limited by the in-trail 2.5 NM MRS on final approach. This solution aims to address this issue by facilitating a reduction of the in-trail MRS on final approach to 2 NM.

The solution will deliver the separation either through a category-based approach, where the new surveillance minima will only be allowed behind a leader aircraft category with a shorter ROT, or, through a separation tool (such as ORD support, part of solution PJ.02-01). It is to be anticipated that the full runway throughput resilience benefits are enabled though the ORD support; the procedural benefits without the ORD tool support are anticipated to be limited.

Application of the in-trail 2 NM MRS on final approach will be dependent on the surveillance service being employed by the controllers responsible for spacing delivery on final approach satisfying the RSP requirements for 2 NM separation. The spacing required between arrival pairs will also be constrained by other factors such as satisfying the Runway Occupancy Time (ROT) requirements for clearance to land, which is being addressed by the Optimised Runway Delivery (ORD) ATC tool support being developed and validated in SESAR Solution PJ.02-03.

The RSP requirements for 2 NM separation on final approach will need to be established in such a way such that the requirements can be applied to the changing technological and operational environments of the future and thus are required to be general performance requirements that are disengaged from a specific technological implementation. The proposed approach to establishing these RSP requirements for 2 NM separation is the expert judgement and modelling extrapolation of the RSP requirements that have been set in Europe for the 5 NM and 3 NM horizontal separations.

Overall cost efficiency will be ensured by considering revision of the MRS on the basis of the performance of currently deployed surveillance technology options for final approach at very large, large and medium airports.

The proposed application of the in-trail 2 NM MRS on final approach is to be demonstrated as safe in design and in application by the controllers responsible for setting up and delivering the arrival aircraft spacing on final approach.

The main development and validation needs include establishing the RSP requirements for 2 NM separation on final approach with particular focus on the safety assurance evidence, the characterisation of the actual performance of currently deployed surveillance technologies employed on final approach at very large, large and medium airports, the validation of the impact of the in-trail 2 NM MRS on the controller delivery of the arrival spacing on final approach with particular focus on the human performance and safety assurance evidence, and the development and validation of the business case with particular focus on the benefits evidence.

The following table gives a brief overview of solution PJ.02-03 referring to the addressed OI step and defined in EATMA v.13 DS19

OI Step

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.02-03 Minimum-Pair separations based on RSP	**AO-0309**	Minimum Radar Separations (MRS) based upon Required Surveillance Performance (RSP)	Fully	

Table 1: SESAR Solution PJ.02-03 Scope and related OI steps

OI Description

AO-0309 - Minimum Radar Separations (MRS) based upon Required Surveillance Performance (RSP)

The runway capacity is improved thanks to the application (by ATC) of a non-wake turbulence separation down to 2 NM for arrivals on final approach (at the point that the leading aircraft in the pair crosses the runway threshold), based upon Required Surveillance Performance (RSP). This Minimum Radar Separation (MRS) could be applied when separation is not constrained by wake turbulence, either because of favourable weather conditions (e.g. cross wind) or simply when the pair-wise wake turbulence separation is shorter than MRS.

The following table lists the enablers linked with the OI step and the stakeholder associated with each of the enablers

Enabler [5] ref.	**Enabler definition**	**Applicable stakeholders**	**Comments on the Enabler / definition**
AO-0309 - Minimum Radar Separations (MRS) based upon Required Surveillance Performance (RSP)			
APP ATC 159	Approach ATC system updated for Minimum Separation Based on Required Surveillance Performance (separation delivery)	ANSPs	CR 03526 Update APP ATC 159

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

A/C-48a	Air broadcast of aircraft position/vector (ADS-B OUT) compliant with DO260B	ANSPs	
AERODROME-ATC-59	Enhanced Surveillance data processing on Airport Surface (APT)	ANSPs	
CTE-S01a	SSR Mode A/C/S	ANSPs	
CTE-S01	Secondary SUR Radars	ANSPs	
CTE-S02a	Primary Surveillance Radar	ANSPs	
CTE-S02	Primary SUR sensor	ANSPs	
CTE-S04a	Wide Area Multilateration (WAM)	ANSPs	
METEO-03	Provision and monitoring of real-time airport weather information (PCP)	ANSPs MET Service provider (Civil & MIL)	
METEO-04b	Generate and provide MET information services relevant for Airport and final approach related operations (PCP)	APT operator (Civil & MIL)	
PRO-257	ATC Procedure to apply spacing minimum of less than 2.5 NM down to 2 NM	ANSPs	CR 03581 Update PRO-257
STD-093	EUROCONTROL Guidelines for Optimised Runway Delivery	ANSPs	CR 03525 Create STD-093

Table 2: OI steps and related Enablers

3.3 Objectives of the CBA

The objective of the V3 CBA is to provide a consolidated assessment of the costs and benefits of deploying Solution PJ.02-03 in the airports that have been identified in the deployment scenario approach.

This CBA will assess whether the benefits of the deployed Solution are expected to exceed the costs over the CBA time horizon. The V3 CBA includes all the evidence gathered in terms of impacts, benefits and costs of the solution. The output is the NPV overall per stakeholder group, sensitivity analysis, CBA model report and recommendations.

The CBA aims also to capture the breakeven year (payback time) i.e. the year when benefits will start compensating for the costs incurred.

Airport capacity, flight efficiency and time savings benefits have been monetised in the CBA for ANSPs, Airspace Users and Airports, in alignment with the Benefit Impact Mechanisms described in the OSED [14]. It was not possible to assess or monetise other potential benefits for other stakeholders (e.g. indirect benefit for NM) due to lack of evidences.

This V3 Cost Benefit Analysis will help in building an assessment of whether the PJ.02-03 Solution is worth deploying from an economic perspective for the involved stakeholders. It should also help in adjusting the deployment scenario approach and find the best option in terms of OIs/ENs implementation. To this aim, this V3 CBA provides accurate results of expected benefits and costs for the stakeholders. The CBA results are intended to support the decision to move to next stage of life-cycle at the maturity gates.

3.4 Stakeholders[6] identification

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
ANSPs	ATCOs, TMA and Tower control Centres	Invest in the system development operate and enjoy benefits from increase in runway throughput	No involvement	Costs and monetised benefits both available in this CBA
Airport Operators	Very Large and Large Airports	Operate and enjoy benefits i.e. increase in runway throughput. Airports are not considered to pay for the PJ.02-03 investments since it has been assumed that systems and relevant upgrades in the airport are owned and paid by ANSPs	No involvement	Benefits monetised available in this CBA
Network Manager	En-Route ANS	Support operations	No involvement	Neither costs nor benefits monetised directly/Indirect impact
Scheduled Airlines (Mainline and Regional)	Flight Crew, Schedule Planner, Safety and Training Department	Operate and enjoy benefits from time efficiency and fuel efficiency	No involvement	Benefits monetised available in this CBA
Regulation Authority	NSA/Ministry of Transport	Approve new operations	No involvement	No costs for regulatory authorities.

Table 3: SESAR Solution PJ.02-03 CBA Stakeholders and impacts

3.5 CBA Scenarios and Assumptions

This section describes the scenarios that are compared in the CBA. The aim is to reflect the delta (difference) between the Reference scenario (where the Solution is not deployed - the orange box in

[6] 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.

Figure 1) and the Solution scenario (reflecting the proposed deployment of the Solution at applicable locations across ECAC - the green box in Figure 1).

Both scenarios encompass the same period of analysis, from 2019 to 2040.

The CBA uses a delta approach, i.e. the Solution Scenario identifies all the additional elements that will have to be put in place on top of what is assumed to be deployed in the Reference Scenario.

The role of SESAR R&D in this area is to demonstrate that tangible benefits can be obtained from implementing SESAR Solutions. Assumptions were made in this V3 maturity phase towards PJ.02-03 potential options in terms of deployment scenario and candidate Airports (with criteria) where PJ.02-03 Solution team identified OIs and ENs that could potentially bring benefits. However due to the expected update of PCP Regulation by 2024, the assumptions may need to be reviewed after that.

The PJ.02-03 Operational Improvements are not applicable everywhere. To answer the need for a scalable Solution, a common approach to PJ.02-03 was used to define a set of deployment assumptions and to identify the airports where the solution could be applicable and having the potential to bring benefits.

Defining the Reference Scenario has proven to be very challenging because of the assumptions that need to be made regarding the 'ongoing deployments' (blue arrow in Figure 1). To avoid being blocked by this issue this V3 CBA is currently based more on the difference between the current situation (2019) and the Solution Scenario; this is reflected in the following scenario descriptions.

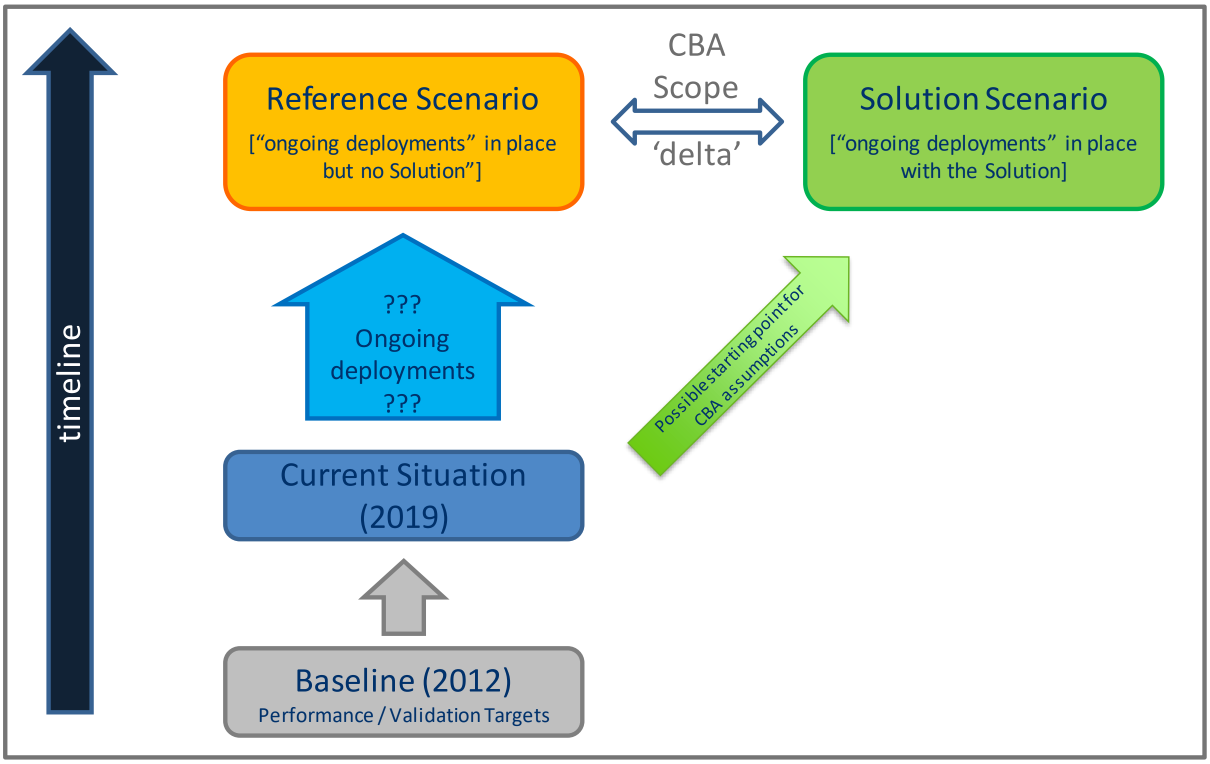

Figure 1: Scenario Overview

3.5.1 Reference Scenario

The Reference Scenario is the scenario without implementing the S2020 PJ.02-03 Solution and corresponds to today's situation (without the solution). It is assumed that the situation does not change significantly during the CBA scope.

PJ.02-03 solution is focused on Minimum Radar Separation (MRS) based upon Required Surveillance Performance (RSP).

The in-trail MRS constraint on final approach is currently typically 3 NM, or can be 2.5 NM under certain conditions as prescribed by international and local regulations. The runway throughput resilience benefits that can be gained from the wake turbulence separation optimisation concepts for arrivals including, Time Based Separation (TBS), Static Pair Wise Separation (S-PWS) and Time Based Static Pairwise Separation (TB S-PWS), are limited by the in-trail 2.5 NM MRS on final approach. This solution aims to address this issue by facilitating a reduction of the in-trail MRS on final approach down to 2 NM. Some airports currently employ procedures that facilitate spacing on final approach below the current 2.5 NM MRS; these airports include Heathrow and Vienna. The employment of these procedures could not be taken into account in this CBA benefits analysis.

Concerning these specific cases: in the case of Vienna, separation below 2.5 NM is allowed if tower ATCO has visual contact with leader and follower within the last 4 NM i.e. leader at 1.5 NM and follower at 4 NM. In the case of Heathrow airport 2.5 NM separation delivered at 4DME can fall below 2.5 NM at threshold under specific conditions.

Currently three wake separation turbulence schemes are in place across European airports

- ICAO (3 categories +A380)
- RECAT-EU (6 categories)
- UK wake turbulence scheme

Wake turbulence scheme choice should not be necessarily followed by a change in Minimum Radar Separation. There are airports operating in 2.5 NM MRS but still using ICAO.

3.5.2 Solution Scenario

PJ.02-03 Solution aims to optimize the Minimum Pair Separations Based on Required Surveillance Performance (RSP) in support of a reduction of the in-trail Minimum Radar Separation (MRS) down to 2 NM on final approach to enhance airport runway throughput resilience.

For the purpose of this CBA it is foreseen that MRS can be applied by incorporating the utilisation of the ORD tool and encompassing spacing requirements including ROT and Wake based separation (RECAT EU, WDS, PWS and TBS). The ORD tool will take in to account the winds and deceleration aspects of the leading aircraft to ensure that the following aircraft will never have less than the greater of the defined spacing or minimum separation.

Without the ORD tool, ATC must provide for additional spacing further back on final approach so as to ensure either at a defined deceleration fix or the runway threshold regardless of wind and realised ROT on landing, the minimum separation will always be respected. The Air Traffic Control (ATC) procedures for an aircraft approaching an aerodrome will be specific to each airport.

Reduction of Minimum Surveillance Separation (MRS) down to 2 NM allows for applying separation minima being the highest value between Runway Occupancy Time (ROT) spacing minima, wake separation minima or the new surveillance separation minima (2 NM).

From a wake turbulence separation point of view, separation minima below 2.5 NM are only found if applying PWS in low wind conditions, TBS in strong headwind conditions or WDS in strong crosswind conditions.

From a ROT point of view, considering the current runway infrastructure (runway exits) and aircraft breaking capabilities, there are very few runways and aircraft types that would allow to go below 2.5 NM in low wind conditions for ROT reasons. This is why we observe in the FTS01, considering low wind conditions, that airports already operating 2.5 NM MRS have very small or negligible benefit. The airports, operating today at MRS=3 NM, take benefit of the aircraft-wise ROT-based MRS definition that allows to customise separation as a function of ROT (ranging from typically 2.4 to 3 NM). However the benefits of reducing the MRS below 3 NM to 2.5 NM are not attributable to OI AO-0309; only the benefits associated with reducing below the ICAO 2.5 NM MRS are attributable to OI AO-0309.

In low wind conditions, significant benefit related to the MRS reduction down to 2 NM will be achieved for airports already operating at 2.5 NM MRS, only if ROTs are significantly reduced compared to these today observed. That might mean local incentive program for changing breaking and vacating behaviour or construction of better located high speed runway exits. The cost associated to these evolution being extremely difficult to quantify (because totally depending on current local airport situation), the CBA will be developed on the basis of typical ROT as observed today.

Note however, that in strong headwind conditions, when applying TBS, significant benefit related to the MRS reduction down to 2 NM will be achieved for airports already operating with 2.5 NM MRS as wake separation minima and ROT Spacing will be allowed to be lower than 2.5 NM. FTS showed expected benefits ranging from 4% up to 7 %, depending on the traffic and the used reference DBS scheme (ICAO, RECAT-EU or PWS).

According to the Operational Service and Environment Definition report (OSED)[14] and the Performance Assessment Report (PAR)[15] the solution is applicable to **Very Large, Large and Medium airports which are capacity constrained during peak hours** and where the runway throughput is impacted by moderate, strong and very strong wind condition on the straight-in approach track resulting in the build-up of arrival delays and the potential need for flight cancelations. The PAR assesses the achievement of the solution target at ECAC level based on the PJ19.04 common assumptions. Looking more specifically into EUROCONTROL NM arrival data for August 2018 (busiest August in terms of IFR movements ever), only very large and some large airports seem to be capacity constrained during the day.

Although the approach followed remains the same as per the PAR this CBA enters in more depth considering traffic data for each single airport allowing a local assessment of the benefits if the solution is being put in place. The CBA is then conducted at ECAC level following an extrapolation of local benefits. This practically represents the effect of diluting specific locations' benefits into the network.

The extensive initial list of airports (local assumptions) considered for the purpose of this cost benefit analysis can be found in the List of PJ.02-03 targeted Airports of this document.

The solution is not considered to be attractive for non-capacity constrained airports therefore some very large, some large and all medium airports will be excluded from the current analysis as-from the NM data- traffic peaks leading to capacity constraints were not identified. Nevertheless, airports that are not included in the current local assumptions (i.e. not capacity constrained during August peaks) have the possibility of requesting a local CBA assessment based on the collection of relevant data and expected forecast growth.

Full set of the 7 finally selected candidate airport results per peak and per location are not disclosed for the purpose of this CBA due to sensitive data used and processed for this analysis. However it should be noted that the 7 selected candidate airports exclude all 5 capacity constrained airports currently employing the 2.5 NM MRS with significant implications with respect to the omission of the runway throughput resilience benefits in moderate, strong and very strong headwinds on the straight-in approach track both for the 5 airports currently employing a 2.5 NM MRS and also the 7 airports including in the low wind conditions benefits profiling of this CBA.

The table below lists the key dates used in the CBA and Figure 2 shows them over a timeline.

Dates	PJ.02-03
Start of deployment date: the start of investments for the first deployment location	**2025**
End of deployment date: the end of the investments for the final deployment location	**2035 (Same as FOC)**
Initial Operating Capability (IOC): the time when the first benefits occur following the *minimum deployment* necessary to provide them. Costs continue after this date as further deployment occurs at other locations.	**2028**
Final Operating Capability (FOC): Maximum benefits from the *full deployment*[7] of the Solution at applicable locations. Investment costs are considered to end[8] here although any operating cost impacts would continue.	**2035**

Table 4: CBA Investment and Benefit Dates

[7] Where ***full deployment*** means deploying the Solution in the all the locations where it makes sense to deploy it (i.e. it does not mean it has to be deployed everywhere)
[8] The basic assumption is that infrastructure does not need to be replaced during the CBA period

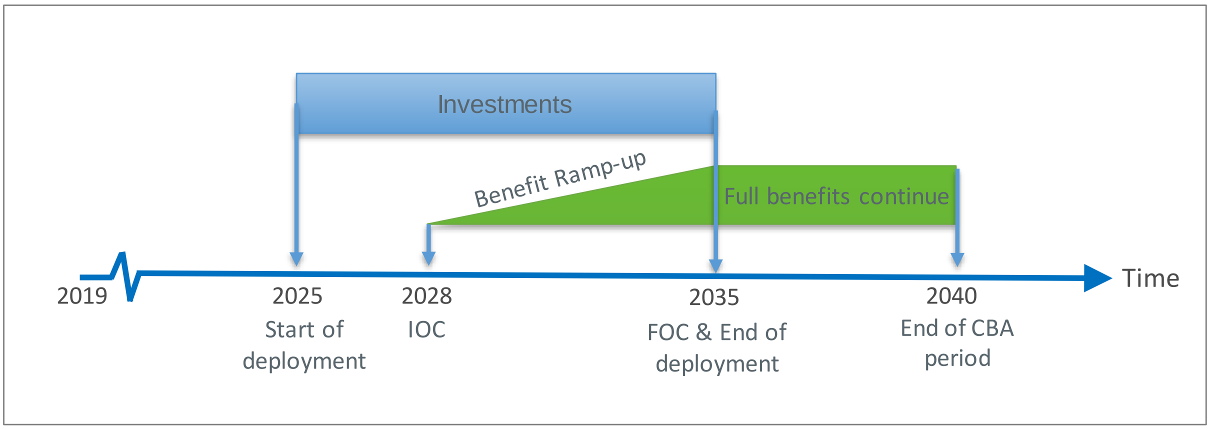

Figure 2: Overview of CBA Dates

Figure 2 shows that:

- Investment costs are spread linearly between the Start and End of Deployment dates.
- Benefits ramp-up linearly between IOC and FOC and then continue up to the end of the CBA period.
- Operating cost impacts (increases or decreases) would also start at IOC and ramp-up linearly to FOC before continuing for the rest of the CBA duration.

In line with PJ.19-04 guidance, the CBA model calculates the cash flows up to 2040 and then discounts the values back to 2019[9] to calculate the Net Present Value. The discount rate of 8% is used for all stakeholders.

3.5.3 Assumptions

Deployment Locations considered in the PJ.02-03 CBA correspond to Very Large and Large airports, in line with SESAR 2020 Airports' Classification Scheme (Airports' Group in 2018 according to SESAR 2020 Airports' Classification Scheme - PJ20 latest updated list – March 2019). For the extensive list please see List of PJ.02-03 targeted Airports.

Scenario feature	Year 2018	Year 2019	Year 2040	Source
ECAC traffic (M # flights) in line with 10.2	**11.4**	**14.0**	**19.5**	STATFOR Long/Medium Term forecasts (2019)[22]
Equipage rate	N/A – no airborne equipage required for PJ.02-03			
Applicability: Number of locations where Solution is deployed (Number of airports)	Deployment location values are provided in the cost assessment section			PJ.02-03 Deployment Scenario based on PJ20 airport dataset

[9] as specified in the PJ19.04 Common Assumptions 10.2

Impacted traffic, i.e. experiencing the benefits from the Solution(s)	'000 # IFR flights per year	Scheduled Airline traffic (≈89% of ECAC traffic) is considered for the Airspace User benefits	ECAC traffic above
	'000 # IFR flight hours per year	No benefits are based on flight hours	

Table 5: SESAR Solution PJ.02-03 CBA Solution Scenario

Costs and benefits have been computed using inputs from fast time validation exercise results, partners' contribution and using average values taken from the PJ.19.04 Common Assumptions for further extrapolation at ECAC Level.

As it is not feasible to exactly identify ANSP costs for each airport separately, these have been estimated assuming that they would be of same order of magnitude implying that all targeted airports will support the same kind of costs.

4 Benefits

The benefits monetised in this CBA are related to **Airport Capacity**, **Fuel** and **Time Efficiency** for arrivals in low wind conditions (no wind scenario) only.

Resilience in itself wasn't directly assessed in the fast time simulation. However, the results indicate that maximum traffic pressure will yield an increase in capacity. As such, runway resilience is seen to improve, although the benefits gained in runway throughput resilience in moderate, strong and very strong headwind conditions on the straight-in approach track will depend on the airport and traffic demands per hour.

Runway throughput resilience benefits were therefore not monetised as there was perceived a risk for double counting while increasing airport capacity; however this should not be the case as there is no or low runway throughput benefits in low wind conditions directly attributable to increasing runway capacity. As a consequence this CBA has adopted a conservative approach and if runway throughput resilience benefits were also taken into account the net benefits of the CBA would potentially significantly increase.

The CBA uses for arrivals the same fast time simulation platform that has been used to run the FTS01 exercise adapted in local conditions and local traffic mix. The FTS01 exercises assessed all the required KPIs according to SESAR Guidelines for different OIs in several scenarios. The analysis however has been performed with a limited number of traffic mix profiles. The CBA results are obtained using specific traffic mix for each local airport, considering a no-wind scenario only. A trade-off had to be made between the large amount of workload needed to prepare and run the platform and the resources available.

To further characterize the CBA, a new traffic mix has been assessed looking in details at data from NM for all very large and large airports, for August 2018.

In particular for each airport the traffic peaks and related traffic mix have been identified in order to characterize better the benefits; concerning airport capacity benefits PJ.02-03 OI provides benefits when the runways are constrained at the airport and where the runway throughput is impacted by moderate, strong and very strong wind condition on the straight-in approach track resulting in the build-up of arrival delays and the potential need for flight cancelations. Out of the 30 airports only 12 are currently experiencing runway capacity constraints; out of these, 2 have been eliminated since they are operating Minimum Radar Separation (MRS) at 5NM and therefore they were considered as non-candidate airports. Istanbul Ataturk has also been eliminated from this analysis following the moving of operations in to the New Istanbul airport. Since New Istanbul airport had not started operations in August 2018, there is no traffic data for it.

Following FTS01 results, considering low wind conditions, airports already operating at 2.5NM MRS have very small or negligible benefit in normal operations (DBS); with TBS allowing to reduce separation under strong headwind conditions, the effect will be significant. However for the purpose of this CBA, most frequent wind conditions has only been analysed, i.e. low wind conditions, without consideration of the potentially significant runway throughput resilience benefits in moderate strong and very strong headwind conditions on the straight-in approach track. As a consequence, 5 capacity constrained airports operating already at 2.5 NM MRS have been omitted from this analysis, including Heathrow and Vienna where significant resilience benefits are anticipated. Additionally for the 7 airports operating with a 3 NM MRS that have been included in this analysis, there are questions as to whether the benefits profiling has only taken into account the benefits of OI AO-0309 of reducing the

MRS from the ICAO 2.5 NM MRS to 2 NM MRS. The benefits of reducing the MRS below 3 NM to 2.5 NM are not attributable to OI AO-0309. It should be anticipated that airports currently operating with a 3 NM MRS are not as capacity and resilience constrained as airports already operating with a 2.5 NM MRS, and that airports operating with a 2.5 NM MRS are not as capacity and resilience constrained as airports that are operating with a 2.5 NM MRS together with additional RSVA procedures to facility spacing reduction below the 2.5 NM MRS on short final such as Heathrow and Vienna.

While in the Performance Assessment Report (PAR)[15], results were obtained assuming specific traffic mix and traffic peaks of 1-2 hours, in reality airports experience different traffic peaks during the day and of different length. This has an impact when quantifying the benefit obtained.

The source for the benefit calculation inputs is based on calculations using inputs from FTS01.

Consequently, benefit results for each airport are very local. In the CBA each KPI is assessed at ECAC level. Therefore an average is used for quantifying the overall benefit for all the airports impacted currently which is then scaled at ECAC Level.

This way a better estimate of the current situation was provided compared to the PAR results where a range of results was used.

4.1 Benefit and Impact Mechanism

The benefit and impacts mechanism for PJ.02-03 shown in Figures 3 are cause-effect description of the improvement proposed by the project. They show how benefits are delivered.

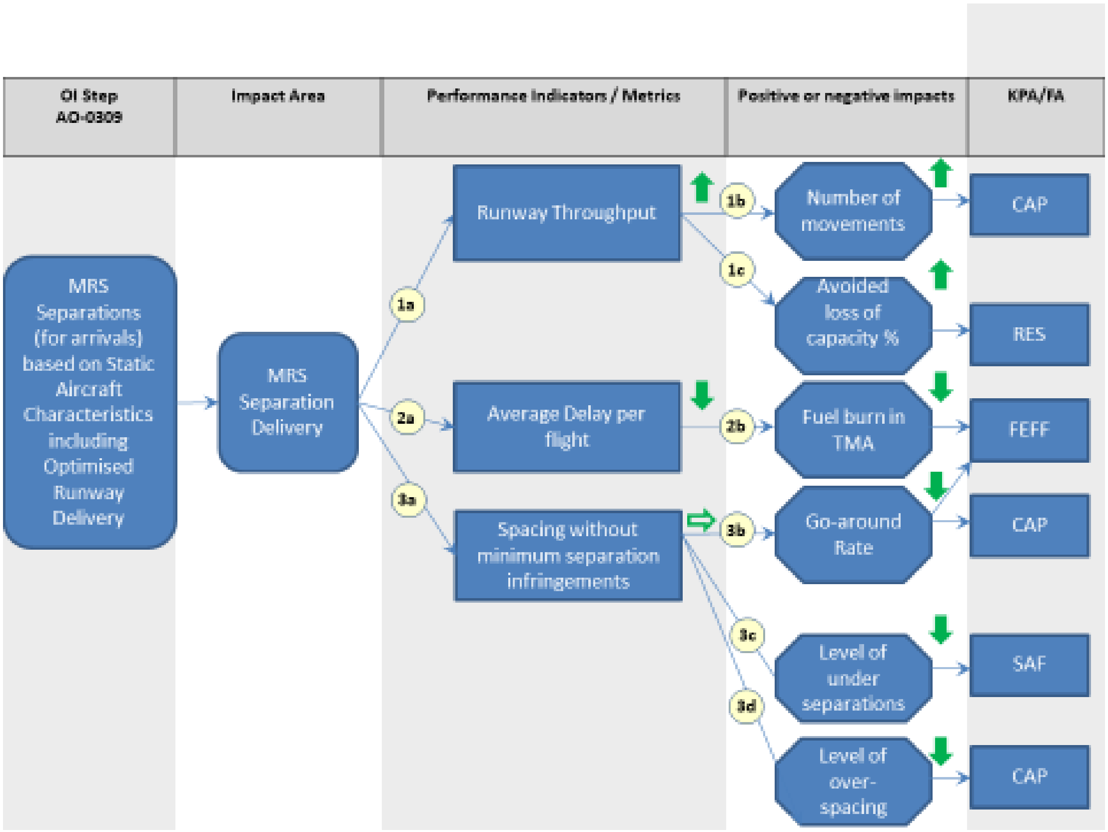

Figure 3: Benefit Mechanism for AO-0309

The use of the MRS down to 2NM reduces current minimum separation so it increases the runway throughput (1a). A reduced spacing between aircraft has positive impact on the runway throughput. The higher the throughput, the higher the number of movements, leading to a positive impact on **Capacity** (1b) (1c) Reduction of separations will result in higher Resilience and avoid loss of capacity.

(2a) Reduction of separations will reduce the average delay per flight.

The use of the down to 2NM MRS reduces current minimum separation and will reduce the average delay per flight (2a). As airborne delay uses more fuel (e.g. in case of holding), a reduction in this delay will result in reduced fuel burn in the TMA. This has a positive impact on **Fuel Efficiency** (2b).

The use of the down to 2NM MRS reduces current minimum separation will lead to controllers reducing buffers to separation minima (3a). The number of go-arounds was not found to increase in the solution scenario where 2NM MRS was applied on the final approach between M-M pairs under strong wind conditions compared to the reference scenario based on current operations (3b). No increase in the number of under spacing observed when 2NM MRS was applied between medium-medium (M-M) pairs (2.5NM MRS) applied between all other MRS pairs (3c).

4.2 Benefit Monetisation Mechanism

Majority of airports use segregated mode for the runways, because mixed mode is more complex to operate and because they are not constrained by the number of runways (e.g. at least 2 are available in the majority of airports).

Once the benefits were identified in FTS01 and validation results became available, extrapolation was applied producing results from local (validation exercise environment) to global (ECAC level) as required by the Performance Assessment and their further monetization. The unit for all benefits is euros.

Capacity benefits for the Very Large and Large airports are calculated based on a combination of advanced processing of surveillance data and the results of the fast time simulations (FTS). Separation schemes used as a baseline are the current ones for each airport.

Fast time simulation has taken into account current operations and:

- the observed traffic mix
- the observed traffic pressure (i.e. assuming that full benefits of the solution are only obtained if the traffic pressure is above 80% of the theoretical capacity when applying reference scheme)
- number of peaks during the day
- number of movements during each peak
- duration of the peak
- minimum radar separation (MRS)
- configuration of the runways

Loss in capacity avoided has been assumed to directly relate to the increase in throughput from each of the OI steps. It would be up to individual airports to decide whether to use the increase in throughput to increase airport capacity (schedule extra movements) or improve resilience (not schedule extra movements).

For airports with a declared maximum capacity that cannot benefit from any increase in runway and airport throughput, the benefits can be translated instead into reduction of flying time. For the purpose of this analysis the capacity benefits are shared between increase in airport capacity for the airport and reduction in flying time for the airspace users assuming that all these congested airports will not be able to allocate all the increase in airport capacity that the solution brings.

4.2.1 Airport Capacity (CAP3)

CAP3 Peak Runway Throughput	+1.1% (ECAC level)

Table 6: Airport Capacity Result

It is to be confirmed that the above benefits profiling has only taken into account the benefits of OI AO-0309 of reducing the MRS from the ICAO 2.5 NM MRS to 2 NM MRS. The benefits of reducing the MRS below 3 NM to 2.5 NM are not attributable to OI AO-0309.

CAP 3 has been quantified taking into account the sum of additional number of movements for each peak is then compared to the sum of movements for each peak. The value is then divided by 2 as for each new movement is considered that half of the spacing saved is used to reduce delay and half to increase the capacity. This has been an assumption taken by the project team for all the airports since it would be quite impossible to predict each individual's airport decision. Taking into account that the current system is rather balanced between delays and capacity, a balanced 50% decision was taken for the distribution of capacity benefits.
ECAC level, benefits scaled by total number of movements for **7 airports**[10], then divided by number of movements for all ECAC area.

These values have been further monetised in terms of additional flights that can be operated per year at airports which are otherwise congested, multiplied by the reference values provided in EUROCONTROL Standard Inputs. This gives the economic value of additional airport capacity.

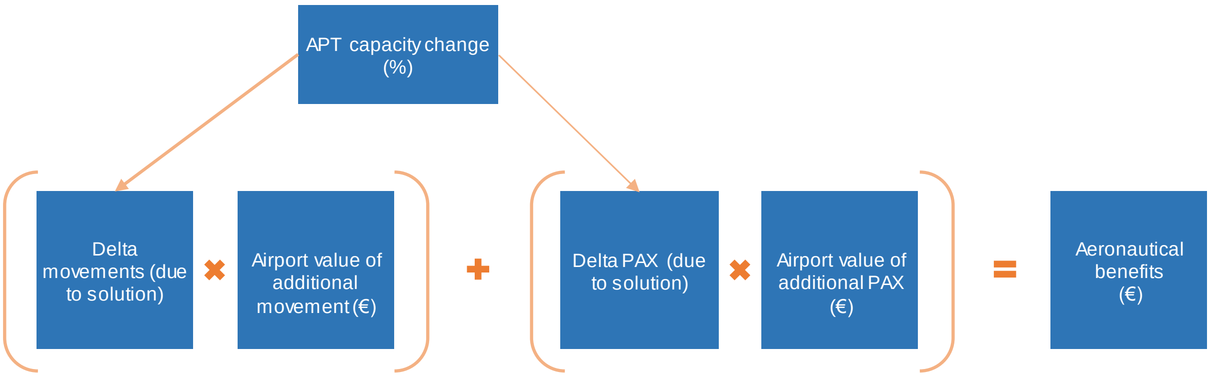

Figure 4: Airport Capacity Monetisation Mechanisms

[10] Airports operating at 5NM or at 2.5NM and below do not make part of this shortlisted airport set.

4.2.2 Fuel Efficiency (FEFF1)

FEFF1: Fuel Efficiency – Fuel burn per flight	-1.7kg/flight (positive impact)

Table 7: Fuel Efficiency Result

It is to be confirmed that the above benefits profiling has only taken into account the benefits of OI AO-0309 of reducing the MRS from the ICAO 2.5 NM MRS to 2 NM MRS. The benefits of reducing the MRS below 3 NM to 2.5 NM are not attributable to OI AO-0309.

The figure below shows the monetisation mechanisms used in the CBA model. The calculation is made in each year so the values includes the evolution of the number of flights and fuel price over the CBA period. The model automatically calculates the change in CO2 costs when there is a change in fuel burn.

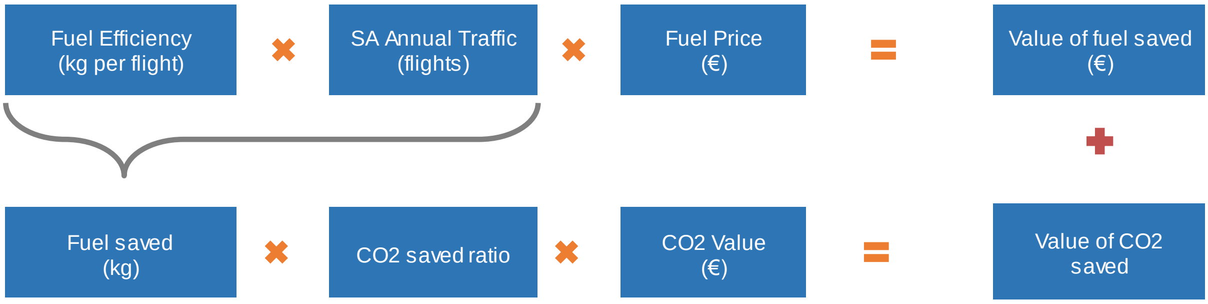

Figure 5: Fuel Efficiency and CO2 Monetisation Mechanisms

4.2.3 Time Efficiency (FEFF3)

Time savings are calculated as the average flying time saved in TMA (minutes /flight) for each aircraft in peak when the OI is applied. The value is then divided by 2 as for each new movement is considered that half of the time saved is used to reduce delay and half to increase the capacity.

Benefits have then been scaled by total number of movements for all airports and then divided by number of movements for all ECAC area.

FEFF3 Reduction in average flight duration	0.14% (reduction in flying time in TMA)

Table 8: Time Efficiency Result

It is to be confirmed that the above benefits profiling has only taken into account the benefits of OI AO-0309 of reducing the MRS from the ICAO 2.5 NM MRS to 2 NM MRS. The benefits of reducing the MRS below 3 NM to 2.5 NM are not attributable to OI AO-0309.

Figure 6: Time Efficiency Monetisation Mechanism

4.3 Benefit Monetisation of the Performance Framework KPI/PI

Performance Framework KPA[11]	Focus Area	KPI/PI from the Performance Framework	Unit	Metric for the CBA	Unit	Total benefits from IOC to 2040
Cost Efficiency	ANS Cost efficiency	**CEF2** Flights per ATCO-Hour on duty	Nb	ATCO employment Cost change	€/year	No Validation Target
				Support Staff Employment Cost Change	€/year	No Validation Target
				Non-staff Operating Costs Change	€/year	No Validation Target
		CEF3 Technology cost per flight	EUR / flight	G2G ANS cost changes related to technology and equipment	€/year	No Validation Target
	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	No Validation Target
		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	No Validation Target

[11] For information, the mapping to the Performance Ambition KPAs (used in the ATM Master Plan) is available in the **Error! Reference source not found.**

Performance Framework KPA[11]	Focus Area	KPI/PI from the Performance Framework	Unit	Metric for the CBA	Unit	Total benefits from IOC to 2040
		AUC5 Overhead costs for an airspace user	EUR / flight	Impact on overhead costs. Examples: dispatchers, training, IT infrastructure, sales.	€/year	No Validation Target
Capacity	Airspace capacity	**CAP1** TMA throughput, in challenging airspace, per unit time	% and # movements	Tactical delay cost (avoided-; additional +)	€/year	No validation target€
			% and # movements	Strategic delay cost (avoided-; additional +)	€/year	No Validation Target
		CAP2 En-route throughput, in challenging airspace, per unit time	% and # movements	Tactical delay cost (avoided-; additional +)	€/year	No Validation Target
			% and # movements	Strategic delay cost (avoided-; additional +)	€/year	No Validation Target
	Airport capacity	**CAP3** Peak Runway Throughput	% and # movements	Value of additional flights	€	873 M€
	Resilience	**RES4a** Minutes of delays	Minutes	Tactical delay cost (avoided-; additional +)	€/year	No Validation Target
		RES4b Cancellations	% and # movements	Cost of cancellations	€/year	No Validation Target
		Diversions	% and # movements	Cost of diversions	€/year	No Validation Target

Performance Framework KPA[11]	Focus Area	KPI/PI from the Performance Framework	Unit	Metric for the CBA	Unit	Total benefits from IOC to 2040
Predictability and punctuality	Predictability	PRD1 Variance of Difference in actual & Flight Plan or RBT durations	Minutes^2	Strategic delay cost (avoided-; additional +)	€	No Validation Target
	Punctuality	**PUN1** % Departures < +/- 3 mins vs. schedule due to ATM causes	% (and # movements)	Tactical delay cost (avoided-; additional +)	€/year	No Validation Target
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	No Validation Target
						No Validation Target
Environment	Time Efficiency	**FEFF3** Reduction in average flight duration	% and minutes	Strategic delay: airborne: direct cost to an airline excl. Fuel (avoided-; additional +)	€	566 M€
	Fuel Efficiency	**FEFF1** Average fuel burn per flight	Kg fuel per movement	Fuel Costs	€	219 M€
	Fuel Efficiency	**FEFF2** CO2 Emissions	Kg CO2 per movement	CO2 Costs	€	15M€

Performance Framework KPA[11]	Focus Area	KPI/PI from the Performance Framework	Unit	Metric for the CBA	Unit	Total benefits from IOC to 2040
Civil-Military Cooperation & Coordination	Civil-Military Cooperation & Coordination	**CMC2.1a** Fuel saving (for GAT operations)	Kg fuel per movement	Fuel Costs	€/year	
		CMC2.1b Distance saving (for GAT operations)	NM per movement	Time Costs	€/year	

Table 9: Results of the benefits monetisation per KPA

5 Cost assessment

5.1 Overall costs approach and main assumptions

Costs were estimated based on expert judgement and are in line with other PJ.02 solutions using the same separation delivery tool (ORD) as optional or required enabler (reflected as a different enabler in the other solutions due to additional adaptations relevant to each OI). Costs for this solution are entirely borne by the ANSPs assuming that airport system costs and relevant maintenance is entirely occurred by the ANSPs for ECAC area. Some additional costs for the airports in this CBA represent some induced investment that the airports would have to do following the additional passengers that the increase in capacity brings.

However it is questionable whether the full cost of the ORD tool support should be attributed to the cost profiling for OI AO-0309 as the ORD tool will be deployed to support Time Based Separation for Arrivals and Static Pairwise Separation for Arrivals and it only requires a minor additional change to the ORD tool to support an in-trail 2 NM MRS instead of a 2.5 NM MRS and to support an in-trail Spacing Minimum that can reduce to 2 NM rather being restricted to 2.5 NM.

5.2 ANSPs costs

5.2.1 ANSPs cost approach

A bottom-up approach was used to estimate the ANSPs implementation and operating costs. The scope of each enabler was analysed, discussed, reviewed and challenged within the CBA team as well as with other operational and technical experts in the PJ-02. With the support of the Solution leader and the partners it was possible to associate a cost to each enabler. Inputs for enabler costs were then aggregated at OI level.

Implementation costs include all type of costs: development of the system, specific adaptation and functionalities, additional inputs of static information, integration costs and regulatory costs.

5.2.2 ANSPs cost assumptions

In order to benefit from an increase in Runway Throughput, there will be indirect costs for the ANSP associated with training and procedure development at the local level however, it is important to note the solution is foreseen to be utilised with a controller support tool although limited benefit maybe obtained in a classic non controller tool environment whilst still employing 2 NM MRS.

Apart from the APP ATC 159 costs, all the other CTE and METEO enablers correspond to infrastructure are considered to be already in place in very large and large airports implementing new MRS; therefore costs assumed to be zero.

PRO enablers correspond also to procedural and the costs assumed are zero.

5.2.3 Number of investment instances (units)

Due to sensitive information used with regard actual traffic, traffic mix, traffic peak information, runway configuration, MRS etc. information on the specific locations identified as target airports are considered as confidential and therefore are not included in this report.

Number of congested airports identified as benefitting from this solution i.e. number of investment instances is 7 airports.

5.2.4 Cost per unit

Average unit cost for arrivals results in around 10.05 M€ investment costs and 100K€ annual operating costs. Below you may find a breakdown at enabler level.

OI Step	Enabler	Enabler Title	Development Costs (M€)	Operating costs (M€/year)
AO-0309 — Minimum Radar Separations based upon Required Surveillance Performance (RSP)	APP ATC 159	Approach ATC system updated for Minimum Separation Based on Required Surveillance Performance (separation delivery)	10	0.10
	A/C-48a	Air broadcast of aircraft position/vector (ADS-B OUT) compliant with DO260B	-	-
	AERODROME-ATC-59	Enhanced Surveillance data processing on Airport Surface (APT)	-	-
	CTE-S01a	SSR Mode A/C/S	-	-
	CTE-S01	Secondary SUR Radars	-	-
	CTE-S02a	Primary Surveillance Radar	-	-
	CTE-S02	Primary SUR sensor	-	-
	CTE-S04a	Wide Area Multilateration (WAM)		
	METEO-03	Provision and monitoring of real-time airport weather information (PCP)		
	METEO-04b	Generate and provide MET information services relevant for Airport and final approach related operations (PCP)		
	PRO-257	ATC Procedure to apply spacing minimum of less than 2.5 NM down to 2 NM	0.025	-

	STD-093	EUROCONTROL Guidelines for Optimised Runway Delivery	0.025	-
	Total		**10.05**	**0.10**

Table 10: Cost per Unit – ANSP

6 CBA Model

The model used to calculate the CBA results is Single Solution CBA model developed by PJ.19. This CBA Model has been developed in Excel and aims at calculating the costs and benefits of the implementation of PJ.02-03 Solution based on the Deployment Scenario approach that has been defined in the context of the CBA task.

The PJ.02-03 V3 CBA Model (xlsx file) is also attached as a supporting document of the CBA report.

PJ02-03-v4-CBA
Model_to be deliver

It must be pointed out that all costs are analysed in the form of a "delta", this is the difference between a reference scenario where current operations continue "as usual" and a solution scenario, where PJ.02-03 is adopted by the stakeholders considered and implemented.

CBA model provides an overview of the costs for ANSPs and a view on the expected benefits for Airport Operators and Airspace Users.

This model is built to support strategic decision-making and although it does not aim to achieve 100% accuracy, it aims to be a good tool to model the problem and obtain results that should be close to the real characteristics of the solution.

6.1 Data sources

Cost Inputs

The cost inputs are provided at an enabler level and contain the main cost component which is the ORD tool and some costs for regulatory provision (implementation of the standard) and ATC procedures. The ORD cost component is in line with what has been assumed for PJ.02-01 and PJ.02-02 and has been agreed at PJ.02-01 level with relevant partners.

Benefit Inputs

The source for the benefit calculation inputs is a combination of Performance Assessment Results from the PJ.02-03 Performance Assessment Report (PAR)[15] and separate calculations using inputs from FTS01. More information on the calculation of these benefits is available in the Benefit section.

Other Inputs Parameters

The data sources for the non-Solution specific CBA Model parameters are referenced in the various inputs sheets of the CBA Model with details provided in the sheet 'Source of Reference'. These are all part of the PJ.19.04 Common Assumptions.

7 CBA Results

The following section provides the results of the PJ.02-03 CBA at V3 Level.

The results presented are already consolidated and can be considered as conclusive. The CBA has been built gathering the following information:

- The Investments costs (pre-implementation and implementation costs) and Operating Costs have been identified for the main stakeholders impacted: ANSPs. Other costs for other stakeholders have been considered as negligible.
- The impact of PJ.02-03 on the Capital Expenditures (CAPEX) has been analysed and only the costs on top of what could be expected in the Reference Scenario have been estimated in the cost assessment and integrated in the CBA Model.
- Benefits (fuel and time efficiency, airport capacity) have been estimated and monetised in the CBA Model for Airspace Users (Scheduled Airlines operating in Large and Very Large Airports) and Airport Operators. Inputs used have been a combination of results from PJ.02-03 Performance Assessment Report (PAR)[15], Validation Report (VALR)[16] and calculations based on NM actual data and potential improvement using results mainly from Fast Time Simulation and Real Time Simulation. Note however the significant limitations of this CBA with respect to only carrying out analysis of the low wind (or no wind) conditions runway throughput benefits, thus omitting to include the potentially significant runway throughput resilience benefits in moderate, strong and very strong headwind conditions on the straight-in final approach track, and also omitting to include any benefits analysis for the five airports that already operate with a 2.5 NM MRS because of runway throughput resilience considerations.

  No benefits are provided for Medium Airport and airport operating in mixed mode due to lack of peaks and limitations in the FTS modelling tool of the FTS.

A CBA can always be improved or refined, even if this is a CBA at V3 level. Further investigation could improve some areas. This is the case of the cost model which could be refined if more data was available. Recommendations are provided in Section Recommendations and next steps.

All the analysis in this Chapter presents the delta between the Solution Scenario (with PJ.02-03) and the Reference Scenario (without PJ.02-03).

The V3 CBA allows calculating the Payback year as the NPV of the Solution changes from negative to positive in the early years of implementation. This is due to the fact that costs are higher than benefits (which are zero or partial) at the beginning.

7.1 PJ.02-03 results

The PJ.02-03 **CBA results**[12] are visible in the CBA model (see section 6) by selecting Scenario 1.

[12] Any differences in totals are due to rounding errors

Costs and Benefits are estimated at ECAC level considering the targeted list of airports where the PJ.02-03 Solution is expected to be deployed according to the Solution Scenario i.e. 7 airports.

CBA results give the following overall figures:

1) **Overall costs** for the period total **140 M€** undiscounted (**50 M€ discounted** at 8% discount rate).
2) **Total benefits** expected reach **1 674 M€** undiscounted (**437 M€ discounted**). As a reminder these benefits include Airport and AUs benefits.
3) The Net Result anticipated for PJ.02-03 would be a **positive NPV of 1 535M€** undiscounted **or 387M€** with an 8% discount rate.

This section is structured in the following way:

- 7.1.1 provides the PJ.02-03 CBA discounted values
- 7.1.2 provides the PJ.02-03 CBA undiscounted values

7.1.1 Discounted Values

This section provides the discounted CBA results for arrival concept. The values shown in table 14 below are discounted to account for the time value of money[13]. Undiscounted values are shown in the next section.

The Net Present Value (NPV) for PJ.02-03 is **387 M€**. This is calculated with an 8% discount rate [Appendix A] over the period 2019 to 2040.

The payback year is **2029** as shown in Figure 7 where the discounted cumulative net benefits line crosses back over the x-axis.

[13] The time value of money reflects the idea that 1€ received today has more value than 1€ received in 2040 because it could be invested and earn interest over that period.

PJ.02-03 2019-2040 Discounted				
in M€	NPV	Costs	Benefits	Discount rate
ANSP	-31	29	-2	8%
Airports	268	21	289	8%
Airports	0	0	0	8%
Business Aviation	0	0	0	8%
Scheduled Airlines	150	0	150	8%
Overall	**387**	**50**	**437**	

Table 11: PJ.02-03 Discounted CBA results (per stakeholder and overall)

Based on the current assumptions and inputs, the expected benefits offset the overall costs.

The sensitivity analysis in section 8 explores these results in more detail to see the impact on the NPV of changing some of the assumptions.

Figure 7 shows these discounted values on a year-by-year basis. The net benefits are the benefit value per year minus the cost value for that year; these are then shown cumulatively as a line in the figure.

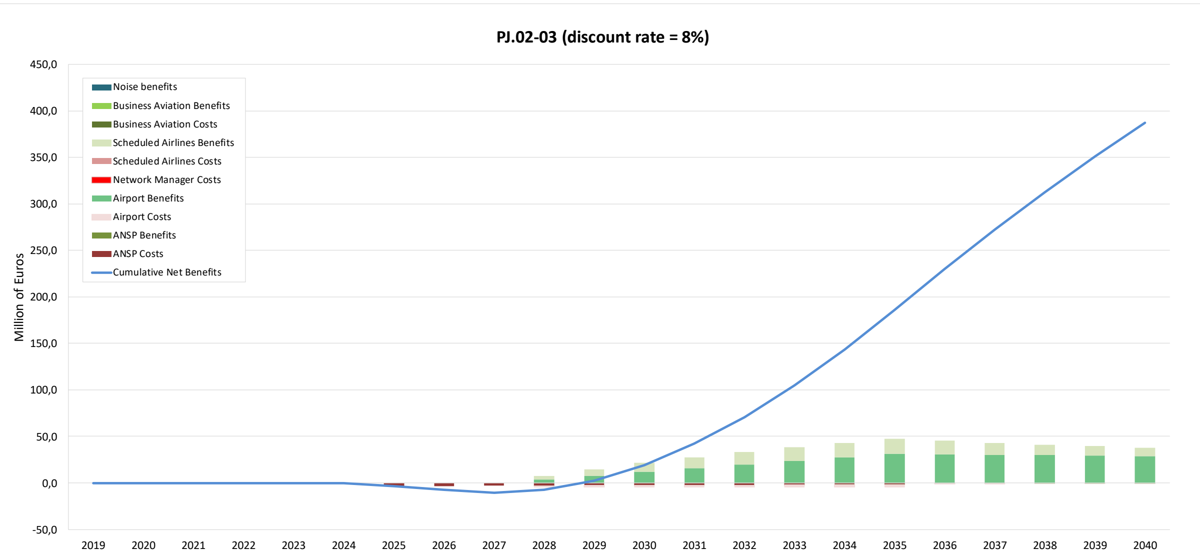

Figure 7: PJ.02-03 Annual Investment Levels and Benefits (discounted)

Figure 8 shows the cost and benefit data without the cumulative net benefits line so that the scale of the costs and benefits per stakeholder are easier to read.

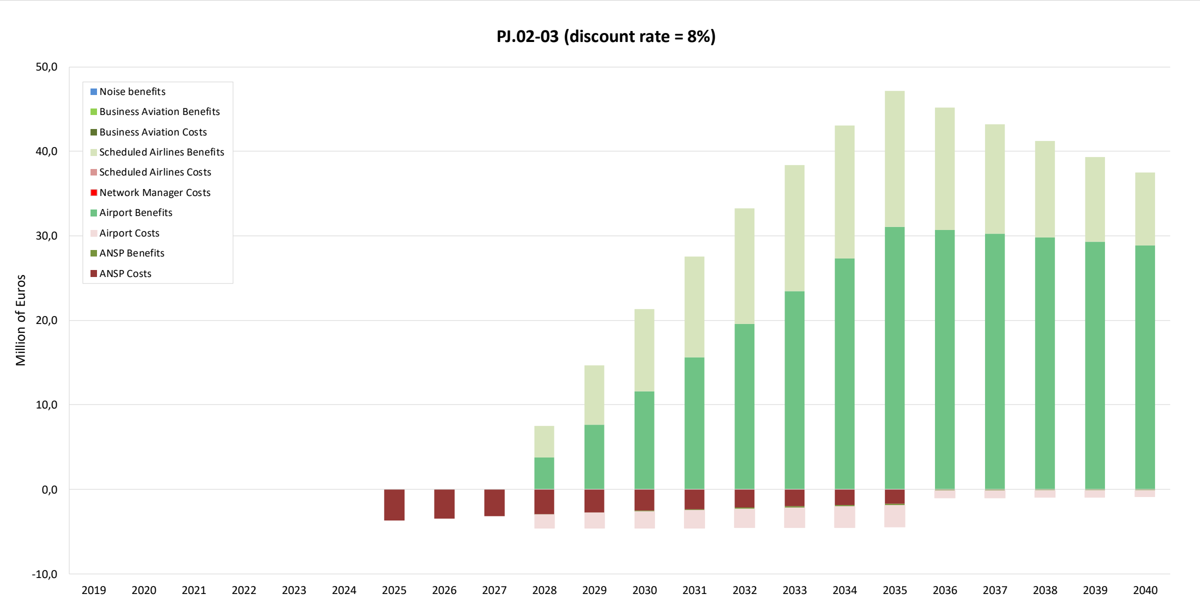

Figure 8: PJ.02-03 Annual Investment Levels and Benefits expanded (discounted)

7.1.2 Undiscounted Values

The values shown in this section do not consider the time value of money, so one unit of currency spent or received in 2040 is considered to have the same value as one unit of currency spent or received today.

PJ.02-03 2019-2040 Undiscounted			
in M€	Net Benefits	Costs	Benefits
ANSP	-77	70	-7
Airports	1 065	69	1 134
Network Manager	0	0	0
Business Aviation	0	0	0
Scheduled Airlines	547	0	547
Overall	**1 535**	**140**	**1 674**

Table 12 contains the undiscounted values, which show that without discounting, i.e. doing the CBA calculation with a discount rate of 0%, the overall net benefits are 1 535 M€.

PJ.02-03 2019-2040 Undiscounted			
in M€	Net Benefits	Costs	Benefits
ANSP	-77	70	-7
Airports	1 065	69	1 134
Network Manager	0	0	0
Business Aviation	0	0	0
Scheduled Airlines	547	0	547
Overall	**1 535**	**140**	**1 674**

Table 12: PJ.02-03 Undiscounted CBA results (per stakeholder and overall)

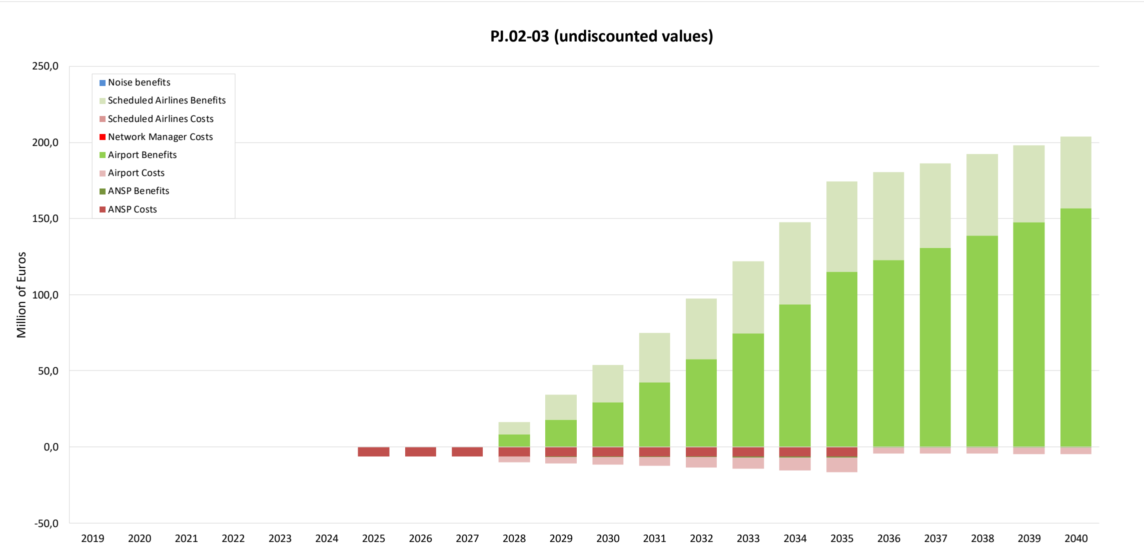

Figure 9 shows the undiscounted costs and benefits over each year. The undiscounted cumulative net benefits line is not included to avoid readers considering the point it crosses the x-axis as the payback year.

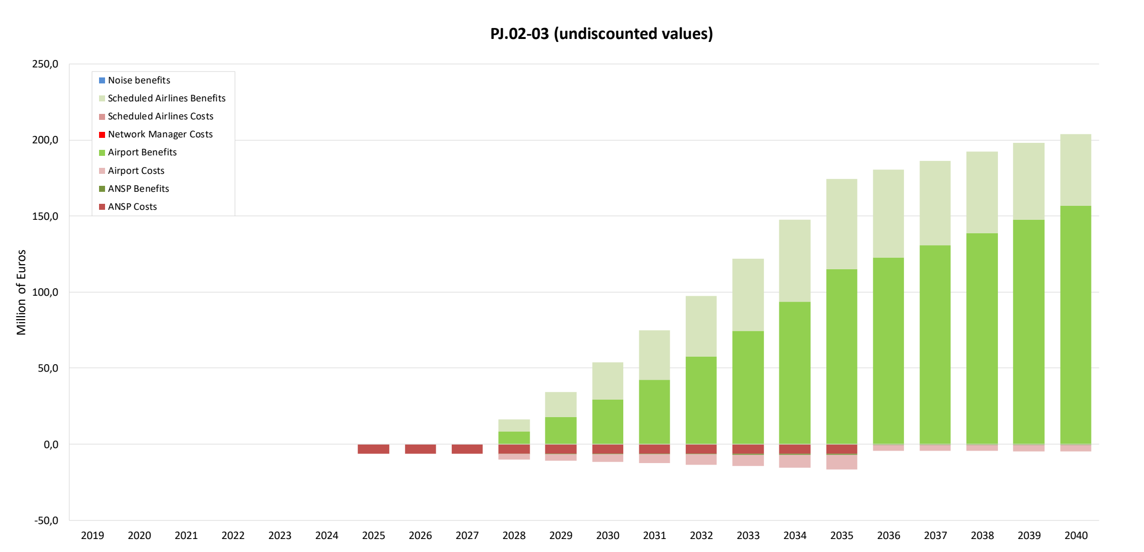

Figure 9: PJ.02-03 Annual Investment Levels and Benefits (undiscounted)

The undiscounted values are useful, especially for the costs, as they provide an idea of the overall investments that will be required. For example, based on these results, the stakeholders will need to invest **140 M€** to deploy this Solution over the deployment period. The **50 M€** discounted cost value, Table 11, simply reflects the present value of those investments in 2019.

8 Sensitivity analysis

This section[14] considers the PJ.02-03 CBA taking into account costs and benefits for all OIs in the scope of this CBA.

The results shown here explore a set of what-ifs to see how sensitive the CBA results are to changes in the input values. The 'base' values, which produce the discounted results in section 7, are shown with a green background. The following sub-sections look at these questions:

8.1 What-if we use a lower discount rate?

8.2 What-if we increase or reduce the ANSP investment and operating cost values?

8.3 What-if we increase or reduce airport capacity benefit?

8.4 What-if we increase or reduce fuel efficiency benefit?

8.5 What-if we increase or reduce time efficiency benefit?

Each of the what-ifs is considered separately, i.e. only the mentioned values are changed and all other inputs are set at their 'base' values.

8.1 Discount Rate

The discount rate is used to reflect the time value of money[15] so reducing the discount rate reduces the difference between the value of money today and its value in the future. Table 13 shows that using a lower discount rate increases the NPV.

Discount Rate	Change compared to base case	NPV (M€)		Change compared to base case
8%	0%	**387**	As shown in Table 11	0%
6%	-25%	539		39%
4%	-50%	757		95%
2%	-75%	1072		177%
0% (undiscounted)	-100%	1535	As shown in Table 12	296%

Table 13: Sensitivity Analysis – Discount Rate

[14] Risk Analysis has not been performed for this V3 CBA due to non-availability of an appropriate tool / Excel. Risk Analysis uses Monte Carlo simulation techniques to calculate the NPV results for thousands of scenarios where different combinations of the input values (taken from probability distributions) are used in each.

[15] The time value of money reflects the idea that 1€ received today has more value than 1€ received in 2040 because it could be invested an earn interest over that period.

8.2 Sensitivity to the Investment and Operating Costs

Table 14 shows that reducing/increasing the ANSP costs by 20% and 40% only increases/reduces the NPV by around 2% and 3% respectively.

ANSP costs		Change compared to base case	NPV (M€)	Change compared to base case
CAPEX	OPEX			
42.2	0.4	-40%	400	3%
56.3	0.6	-20%	394	2%
70.4	0.7	0%	**387**	0%
84.4	0.8	20%	381	-2%
98.5	1.0	40%	375	-3%
140.7	1.4	100%	357	-8%

Table 14: Sensitivity Analysis – ANSP Costs

8.3 Sensitivity to the Airport Capacity Benefit

Table 15 shows that reducing/increasing the airport capacity at ECAC level by 50%, this reduces/increases the NPV by around 27%.

Airport CAP	Change compared to base case	NPV (M€)	Change compared to base case
0.6%	-50%	284	-27%
1.1%	0%	**387**	0%
1.7%	50%	490	27%

Table 15: Sensitivity Analysis – Airport Capacity

8.4 Sensitivity to the Fuel Efficiency Benefit

Table 16 shows that shows that reducing/increasing the fuel efficiency for the Airspace Users by 40%, this reduces/increases the NPV by around 6%.

Airport CAP	Change compared to base case	NPV (M€)	Change compared to base case
1.01	-40%	363	-6%
1.67	0%	**387**	0%
2.34	40%	412	6%

Table 16: Sensitivity Analysis – Fuel Efficiency

8.5 Sensitivity to the Time Efficiency Benefit

Table 17 shows that reducing/increasing the time efficiency for the Airspace Users by 40%, this reduces/increases the NPV by around 16%.

Airport CAP	Change compared to base case	NPV (M€)	Change compared to base case
0.09%	-40%	327	-16%
0.14%	0%	**387**	0%
0.20%	40%	447	16%

Table 17: Sensitivity Analysis – Time Efficiency

9 Recommendations and next steps

This report has identified that the effective implementation of PJ.02-03 would have a significant positive impact for European ATM. A wider European-level implementation of PJ.02-03 would extend the economic benefits, as well as the operational performance, to the wider ANSP community.

The deployment of PJ.02-03 would achieve a positive global business case with the deployment phase estimated to kick off as from 2025. The net present value of such initiative could reach higher NPVs after 2040, since only OPEX remains and full benefits are accounted. Additionally, if more Airports/ANSPs adopt such a stance the benefits will also be higher.

The expected benefits are an **increase in runway capacity/resilience** (with no detrimental impact on safety), an **increase in efficiency** (increase in the runway throughput resulting in the more efficient use of the runway) and an **increase in fuel and time efficiency** (reduction of airborne delay e.g. in case of holding). Resilience has not been directly addressed in this CBA due to limitations of wind conditions reproduction in the Fast Time Simulation stemming from the lack of wind measurements in specific runways across the airports. FTS results used for the CBA contain no wind effect and thus do not address the moderate, strong and very strong headwind conditions on the straight-in approach track where the reduction of the MRS from 2.5 NM to 2NM provides the runway throughput resilience benefits. This CBA has therefore been a conservative approach to the potential benefits the reduction of the MRS from 2.5 NM to 2 NM and if it would be more representative of the potential benefits to add also the runway throughput resilience benefits in moderate, strong and very strong conditions, and then the net benefits of the CBA would potentially be significantly increased.

Benefits from Human Performance are not part of this CBA as these have not been measured.

CBA is presented at ECAC level following an extrapolation of local benefits. The local analysis is conducted for capacity constrained Very Large and Large airports (following SESAR Classification Scheme) operating in segregated mode, using Fast Time Simulation exercise. The number of airports identified as candidate for this solution is 7. However this has excluded the five airports that currently employ the 2.5 NM MRS on the straight-in approach track that would benefit from the runway throughput resilience to moderate, strong and very strong headwind condition on the straight-in approach track; including Heathrow and Vienna, which is a significant limitation of this CBA. The deployment of PJ.02-03 will require only ANSPs[16] to invest.

The CBA results are discounted at 8% between 2019 and 2040, with PJ.02-03 being deployed between 2025 and 2035 and with benefits starting to be realised in 2028. PJ.02-03 would achieve a Net Present Value of **387M€** by 2040 (1 535M€ undiscounted value) with overall costs of 140 M€ (undiscounted value). Different scenarios of sensitivity analysis are included in this CBA.

Although the CBA may seem negative from an ANSP point of view, delivering better services to airports and airspace users is a key benefit.

[16] A simplifying assumption that airport systems are owned by the ANSPs has been taken; ANSPs are incurring also all the relevant upgrade costs of these systems.

There is a strong link between minimum radar separation, wake vortex, runway occupancy and enhanced approach procedure. Combining these concepts will optimise the approach sequence. By improving wake separation, reducing surveillance minima and predicting accurate runway occupancy, it will be possible to deliver an enhanced sequence with reduced separation distances, optimising runway throughput.

It is recommended to present this CBA to ANSPs who may be interested in pursuing the concept solution, or similar, and to the airspace users and airports who might benefit highly from it.

10 References and Applicable Documents

10.1 Applicable Documents

This CBA complies with the requirements set out in the following documents:

[1] SESAR 2020 Project Handbook, edition 01.00.01, 06 June 2017

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

[3] SESAR 16.06.06-D26_03, Methods to Assess Costs and Monetise Benefits for CBAs, Ed. 00.02.02

[4] Method to assess cost of European ATM improvements and technologies, v1.0, 28 July 2014

[5] Cost-Benefit Analyses – Model and Methods – Part I, edition 00.01.01, 30 April 2017

[6] Cost-Benefit Analyses – Model and Methods – Part II, edition 00.01.01, 30 April 2017

[7] SESAR 16.06.06-D51 SESAR 1 Business Case 2016, Edition 00.01.01, 13 July 2016

[8] SESAR 16.06.06-D68-New CBA Models and Methods 2015-Part 1 of 2-00_01_01 (1_0).docx

10.2 Reference Documents

The following documents were used to provide input / guidance / further information / other:

[9] SESAR 2020, PJ19, D4.0.30 S2020 Common Assumptions (2019), Edition 00.00.02

[10]European ATM Master Plan Portal 2019, https://www.atmmasterplan.eu/

[11]SESAR C.02-D110, Updated D02 after MP Campaign, Edition 00.01.00

[12]SESAR 2020 D108, Transition Performance Framework, Edition 00.06.00

[13]SESAR 2020 D4.2, PJ19: Validation Targets (2019), Edition 01.01.00

[14]SESAR 2020 PJ.02-03 V3 SPR-INTEROP/OSED - Part I, Deliverable ID D1.1.021, Edition 00.00.05, 22 March 2019

[15]SESAR 2020 PJ.02-03 V3 SPR-INTEROP/OSED - Part V, Performance Assessment Report Deliverable D1.1.021, Edition 00.00.01, 31 October 2019

[16] SESAR 2020 PJ.02-03 VALR (V3), Deliverable D2.1.048, Edition 00.00.03, 20 June 2019

[17]EUROCONTROL - CODA Digest 2017 report (Edition CDA_2017_004 - 31/05/2018)

[18]EUROCONTROL - European Aviation in 2040 – Challenges of Growth. Edition 2.

[19]Standard Inputs for EUROCONTROL Cost-Benefit Analyses. Edition 8.0, January 2018.

[20]EUROCONTROL – Performance Review Report 2011 (PRR 2011, Final Report - PRC, May 2012)

[21]SESAR 2020 PJ20 Classification of APTs (SESAR 2018 list)

[22]STATFOR traffic forecast data (2019) – Regulation & growth scenario

[23]Performance Review Unit - ATM Cost-Effectiveness (ACE) 2016 Benchmarking Report with 2017-2021 outlook

Appendix A List of PJ.02-03 targeted Airports

The table below presents the list of targeted APTs as defined by WP2.2 (PJ20). Complexity is forecasted for 31/12/2026 mainly according the traffic growth (IFR movements).

These are the very large and large airports in 2018. Between 2018 and 2040 it is expected that many more airports will become capacity constrained.

ICAO Code	Full Name of Airport	State Name	Airports' Group in 2018 according to SESAR 2020 Airports' Classification Scheme
EDDF	Flughafen Frankfurt/Main	Germany	Very large
EHAM	Amsterdam Airport	Netherlands	Very large
LFPG	Aéroport de Paris-Charles de Gaulle	France	Very large
EGLL	Heathrow Airport	United Kingdom	Very large
LTBA	Atatürk International Airport	Turkey	Very large
EDDM	Munich Airport	Germany	Very large
LEMD	Aeropuerto de Adolfo Suárez Madrid-Barajas	Spain	Very large
LEBL	Aeropuerto de Barcelona-El Prat	Spain	Very large
LIRF	Aeroporto di Roma-Fiumicino	Italy	Very large
EGKK	Gatwick Airport	United Kingdom	Very large
LSZH	Flughafen Zürich	Switzerland	Very large
EKCH	Copenhagen Airport	Denmark	Very large
ENGM	Oslo-Garnemoen Airport	Norway	Very large
LOWW	Vienna International Airport	Austria	Very large
ESSA	Stockholm-Arlanda Airport	Sweden	Large
EIDW	Dublin Airport	Ireland	Large
LFPO	Aéroport de Paris-Orly	France	Large
EBBR	Brussels Airport	Belgium	Large
LTFJ	Sabiha Gökçen International Airport	Turkey	Large
LEPA	Aeropuerto de Palma de Mallorca	Spain	Large
EDDL	Düsseldorf International Airport	Germany	Large
LPPT	Lisbon Airport	Portugal (Madeira and Azores)	Large
LGAV	Athens International Airport	Greece	Large
EGCC	Manchester Airport	United Kingdom	Large
EGSS	Stansted Airport	United Kingdom	Large
LIMC	Milano Malpensa	Italy	Large
EFHK	Helsinki-Vantaa Airport	Finland	Large
EPWA	Warsaw Frederic Chopin Airport	Poland	Large
LTAI	Antalya International Airport	Turkey	Large

Appendix B Discount rate

This note explains the choice of 8% for the discount rate in the SESAR CBAs.

The discount rate is used to reflect the Time Value of Money (i.e. money received today has more value than money that will be received in 10 years because money received today can be invested to get some income.)

The discount rate used to calculate the Net Present Value (NPV) can be interpreted as the interest on invested money (from a project or a savings account) or as the interest charged on borrowing money (to fund an investment).

The 8% discount rate used in the SESAR CBA model to calculate the NPV reflects the higher end of the range of Cost of Capital values faced by the partners involved in PJ.20 sWP2.6 (Business Cases) to acquire the funds necessary to invest. This value is used by some partners in their local CBAs.

If a Solution has a positive NPV at 8% then it will be more positive at lower discount rates. However, a positive NPV with a lower rate, e.g. 4%, may be negative at an 8% discount rate. Therefore 8% is a conservative value, which can also be considered to include a risk premium to cover the uncertainties associated with such broad CBAs. The undiscounted values (i.e. a discount rate of 0%) are also provided to allow a comparison.

In addition, the SESAR CBAs do not consider inflation (i.e. the discount rate is the real rate and not the nominal rate). This is because it would be necessary to make many, many assumptions about how inflation rates evolve over the CBA period and how they would differ in the different states and how they would apply to the costs and benefits in each state.

Appendix C Mapping ATM Master Plan Performance Ambition KPAs and SESAR 2020 Performance Framework KPAs

Mapping between ATM Master Plan Performance Ambition KPAs and SESAR 2020 Performance Framework KPAs, Focus Areas and KPIs, source reference Benefit Monetisation of the Performance Framework KPI/PI.

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

ATM Master Plan SESAR Performance Ambition KPA	ATM Master Plan SESAR Performance Ambition KPI	Performance Framework KPA	Focus Area	#KPI / (#PI) / <Design goal>	KPI definition
Operational Efficiency	PA5 - Arrival predictability: 2 minute time window for 70% of flights actually arriving at gate		Variance of actual and reference business trajectories	PRD1	Variance of differences between actual and flight plan or Reference Business Trajectory (RBT) durations
	PA2 - 3-6% reduction in flight time	Environment	Fuel efficiency	(FEFF3)	Reduction in average flight duration
	PA3 - 5-10% reduction in fuel burn			FEFF1	Average fuel burn per flight
Environment	PA8 - 5-10% reduction in CO2 emissions			(FEFF2)	CO2 Emissions
Safety	PA9 - Safety improvement by a factor 3-4	Safety	Accidents/incidents with ATM contribution	<SAF1> see section 3.4	Total number of fatal accidents and incidents
Security	PA10 - No increase in ATM related security incidents resulting in traffic disruptions	Security	Self- Protection of the ATM System / Collaborative Support	(SEC1)	Personnel (safety) risk after mitigation
				(SEC2)	Capacity risk after mitigation
				(SEC3)	Economic risk after mitigation
				(SEC4)	Military mission effectiveness risk after mitigation

Table 18: Mapping between ATM Master Plan Performance Ambition KPAs and SESAR 2020 Performance Framework KPAs, Focus Areas and KPIs

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