SESAR SOLUTION 02-08 COST BENEFIT ANALYSIS (CBA) FOR V3

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EARTH

INCREASED RUNWAY AND AIRPORT THROUGHPUT

This CBA V3 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 along with the attached CBA Model spreadsheet provides the Cost Benefit Analysis (CBA) for SESAR Project PJ02 - Solution 08 - Traffic optimisation on single and multiple runway airports. The CBA forms part of the data pack supporting the V3 maturity gate session. It determines if the development of four concepts integrated in Solution 08 is sound, ascertaining if – and by how much – its discounted benefits outweigh its costs. The scope of the CBA covers ECAC area within 2019-2040 timeframe. The costs have been estimated mainly by expert judgment previous, whereas the benefits have been calculated through monetisation of aggregated and extrapolated results of validation exercises. All 4 concepts have been proved economically feasible as their benefits in terms of increased airports capacity and reduced average flight duration significantly outweigh the costs of implementing the new technologies which gives basis for the first phase of Industrialisation & deployment i.e. developing a Very Large Demonstrator.

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1 Executive Summary

This document provides the Cost Benefit Analysis (CBA) related to a SESAR Solution PJ02-08 that has been validated during validation activities at V3 level and forms part of the data pack supporting the V3 maturity gate session. Its objective is to provide information on costs and benefits of Solution PJ02-08 deployment at an ECAC-level CBA Scenario which would support the decision of proceeding with the Solution into V4 phase.

In V3 four Concepts (each representing a single OI) have been validated:

- **Concept 1:** Optimised integration of arrival and departure traffic flows with the use of a trajectory based Integrated Runway Sequence (TS-0301). This concept applies mainly to execution phase and addresses mainly TWR and TMA ATCOs.
- **Concept 2:** Optimised use of RWY capacity for multiple runway airports with the combined use of an Integrated Runway Sequence and RMAN (TS-0313).
- **Concept 3:** Increased Runway Throughput based on local ROT characterization (ROCAT) (AO-0337).
- **Concept 4:** Optimised use of RWY capacity for medium airports with the use of enhanced prediction of Runway Occupancy Time (ROT) (AO-0338).

There have been 3 categories of stakeholders identified: ANSPs who are expected to deploy the Solution and consequently bear the costs of investment without impairing Safety or Human Performance, and Airspace Users and Airport Operators who are expected to benefit from the Solution in improved Environmental Sustainability, Capacity, Predictability and Punctuality with no additional costs.

The results of validation exercises have been aggregated into ECAC level in the Performance Assessment Report[13] and thereafter monetised in the CBA to provide monetary values of the benefits which each Concept is expected to produce. In parallel, a cost assessment at identified deployment locations has been performed. Both costs and benefits have then been confronted per each Concept.

Item		Result
Concept 1	Net Present Value (€)	1,618,851,130
	B/C ratio	75.1
Concept 2	Net Present Value (€)	719,858,825
	B/C ratio	38.1
Concept 3	Net Present Value (€)	924,791,948
	B/C ratio	5.7
Concept 4	Net Present Value (€)	12,994,917
	B/C ratio	13.5

Table 1: Main CBA results

The positive NPVs indicate that overall benefits attributed to Airspace Users and Airport Operators exceed overall costs of ANSPs. Additionally, the results' sensitivity to main risk factors has been tested, particularly on total costs, proving that within given ranges of confidence all NPVs remain positive.

The results of V3 CBA demonstrate economic feasibility of each Solution concept and support the decision to proceed to V4 phase. In addition, several recommendations have been suggested which may improve performance and development of final product within the next V-phases.

2 Introduction

2.1 Purpose of the document

This document provides the Cost Benefit Analysis (CBA) related to a SESAR Solution PJ02-08 at V3 level. It presents the cost profile results and a qualified assessment of both costs and benefits of the Concepts integrating Solution PJ02-08 in an ECAC-level CBA Scenario. The objective of V3 – Pre-industrial development & integration is threefold:

- To further develop and refine operational concepts and supporting enablers to prepare their transition from research to an operational environment;
- To validate that all concurrently developed concepts and supporting enablers (procedures, technology and human performance aspects) can work coherently together and are capable of delivering the required benefits;
- To establish that the concurrent packages can be integrated into the target ATM system.

The output from this lifecycle phase is this V3 CBA.

2.2 Scope

This document provides the Cost Benefit Analysis (CBA) related to a SESAR Solution PJ02-08 at V3 level. The solution integrates 4 different concepts operating in both Execution and Planning Phases (Short and Medium term) to support both APP Controllers, Tower Controllers and Supervisors in monitoring and optimising runway system usage:

- **Concept 1:** Optimised integration of arrival and departure traffic flows with the use of a trajectory based Integrated Runway Sequence (TS-0301). This concept applies mainly to execution phase and addresses mainly TWR and TMA ATCOs.
- **Concept 2:** Optimised use of RWY capacity for multiple runway airports with the combined use of an Integrated Runway Sequence and RMAN (TS-0313).
- **Concept 3:** Increased Runway Throughput based on local ROT characterization (ROCAT) (AO-0337).
- **Concept 4:** Optimised use of RWY capacity for medium airports with the use of enhanced prediction of Runway Occupancy Time (ROT) (AO-0338).

As a result of an incorporation in V3 to the Solution a new operational improvement (AOU-0704), separate from the previously validated in V2 OIs (TS-0301 and TS-0313)) and its subsequent split into two separate OIs: AO-0337 and AO-0338, with little or no dependencies between the OIs, the decision has been taken to split the Solution into 4 separate concepts. Each concept in entire data pack documentation has been described, validated and evaluated individually. As a consequence of a split 4 separate Performance Assessment Reports (per Concept)[13] have been produced and 4 separate CBAs (per Concept). Therefore, the CBA compares individually the costs and benefits of each of the Concepts.

The CBA results are presented at the aggregated level and individually from the viewpoint of the impacted stakeholders:

- Airport Operators
- ANSPs
- Airspace Users

The geographical scope of the PJ02-08 CBA covers the European Civil Aviation Conference (ECAC) countries. Although in the CBA specific airports are indicated by location and names, the CBA does not aim to provide an individual result for Solution deployment at one specific location. In such cases a much deeper level of granularity would be needed taking account all local characteristics and conditions for deployment.

The Solution and Reference Scenarios consider a 21 years period of time for the analysis of all potential costs and benefits, from 2019 to 2040. Despite the deployment of the Operational Improvements of the Solution is not expected before 2025, the time horizon has been aligned with the Common assumptions for CBAs as maintained by PJ19[5].

2.3 Intended readership

This document is intended for the following audience, due to the highlighted dependencies:

- SESAR 2020 Projects/Solutions:
  - PJ01-01 (Enhanced Arrivals and Departures): Extended arrival management with overlapping AMAN operations and interaction with DCB.
  - PJ01-02 (Enhanced Arrivals and Departures): Use of arrival and departure management information for traffic optimisation in the TMA.
  - PJ02-01, Optimised Runway Delivery on Final Approach, AO-328.
  - PJ02-03 develops the concept of Minimum Pair Separations Based on Required Surveillance Performance (RSP) in support of a reduction of the in-trail Minimum Radar Separation (MRS) from 2.5 NM to 2 NM on final approach.
  - PJ03a-01, since it provides the Routing function.
  - PJ.03b-06 which develops runway condition continuous monitoring and prediction tools.
  - PJ04 (Total Airport Management): Improved prediction and quality of estimated take-off and landing time for Airport DCB.
  - PJ09 (Advanced DCB): Improved prediction and quality of estimated take-off and landing time for Network management.
  - PJ16 (Controller Working Position / Human Machine Interface): HMI integration aspects.
  - PJ18 (4D Trajectory Management): Improved prediction and quality of estimated take-off times for trajectory management processes.
  - PJ20 (Master Plan Maintenance).
  - PJ22 Validation and Demonstration Engineering.

    - PJ19: Content Integration.
- In general, the SESAR JU community.

2.4 Structure of the document

The structure of this CBA is as follows:

- **Section 2** (the present section) provides general information on the document.
- **Section 3** describes the scope and objectives of the CBA.
- **Sections 4 and 5** detail, respectively, the benefits and the costs.
- **Sections 6, 7 and 8** detail, respectively, the CBA model, the CBA results and sensitivity analysis.
- **Section 9** provides recommendations and next steps.
- **Section 10** provides a list of applicable documents and reference documents.

2.5 Background

There is no information on previous activities in the same domain e.g. previous CBAs or economic appraisals covering the SESAR Solution or parts (precursors) of it and thus defined the input(s) to the project a part of the previous PJ.02-08 V2 CBA.

2.6 Glossary of terms

Term	Definition	Source of the definition
Net Present Value	Net Present Value (NPV) is the sum of all discounted cash inflows and outflows during the time horizon period.	*Investopedia*
Cost Benefit Analysis	A Cost Benefit Analysis is a process of quantifying in economic terms the costs and benefits of a project or a program over a certain period, and those of its alternatives (within the same period), in order to have a single scale of comparison for unbiased evaluation.	*SESAR 1*
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.	*SESAR 1*
Time Horizon	Time horizon refers to a definite time period during which all cost and benefits related to a given project occur.	*SESAR 1 - ATM CBA for Beginners [4]*
Stakeholder	Stakeholders are organizations and entities who will have to pay for or will be impacted by the project directly or indirectly.	*SESAR 1 - ATM CBA for Beginners [4]*

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 1 - ATM CBA for Beginners [4]*
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 1 - ATM CBA for Beginners [4]*
Benefit mechanisms	Benefit mechanisms are a cause effect description of the improvement proposed by the project. They show how benefits are delivered.	*SESAR 1 - ATM CBA for Beginners [4]*
Benefit	Benefit is a positive impact of monetary value to stakeholders.	*SESAR 1 - ATM CBA for Beginners [4]*

2.7 List of Acronyms

Acronym	Definition
ACC	Area Control Centre
AMAN	Arrival Manager
ANSP	Air Navigation Service Provider
APT	Airport
AROT	Arrival Occupancy Time
ATM	Air Traffic Management
ATCO	Air Traffic Control Officer
BIM	Benefit and Impact Mechanism
CBA	Cost Benefit Analysis
C/B	Cost to Benefit
CR	Change Request
DCB	Demand Capacity Balancing
DMAN	Departure Manager
ECAC	European Civil Aviation Conference
EU	European Union
EXE	Exercise
FOC	Final Operating Capability
FLTD	Forecasted Landing Time
FTD	Final Target Distance
FTOT	Forecasted Take-Off Time
HMI	Human Machine Interface

Acronym	Definition
HP	Human Performance
IOC	Initial Operating Capability
IRR	Internal Rate of Return
ITD	Initial Target Distance
KPA	Key Performance Area
KPI	Key Performance Indicator
N/A	Not Applicable
NPV	Net Present Value
OE	Operating Environment
OI	Operational Improvement
OSED	Operational Service and Environment Definition
PAR	Performance Assessment Report
PIRM	Programme Information Reference Model
PAR	Performance Assessment Report
PCP	Pilot Common Project
PI	Performance Indicator
PJ	Project
PMP	Project Management Plan
RMAN	Runway Manager
ROCAT	Runway Occupancy Categorisation
ROT	Runway Occupancy Time
RWY	Runway
SESAR	Single European Sky ATM Research Programme
SJU	SESAR Joint Undertaking (Agency of the European Commission)
TBC	To be confirmed
TBD	To be defined
TLDT	Target Landing Time
TMA	Terminal Manoeuvring Area
TTOT	Target Take Off Time
TWR	Tower
VALP	Validation Plan
VALR	Validation Report

3 Objectives and scope of the CBA

3.1 Problem addressed by the solution

This document provides the Cost Benefit Analysis (CBA) related to a SESAR Solution PJ02-08 that has been validated during validation activities at V3 level and forms part of the data pack supporting the V3 maturity gate session. Its objective is to provide information on costs and benefits of Solution PJ02-08 deployment at an ECAC-level CBA Scenario which would support the decision of proceeding with the Solution into V4 phase.

In V3 four Concepts (each representing a single OI) have been validated:

- **Concept 1:** Optimised integration of arrival and departure traffic flows with the use of a trajectory based Integrated Runway Sequence (TS-0301). This concept applies mainly to execution phase and addresses mainly TWR and TMA ATCOs.
- **Concept 2:** Optimised use of RWY capacity for multiple runway airports with the combined use of an Integrated Runway Sequence and RMAN (TS-0313).
- **Concept 3:** Increased Runway Throughput based on local ROT characterization (ROCAT) (AO-0337).
- **Concept 4:** Optimised use of RWY capacity for medium airports with the use of enhanced prediction of Runway Occupancy Time (ROT) (AO-0338).

3.2 SESAR Solution description

Solution PJ.02-08 — Traffic optimisation on single and multiple runway airports provides tower and approach controllers with system support to optimise runway operations, arrival and/or departure spacing and make the best use of minimum separations, runway occupancy, runway capacity and airport capacity.

The Solution aims at improving single and multiple runway airport operations by:

- increasing the predictability and punctuality as well as fuel efficiency through the management of an Integrated Runway Sequence (TS-0301), or with a combination of optimised runway configuration management and Integrated Runway Sequence in case of multiple runways (TS-0313).
- Increased Runway Throughput based on local ROT characterization (ROCAT) (AO-0337) and Increased Runway Throughput based AROT optimisation (AO-0338).

The solution aims to provide these improvements without impairing Safety or Human Performance, which are overall expected to be maintained even if the sharing of an Integrated Runway Sequence between the different actors should enhance situation awareness and therefore safety.

The solution integrates different concepts operating in both Execution and Planning Phases (Short and Medium term) to support both APP Controllers, Tower Controllers and Supervisors in monitoring and optimising runway system usage:

- **Concept 1:** Optimised integration of arrival and departure traffic flows with the use of a trajectory based Integrated Runway Sequence (TS-0301). This concept applies mainly to execution phase and addresses mainly TWR and TMA ATCOs.
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- **Concept 4:** Optimised use of RWY capacity for medium airports with the use of enhanced prediction of Runway Occupancy Time (ROT) (AO-0338).

The tables provided below summarise Validation Targets assigned to the Solution, OIs covered by the Solution and enablers associated to OIs:

SOL CODE	APT CAP	TMA CAP	ER CAP	PUN	PRD	FEFF	CEF2	CEF3	SAF
Solution PJ.02-08	1,341%	3,599%	0,000%	0,000%	5,030%	8,5 kg	0,000%	0,000%	-0,45%

Table 2: Solution PJ.02-08 Validation Targets as in PJ19: Validation Targets (2019) D4.8 (Word)

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.02-08 — Traffic optimisation on single and multiple runway airports	TS-0301	Integrated Arrival Departure Management for full traffic optimization on the Runway	Fully	
	TS-0313	Optimized use of runway capacity for multiple runway airports.	Fully	
	AO-0337	Increased Runway Throughput based on local ROT characterization (ROCAT)	Fully	New OI Step. CR 03274 creates AO-0337 to replace AUO-0704
	AO-0338	Use of Enhanced Runway Occupancy Time (ROT) for medium airports	Fully	New OI Step. CR 03275 creates AO-0338 to complement former AUO-0704 New enabler to be created: AERODROME-ATC-55a

Table 3: SESAR Solution PJ.02-08 Scope and related OI steps

OI Steps ref.	Enabler[1] ref.	Enabler definition	Enabler coverage	Applicable stakeholder	Comments on the Enabler / definition
TS-0301	AERODROME-ATC-33 (R)	Coupled sequencing tool enhanced to better handle arrivals and departures.	Fully	ANSP	
	AERODROME-ATC-58 (R)	Agile synchronization of arrivals with departure information for the same airport	Fully	ANSP	
	APP-ATC-164 (R)	APP ATC System adapted to support integrated arrival/departure sequence functionalities in ATCO's HMI	Fully	ANSP	
	AERODROME-ATC-09c (O)	Improvement of operational orchestration among arrival / departure management and surface management services	Not addressed		
	AERODROME-ATC-27 (O)	Sequence Management system enhanced to use new wake turbulence separations	Not addressed		
	AERODROME-ATC-34 (O)	Sequence Management system enhanced to use reduced and predicted ROT	Not addressed		
	AIMS-16 (O)	Electronic Terrain and Obstacle Data (TOD)	Not addressed		
	AIMS-23 (O)	Enhanced digital data chain to ensure Aeronautical Information data provision to meet full 4D trajectory management requirements	Not addressed		
	METEO-03c (O)	Provision and monitoring of real-time airport weather information for time-based separation and curved approaches	Not addressed		

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

	METEO-04c (O)	Generate and provide MET information relevant for Airport and approach related operations at short notice ('time to decision' between 3 minutes and 7days) including rotorcraft and RPAS	Not addressed		
	NIMS-12 (O)	Demand Capacity Balancing equipped with a tool to identify and arbitrate multiple imbalance and hotspots	Not addressed		
	SWIM-APS-07b (O)	Consumption of Meteorological Information services for Step 2	Not addressed		
	SWIM-APS-08b (O)	Provision of Airport Information services for Step 2	Not addressed		
	SWIM-APS-09b (O)	Consumption of Airport Information services for Step 2	Not addressed		
TS-0313	APP-ATC-164 (R)	APP ATC System adapted to support integrated arrival/departure sequence functionalities in ATCO's HMI.	Fully	ANSP	
	AERODROME-ATC-74 (R)	Airport Demand and Capacity system enhanced for multiple runway airport	Fully	ANSP	
	AERODROME-ATC-29 (O)	Enhanced Runway Demand and Capacity system for mixed mode runway	Not addressed		
	METEO-03c (O)	Provision and monitoring of real-time airport weather information for time-based separation and curved approaches	Not addressed		
	METEO-04c (O)	Generate and provide MET information relevant for Airport and approach related operations at short notice ('time to decision' between 3 minutes and 7days) including rotorcraft and RPAS	Not addressed		

AO-0337	AERODROME-ATC-55 (R)	Airport ATC analyser tool for predicting ROT	Fully	ANSP	New OI Step. CR 03274 creates AO-0337 to replace AUO-0704
AO-0338	AERODROME-ATC-55a (R)	Airport ATC analyser tool for optimising AROT	Fully	ANSP	New OI Step. CR 03275 creates AO-0338 to complement former AUO-0704 New enabler to be created: AERODROME-ATC-55a
	AERODROME-ATC-32 (O)	Runway condition awareness management system based on weather-based runway condition model	Not addressed		

Table 4: OI steps and related Enablers

3.3 Objectives of the CBA

The objective of the V3 CBA is to provide information on the costs and benefits of deploying Solution PJ02-08 in an ECAC-level CBA Scenario. This assessment will help build the 'big picture' of whether the Solution is worth deploying. While the views of individual stakeholders involved in the deployment are considered, this CBA task does not provide CBA results for specific local deployments.

The V3 CBA presents the cost profile results and a qualified assessment of both costs and benefits (i.e. the performance assessment) per each of the Concepts integrating Solution PJ02-08.

3.4 Stakeholders[2] identification

3.4.1 Stakeholders identification (Concept 1)

Sources used to identify the stakeholders were the:

- Benefit and Impact Mechanisms (From the OSED Appendix A [12]); this focuses on who is impacted (benefits or negative impacts);
- List of stakeholders assigned to each Enabler in the eATM Portal [6]; this focuses on who will bear the costs;
- Internal evaluation with Solution partners.

Stakeholder	The type of stakeholder and/or applicable sub-OE	Type of Impact	Involvement in the analysis	Quantitative results available in the current CBA version
ANSP	ANSPs providing TWR/APP at deployment airports	Invest, operate	Provided inputs, reviewed results	Yes
Airport Operators	Deployment airports	Enjoy benefits	reviewed results	Yes
Airspace Users	Airspace Users operating at deployment airports	Enjoy benefits	not involved	Yes

Table 5: Stakeholders and impacts – Concept 1

3.4.2 Stakeholders identification (Concept 2)

Stakeholder	The type of stakeholder and/or applicable sub-OE	Type of Impact	Involvement in the analysis	Quantitative results available in the current CBA version
ANSP	ANSPs providing TWR at deployment airports	Invest, operate	Provided inputs, reviewed results	Yes
Airport Operators	Deployment Airports	No cost, no benefits	not involved	No
Airspace Users	Airspace Users operating at	Enjoy benefits	not involved	Yes

[2] 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.

	deployment airports			

Table 6: Stakeholders and impacts – Concept 2

3.4.3 Stakeholders identification (Concept 3)

Stakeholder	The type of stakeholder and/or applicable sub-OE	Type of Impact	Involvement in the analysis	Quantitative results available in the current CBA version
ANSP	ANSPs providing TWR/APP at deployment airports	Invest, operate	Provided inputs, reviewed results	Yes
Airport Operators	Deployment airports	Enjoy benefits	reviewed results	Yes
Airspace Users	Airspace Users operating at deployment airports	Enjoy benefits	not involved	Yes

Table 7: Stakeholders and impacts – Concept 3

3.4.4 Stakeholders identification (Concept 4)

Stakeholder	The type of stakeholder and/or applicable sub-OE	Type of Impact	Involvement in the analysis	Quantitative results available in the current CBA version
ANSP	ANSPs providing TWR/APP at deploying airports	Invest, operate	Provided inputs, reviewed results	Yes
Airport Operators	Deploying airports	Enjoy benefits	not involved	Yes
Airspace Users	Airspace Users operating at deploying airports	Enjoy benefits	not involved	Yes

Table 8: Stakeholders and impacts – Concept 4

3.5 CBA Scenarios and Assumptions

3.5.1 CBA Scenarios and Assumptions (Concept 1)

The following sections 3.5.1.1 and 3.5.1.2 provide a detailed description of reference and solution scenarios simulated in the performed V3 validation exercises (including both RTS and FTS) to evaluate the benefits brought by the implementation of Concept 1.

3.5.1.1 Reference Scenario (Concept 1)

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

The Traffic Optimisation on single and multiple runway airports concept (TS-0301), considers the current situation where AMAN and DMAN work separately.

The procedures used are the following:

- The Tower Runway Controller uses the arrival and departure sequences calculated by the AMAN and DMAN as support in order to maximise runway throughput. The integration of both sequences and the use of the runway occupancy time per flight is done in the ATCOs head and not shared via HMI with the other stakeholders.
- The Tower Ground Controller manages the traffic taking into account the arrival and departure sequences calculated by the AMAN and DMAN. The Tower Ground Controller mostly manages the departure sequence calculated by the DMAN taking into account the arrival sequence calculated by the AMAN.
- The Apron Controller manages the traffic in order to permit the Tower Ground Controller to manage the departure sequence calculated by the DMAN.
- The Executive TMA controller manages the traffic taking into account the arrival and departure sequences calculated by the AMAN and DMAN. The Executive TMA controller mostly manages the arrival sequence calculated by the AMAN taking into account the departure sequence calculated by the DMAN.

The TWR Supervisor/Sequence Manager manages the arrival sequence by planning, setting and adjusting runway landing rates according to changes, by monitoring the arrival sequence and by introducing on it the necessary manual changes when required. In this situation, consistency between tools are only maintained by coordination between TWR Supervisor and TMA and TWR ATCOs.

3.5.1.2 Solution Scenario (Concept 1)

The Solution Scenario considers the future situation with the deployment of the Solution.

The main goal for the Integrated Runway Sequence function is to establish an integrated arrival and departure sequence by providing accurate TTOTs and TLDTs, including dynamic balancing of arrivals and departures while optimising the runway throughput.

The following tasks will be performed by the Integrated Runway Sequence function:

- Calculation of an integrated arrival/departure sequence based on a dynamic balancing of arrival and departures, by using the estimated times at the runway;
- For multiple runway airports, provide balancing of flights between the runways for the best utilisation of runways;
- Assign TLDTs and TTOTs to arrivals and departures based on the best runway sequence which optimise the runway throughput;
- Update applicable parts of the sequence based on new information on arrival and departure flight progress;
- Provide a buffer of departing flights (predefined number) at the Runway hold to consider variability and delays depending on specific situation;
- Balancing of performance parameters:
  - Runway Throughput
  - Fuel Efficiency
  - Predictability
  - Punctuality

3.5.1.2.1 Geographical scope and deployment locations

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

OI Step	OI Step Title	Operating Environment	Additional Constraints for deployment
TS-0301	Integrated Arrival Departure management for full traffic optimisation on the RWY	APT Very Large APT Large APT Medium	Single and multiple RWY airports with AMAN/DMAN implemented

Table 9: Operating Environment - Concept 1

The Solution 02-08 / The concept of Traffic Optimisation on single and multiple runway airports is applicable in Medium to Very Large Airports with runways operated in mixed mode or having other dependencies between arrivals and departures between the runways. TS-0301 is applicable to all these airports.

The Traffic Optimisation on single and multiple runway airports concept applies to complex as well as to non-complex taxiway layouts.

There is no specific CNS technology identified for the development of the concept.

As the main goal of the concept is traffic optimisation on single and multiple runway airports aims at providing ATC with an integrated support tool (Integrated Runway Sequence Function), prerequisite for deployment of this concept is their previous successful implementation. The Basic AMAN will be implemented, regarding the European ATM Master Plan, at 24 PCP + 8 Non-PCP Airports in ECAC area by 12/2019. In further development, Extended AMAN is a SESAR Solution which has been selected by the European Commission to be part of the Pilot Common Project (PCP) 1 and shall be operated at 25 European Airports as from 1st January 2024 (REGULATION (EU) No 716/2014).

The following table summarises the applicable deployment locations.

Region	Category		Airport	APT Sub-OE	Number of movements (2018)
ECAC	EU and EFTA Member States	PCP airports	EGGL - Heathrow Airport	Very large	477 464
			LFPG - Aéroport de Paris-Charles de Gaulle	Very large	488 038
			EGKK - Gatwick Airport	Very large	283 804
			LFPO - Aéroport de Paris-Orly	Large	232 369
			EGSS – Stansted Airport	Large	200 252
			LIMC - Milano Malpensa	Large	194 355
			EDDF – Flughafen Frankfurt/Main	Very large	511 773
			LEMD – Aeropuerto de Adolfo Suárez Madrid-Barajas	Very large	409 455
			EHAM - Amsterdam Airport	Very large	510 966
			EDDM - Munich Airport	Very large	410 301
			LIRF - Aeroporto di Roma - Fiumicino	Very large	307 873
			LEBL - Aeropuerto de Barcelona-El Prat	Very large	335 521
			LSZH - Flughafen Zürich	Very large	271 348
			EDDL - Düsseldorf International Airport	Large	218 429
			EBBR - Brussels Airport	Large	229 847
			ENGM - Oslo-Gardermoen Airport	Very large	257 638
			ESSA - Stockholm-Arlanda Airport	Large	243 690
			EDDB - Schoenefeld Airport	Medium	100 984
			EGCC - Manchester Airport	Large	201 110
			LEPA - Aeropuerto de Palma de Mallorca	Large	220 242
			EKCH - Copenhagen Airport	Very large	265 977
			LOWW - Vienna International Airport	Very Large	256 343

		EIDW - Dublin Airport	Large	232 449
		LFMN - Aéroport Nice Cote d'Azur	Medium	143 779
	Non-PCP airports	LPPT - Lisbon Airport	Large	217 946
		LSGG - Genève Aéroport	Large	180 255
		LKPR - Prague Airport	Large	150 961
		LROP - Henri Coanda International Airport	Medium	122 660
		EVRA - Riga International Airport	Medium	82 986
		UKBB - Boryspil State International Airport	Medium	97 272
		EPWA - Warsaw Federic Chopin Airport	Large	187 263
		EFHK - Helsinki-Vantaa Airport	Large	192 291
Other third countries		LTBA - Atatürk International Airport	Very large	455 660

Table 10: Deployment airports – Concept 1

3.5.1.2.2 Time horizon

CBA results will be calculated up to 2040. Although the deployment of the Operational Improvements of the Concept is not expected before 2026, the time horizon has been aligned with the Common assumptions for CBAs as maintained by PJ19 [5] and the time-horizon will cover a 21 years period from 2019 to 2040.

Deployment timeframe is based on Solution OI steps / Enablers:

a. Deployment Start date(s) – reflect the start of investments for the first deployment location

b. Deployment End date(s) – reflect the end of the investments for the final deployment location

c. Initial and Final Operating Capability (IOC/FOC dates) – reflect the ramp-up of benefits across ECAC as more locations deploy the Solution

	OI step	Deployment Start date (CBA)	Deployment End date (CBA)	Initial Operating Capability (EATMA)	Final Operating Capability (EATMA)
Concept 1	TS-0301	31-12-2026	31-12-2030	31-08-2026	31-08-2030

Table 11: Deployment timeframe – Concept 1

3.5.1.2.3 Traffic evolution and discount rate

The traffic evolution values will be taken from the Challenges of Growth 2018 traffic forecast which assumed a growth of traffic of approximately 53% from 10,6M flights in 2017 to 16.2M flights in 2040 [21].

A discount rate of 8% will be used for all stakeholder's segments in the NPV calculation in line with S2020 Common Assumptions [5].

If required, residual values will be calculated when an investment is made near the end of the CBA period and a significant proportion of the benefits are expected to be realised after the end of the CBA period.

3.5.1.3 Assumptions

Assumptions are captured in the following table. Additional assumptions are also captured when relevant to the CBA.

	Common assumptions	Description
1.	The deployment is ECAC	S2020 Common Assumptions
2.	Traffic evolution	European Aviation in 2040: Challenges of Growth 2018, Flight forecast to 2040
3.	Cost of fuel	SESAR Cost Benefit Analysis Single Solution s.6.3.2
4.	Cost of CO2	SESAR Cost Benefit Analysis Single Solution s.6.3.2
5.	Cost of strategic delay	Standard Inputs for EUROCONTROL Cost-Benefit Analyses vol. 7.0,
6.	Discount rate	S2020 Common Assumptions
7.	CBA time frame	S2020 Common Assumptions
8.	Unaccommodated demand	SESAR Cost Benefit Analysis Single Solution s.6.3.2

Table 12: Common assumptions – Concept 1

	Local Assumptions	Description
1.	Deployment locations	See 3.5.1.2.1
2.	Deployment period	See 3.5.1.2.2
3.	Traffic shares	Airports traffic shares were counted on base of traffic values in 2018 reported in Airport OE Dataset February 2019
4.	Peak hours traffic share	Peak hours traffic share was calculated on common assumptions data on high density airports.
5.	ANSP costs	It was assumed that the cost of Integrated Runway Sequence will be managed by ANSP.
6.	Cost share	Operating cost were established as a portion of investment costs.
7.	Sensitivities	Sensitivity ranges were based on expert judgment.

Table 13: Local assumptions – Concept 1

Scenario feature		2030	2035	2040	Source
ECAC traffic ('000 # flights) in line with		13 846	15 174	16 200	CoG 2018
Equipage rate		N/A	N/A	N/A	
Applicability: Number of locations where Solution is deployed (# ROEs)	TS-0301	33 Airports	33 Airport	33 Airports	internal
Impacted traffic, i.e. experiencing the benefits from the Solution(s)	% of ECAC traffic	45,3%	45,3%	45,3%	internal

Table 14: Solution Scenario – Concept 1

Equipage rate is not applicable for this solution.

3.5.2 CBA Scenarios and Assumptions (Concept 2)

The following sections 3.5.2.1 and 3.5.2.2 provide a detailed description of reference and solution scenarios simulated in the performed V3 validation RTS exercise to evaluate the benefits brought by the implementation of Concept 2.

3.5.2.1 Reference Scenario (Concept 2)

The Reference Scenario considers the future situation but without the deployment of the Solution. The CBA takes a 'delta' approach so the aspects that are monetised are the differences between the Reference and Solution scenarios.

The Reference scenario for Concept 2 (TS-0313 – Optimized Use of Runway Configuration for Multiple Runway Airports) is the Solution scenario for Concept 1 (TS-0310). This scenario consists of the use of an Integrated Runway Sequence not fed by a Runway Manager tool. The Tower Supervisor establishes the runway configuration based on experience. Changes in runway conditions need to be reported from Tower Supervisor to the Tower Controllers in order to ensure consistency from the planning to the execution phase.

The procedures followed are:

- The **Tower Runway Controller**, **Tower Ground Controller**, **Apron Manager**, **Executive TMA controller** and **Sequence Manager** follow the common plan provided by the Integrated Runway Sequence function.
- The **Airport Tower Supervisor** decides a Runway Configuration based on experience and information about the planned demand without any decision support tool.

The Solution applies to the locations where an Integrated Runway Sequence function will have been deployed, and that have a multiple runway environment.

3.5.2.2 Solution Scenario (Concept 2)

The Solution scenario considers the future situation with the deployment of the Solution.

The Solution scenario consists of the use of the Runway Manager (RMAN) tool integrated with the Integrated Runway Sequence function. RMAN is a support tool for the Tower Supervisor to determine the optimal runway configuration and distribution of demand according to capacity and local constraints.

Prediction of capacity on complex airports might be difficult for the controllers, since available capacity can be distributed over the runways in different ways according to the applicable dependencies.

For the time horizon in which the Integrated RWY Sequence function is active, the RMAN continuously monitors the planning in order to take appropriate actions for the following hours. The optimal runway configuration is assessed by calculating operational KPIs (delay, shortage and punctuality).

Since the demand is continuously evolving along time, the RMAN continuously computes the optimal runway configuration and the associated Forecasted Landing (FLDT) and Take Off (FTOT)

Times of arrival and departures flights that maximises the runway throughput. The output of RMAN is taken as an input by the Integrated Runway Sequence function.

Concept 2 is therefore built on top of Concept 1. It may be considered as an upgrade of Integrated Runway Sequence which provides additional functionalities (RMAN) to the airports with multiple runways.

3.5.2.2.1 Geographical scope and deployment locations

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

The Solution 02-08 Concept 2 is applicable in Medium to Very Large Airports with runways operated in mixed mode or having other dependencies between arrivals and departures between the runways. TS-0313 is only applicable to the locations where an Integrated Runway Sequence function is deployed and with a multiple runway environment.

OI Step	OI Step Title	Operating Environment	Additional Constraints for deployment
TS-0313	Optimised Use of Runway Capacity for Multiple Runway Airports	APT Very Large APT Large APT Medium	Multiple RWY airport Integrated Runway Sequence implemented

Table 15: Operating Environment – Concept 2

There is no specific CNS technology identified for the development of the concept.

The table below summarises the applicable deployment locations It should be noted that Concept 2 deployment locations are the same as in Concept 1 with a difference of 2 excluded single-runway airports (London Stansted and Riga).

Region		Category	Airport	RWY	APT Sub-OE	Number of movements (2018)
ECAC	EU and EFTA Member States	PCP airports	Flughafen Frankfurt/Main	Multiple	Very large	511 773
			Munich Airport	Multiple	Very large	410 301
			Gatwick Airport	Multiple	Very large	283 804
			Heathrow Airport	Multiple	Very large	477 464
			Amsterdam Airport	Multiple	Very large	510 966
			Copenhagen Airport	Multiple	Very large	265 977
			Aeropuerto de Barcelona-El Prat	Multiple	Very large	335 521

			Aeropuerto de Adolfo Suárez Madrid-Barajas	Multiple	Very large	409 455
			Aéroport de Paris-Charles de Gaulle	Multiple	Very large	488 038
			Aeroporto di Roma-Fiumicino	Multiple	Very large	307 873
			Flughafen Zürich	Multiple	Very large	271 348
			Oslo-Gardermoen Airport	Multiple	Very large	257 638
			Vienna International Airport	Multiple	Very large	256 343
			Aéroport de Paris-Orly	Multiple	Large	232 369
			Stockholm-Arlanda Airport	Multiple	Large	243 690
			Brussels Airport	Multiple	Large	229 847
			Düsseldorf International Airport	Multiple	Large	218 429
			Dublin Airport	Multiple	Large	232 449
			Aeropuerto de Palma de Mallorca	Multiple	Large	220 242
			Manchester Airport	Multiple	Large	201 110
			Milano Malpensa	Multiple	Large	194 355
			Aéroport Nice Côte d'Azur	Multiple	Medium	143 779
			Schoenefeld Airport	Multiple	Medium	100 984
		Non-PCP airports	Genève Aéroport	Multiple	Large	180 255
			Lisbon Airport	Multiple	Large	217 946
			Helsinki-Vantaa Airport	Multiple	Large	192 291
			Warsaw Frederic Chopin Airport	Multiple	Large	187 263
			Prague Airport	Multiple	Large	150 961
			Henri Coanda International Airport	Multiple	Medium	122 660
			Boryspil State International	Multiple	Medium	97 272

			Airport			
	Other third countries		Atatürk International Airport	Multiple	Very large	455 660

Table 16: Deployment airports – Concept 2

3.5.2.2.2 Time horizon

CBA results will be calculated up to 2040. Although the deployment of the Operational Improvements of the Concept is not expected before 2026, the time horizon has been aligned with the Common assumptions for CBAs [5] and the time-horizon will cover a 21 years period from 2019 to 2040.

Deployment timeframe is based on Solution OI steps / Enablers:

a. Deployment Start date(s) – reflect the start of investments for the first deployment location

b. Deployment End date(s) – reflect the end of the investments for the final deployment location

c. Initial and Final Operating Capability (IOC/FOC dates) – reflect the ramp-up of benefits across ECAC as more locations deploy the Solution

	OI step	Deployment Start date (CBA)	Deployment End date (CBA)	Initial Operating Capability (EATMA)	Final Operating Capability (EATMA)
Concept 2	TS-0313	31-12-2026	31-12-2030	31-08-2026	31-08-2030

Table 17: Deployment timeframe – Concept 2

3.5.2.2.3 Traffic evolution and discount rate

The traffic evolution values will be taken from the Challenges of Growth 2018 traffic forecast which assumed a growth of traffic of approximately 53% from 10,6M flights in 2017 to 16.2M flights in 2040 [21].

A discount rate of 8% will be used for all stakeholder's segments in the NPV calculation in line with S2020 Common Assumptions [5].

If required, residual values will be calculated when an investment is made near the end of the CBA period and a significant proportion of the benefits are expected to be realised after the end of the CBA period.

3.5.2.3 Assumptions

Assumptions are captured in the following table. Additional assumptions are also captured when relevant to the CBA.

	Common assumptions	Description
1.	The deployment is ECAC	S2020 Common Assumptions

2.	Traffic evolution	European Aviation in 2040: Challenges of Growth 2018, Flight forecast to 2040
3.	Cost of fuel	SESAR Cost Benefit Analysis Single Solution s.6.3.2
4.	Cost of CO2	SESAR Cost Benefit Analysis Single Solution s.6.3.2
5.	Cost of strategic delay	Standard Inputs for EUROCONTROL Cost-Benefit Analyses vol. 7.0,
6.	Discount rate	S2020 Common Assumptions
7.	CBA time frame	S2020 Common Assumptions
8.	Unaccommodated demand	SESAR Cost Benefit Analysis Single Solution s.6.3.2

Table 18: Common assumptions – Concept 2

	Local Assumptions	Description
1.	Deployment locations	See 3.5.2.2.1
2.	Deployment period	See 3.5.2.2.2
3.	Traffic shares	Airports traffic shares were counted on base of traffic values in 2018 reported in Airport OE Dataset February 2019
4.	Peak hours traffic share	Peak hours traffic share was calculated on common assumptions data on high density airports.
5.	ANSP costs	All costs managed by ANSP.
6.	Cost share	Operating cost were established as a portion of investment costs.
7.	Sensitivities	Sensitivity ranges were based on expert judgment.

Table 19: Local assumptions – Concept 2

Scenario feature		2030	2035	2040	Source
ECAC traffic ('000 # flights) in line with		13 846	15 174	16 200	CoG 2018
Equipage rate		N/A	N/A	N/A	
Applicability: Number of locations where Solution is deployed (# ROEs)	TS-0313	31 Airports	31 Airport	31 Airports	internal
Impacted traffic, i.e. experiencing the benefits from the Solution(s)	% of ECAC traffic	43,8%	43,8%	43,8%	internal

Table 20: Solution Scenario – Concept 2

Equipage rate is not applicable for this solution.

3.5.3 CBA Scenarios and Assumptions (Concept 3)

The following sections 3.5.3.1 and 3.5.3.2 provide a detailed description of reference and solution scenarios simulated in the performed V3 validation RTS exercise to evaluate the benefits brought by the implementation of Concept 3. EXE.02-08.V3.005 was a joint exercise which aimed to assess the operational feasibility and acceptability of the enhanced predictability of ROT concept based on aircraft type when combined with the ORD tool (EUROCONTROL LORD tool with FTD and ITD) (AO-0328) and TB PWS-A separation scheme (AO-0306) under segregated runway operations. The latter OIs are to be fully validated by PJ.02-01.

3.5.3.1 Reference Scenario

In Concept 3 reference scenario radar separation standards for arrivals and departures include MRS which prevents aircraft collision and WT separation which is intended to protect aircraft from adverse WTEs. In current day operations WT separations are defined between categories of aircraft which are grouped based on their MTOW. Examples of WT category schemes include ICAO, RECAT-EU 6 category and UK 6 category. When no WT separation is applicable then MRS is applied. This is typically 3Nm although can be 2.5Nm under certain conditions. Radar separations in current operations are defined in distance for arrival aircraft.

If the Flight Crew perform a visual approach, the separation mode changes, and the responsibility lies with the Flight Crew to determine the spacing.

Radar separation is applied by observing the headings, distances, and speeds, between consecutive aircraft. The Final Approach Controller knows the locally applied wake turbulence radar separation table (i.e. ICAO). From the respective aircraft wake turbulence categories from the flight strips, or from the target labels, the Controller establishes the wake turbulence radar separation required between the respective aircraft.

The separation distance limits are determined by the Controller by the use of scales on the radar map and through the observation of catch-up from the separation distance progression observed between the follower aircraft and the lead aircraft. In case of possible infringement, the Controller will first use speed instructions, and then use vectoring, or order a go-around. Inside of 4Nm from the runway threshold no speed instructions are advised.

3.5.3.2 Solution Scenario

In order to influence performance the Enhanced AROT Prediction concept requires further integration into the dedicated ATC systems.

The hypothesis taken by Concept 3 for Solution Scenario are based on the hypothesis of an Enhance Predicted ROT model that require a separation delivery tool, i.e. when the ROT provided is aircraft type dependent when the Enhanced Predicted ROT model output vary for aircraft types within the same Wake Categories.

When a separation delivery tool is not required, the operating method are deemed identical to Previous Operating method described in previous section.

The present section summarizes most important element of the Separation Delivery tool that supports the Controller in delivering the required separation or spacing, including the ROT spacing constraint.

The Separation Delivery function aims to compute the minimum applicable separation per pair, considering a wake separation scheme, applicable MRS down to 2.0 NM and leader ROT.

The separation delivery function could be distance based or times based. In the latter case, it considers the wind conditions accounting for wake constraint (if any).

The Separation Delivery tool calculates and displays Target Distance Indicators (TDIs) on the Approach and Tower CWPs. The TDIs include an FTD indicator which displays the required separation/spacing to be delivered to the required delivery point and an Initial Target Distance (ITD) indicator which displays the required spacing to deliver at the DF to support the Controller in delivering the required separation / spacing.

The key steps regarding the calculation and display of these TDIs are as follows:

- Determine the Approach Arrival Sequence;
- Identify all applicable separations / spacing's per arrival pair (includes in-trail and not-in-trail pairs);
- Compute the equivalent distance for any time separations or spacing's;
- Select the maximum applicable separation or spacing which is known as the FTD
- Compute the ITD by taking into account the effect of compression;
- Determine if the TDI should be displayed;
- Display the TDI on all applicable CWPs.

The time when an aircraft needs to be given clearance to land will depend on the local operation, but this should be considered when defining the ROT spacing constraint which the Separation Delivery tool will use.

See PJ02-01 SPR-INTEROP/OSED for V3 for full description of the Separation Delivery tool.

3.5.3.2.1 Geographical scope and deployment locations

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

The Solution 02-08 Concept 3 is applicable in capacity constrained Large to Very Large Airports with runways operated in segregated mode with series of consecutive arrivals and operating at or close to maximum runway capacity during peak hours in line with PJ.02-01 assumption on deployment locations.

The following table summarises the applicable operating environment:

OE	Applicable sub-OE	Special characteristics

Airport	Very Large / Large	EBBR EDDF EGLL EHAM EKCH ESSA LEBL LEMD LEPA LFPG LGAV LOWW LSZH LTBA	Brussels / Brussels – National Frankfurt - Main London Heathrow Amsterdam - Schipol Kobenhavn - Kastrup Stockholm – Arlanda Barcelona Madrid Palma de Mallorca Paris Charles de Gaulle Athens Vienna Zürich Istanbul – Ataturk

Table 21: Operating Environment - Concept 3.

3.5.3.2.2 Time horizon

CBA results will be calculated up to 2040. Although the deployment of the Operational Improvements of the Concept is not expected before 2026, the time horizon has been aligned with the Common assumptions for CBAs as maintained by PJ19 [5] and the time-horizon will cover a 21 years period from 2019 to 2040.

Deployment timeframe is based on Solution OI steps / Enablers:

d. Deployment Start date(s) – reflect the start of investments for the first deployment location

e. Deployment End date(s) – reflect the end of the investments for the final deployment location

f. Initial and Final Operating Capability (IOC/FOC dates) – reflect the ramp-up of benefits across ECAC as more locations deploy the Solution

	OI step	Deployment Start date (CBA)	Deployment End date (CBA)	Initial Operating Capability (CR 20)	Final Operating Capability (CR 20)
Concept 3	AO-0337	31-12-2026	31-12-2030	31-12-2026	31-12-2030

Table 22: Deployment timeframe – Concept 3

3.5.3.2.3 Traffic evolution and discount rate

The traffic evolution values will be taken from the Challenges of Growth 2018 traffic forecast which assumed a growth of traffic of approximately 53% from 10,6M flights in 2017 to 16.2M flights in 2040 [21].

A discount rate of 8% will be used for all stakeholder's segments in the NPV calculation in line with S2020 Common Assumptions [5].

If required, residual values will be calculated when an investment is made near the end of the CBA period and a significant proportion of the benefits are expected to be realised after the end of the CBA period.

3.5.3.3 Assumptions

Assumptions are captured in the following table. Additional assumptions are also captured when relevant to the CBA.

	Common assumptions	Description
1.	The deployment is ECAC	S2020 Common Assumptions
2.	Traffic evolution	European Aviation in 2040: Challenges of Growth 2018, Flight forecast to 2040
3.	Cost of fuel	SESAR Cost Benefit Analysis Single Solution s.6.3.2
4.	Cost of CO2	SESAR Cost Benefit Analysis Single Solution s.6.3.2
5.	Cost of strategic delay	Standard Inputs for EUROCONTROL Cost-Benefit Analyses vol. 7.0,
6.	Discount rate	S2020 Common Assumptions
7.	CBA time frame	S2020 Common Assumptions
8.	Unaccommodated demand	SESAR Cost Benefit Analysis Single Solution s.6.3.2

Table 23: Common assumptions – Concept 3

	Local Assumptions	Description
1.	Deployment locations	See 3.5.3.2.1
2.	Deployment period	See 3.5.3.2.2
3.	Traffic shares	Airports traffic shares were counted on base of traffic values in 2018 reported in Airport OE Dataset February 2019
4.	Peak hours traffic share	Peak hours traffic share was calculated on common assumptions data on high density airports.
5.	ANSP costs	All costs managed by ANSP.
6	Capacity	Monetisation mechanism of CAP3.2 for segregated mode operations follows the same mechanism as CAP3 for mixed mode operations.
7.	Cost share	Operating cost were established as a portion of investment costs.
8.	Sensitivities	Sensitivity ranges were based on expert judgment.

Table 24: Local assumptions – Concept 3

Scenario feature		Year 2030	Year 2035	Year 2040	Source
ECAC traffic ('000 # flights) in line with [5]		13 846	15 174	16 200	CoG 2018
Equipage rate	ENB XX	N/A	N/A	N/A	

	ENB YY	N/A	N/A	N/A	
Applicability: Number of locations where Solution is deployed (# ROEs)	OI ZZ	14 airports	14 airports	14 airports	internal
Impacted traffic, i.e. experiencing the benefits from the Solution(s)	'000 # IFR flights per year	175 additional	193 additional	206 additional	internal
	'000 # IFR flight hours per year	N/A	N/A	N/A	

Table 25: Solution Scenario – Concept 3

Equipage rate is not applicable for this solution.

3.5.4 CBA Scenarios and Assumptions (Concept 4)

3.5.4.1 Reference Scenario

In current operations, the Tower Runway Controller is responsible for providing landing clearance to arriving aircraft. In order to do this, the arrival traffic is transferred to the Tower Runway Controller a few nautical miles from the threshold, and the Tower Runway Controller monitors that the runway occupancy of preceding aircraft is progressing as expected. The Tower Runway Controller monitors the speed and position of the next approaching arrival, in order to determine when to give a landing clearance, or to order a go-around, if the previous aircraft runway occupancy exceeds the applied separation. Both visual out of the window, and surveillance equipment, is used.

If in mixed mode, the Tower Runway Controller also has to deliver line-up and take-off clearances to departing aircraft, and time this so that the gap between the two associated arrivals can be used.

3.5.4.2 Solution Scenario

Concept 4 solution scenario assumes that the Enhanced AROT Prediction concept is integrated into the dedicated ATC systems. The proposed in Concept 4 scenario is of a simplest integration where Enhanced AROT Predictor is used directly in Tower Runway Controller CWP via modification of the information available via EFS.

In Concept 4 it is assumed that Enhanced AROT Prediction is available at a certain time interval before the estimated time of touchdown for each arriving flight. The prediction algorithm not only takes into account the aircraft type and Wake Category but also other parameters that are related to current approach performance and designated runway condition. In this setting each time an aircraft is on final approach there is an AROT estimate available for this flight at some point in time. Currently based on operational and technical constrains the lead time of AROT prediction is set to be 5 min. before planned touchdown.

3.5.4.2.1 Geographical scope and deployment locations

Establishing deployment Concept 4 deployment locations requires some extended explanation.

As a consequence of a split of AOU-0704 into two separate OIs, Solution 02-08 Concept 3 was reinvented to target Very Large and Large airports while Concept 4 was reinvented to target Medium Airports. Concept 4 aims to increase capacity of medium airports with runways operating in segregated mode or mix-mode with series of consecutive arrivals and operating at or close to maximum runway capacity during peak hours by allowing easier operations in reduced separation minima on final approach. In SESAR 2020 airport capacity increases are primarily measured by CAP3 KPI: Peak Runway Throughput (mixed mode) and later on monetized by the value of additionally accommodated traffic. This KPI is however reserved to the most challenging (or constrained) environments targeting on the basis of busy hours at certain reference airports, i.e. the capacity at “Best-in-Class” (BIC) airports. A question arises if any of medium sized airport (accommodating annually 40.000-150.000 movements) can be regarded as one of those most capacity constrained airports, where provision of extra runway capacity would create additional traffic that otherwise could not be accommodated. In the absence of a strict definition or a categorisation of a “Best-in-Class” airports some evidence has been gathered to support a thesis that those airports capped at 150.000 movements annually will not contribute to generating additional traffic by a mean of increasing runway capacity:

1) European Aviation in 2040 Challenges of Growth defines congested airports as those *operating at 80% or more of capacity for 6 consecutive hours: There were 6 airports at this level of congestion in Summer 2016; London Heathrow being like this year-round. The forecast is now for this to climb to 16 congested ‚Heathrow-like' airports by 2040 in Regulation and Growth, or even 28 in Global Growth scenario*. As the group of Very Large and Large airports amounted to 31 and is expected to grow to 48 it is unlikely that any Medium size airport could be regarded as "congested"

2) European Aviation in 2040 Challenges of Growth Annex 3 Mitigation Measures identified 27 airports whose capacity could be increased by SESAR improvements

3) European Aviation in 2040 Challenges of Growth Annex 3 Mitigation Measures suggests that for Medium airports there is a link with current traffic and declared future capacities: *Half of single-runway airports reported future airport capacities under 150,000 movements per year. These low values seem to be driven more by current traffic and demand than by fundamental limits to capacity.*

Following this approach if CAP3 measurement – and subsequent benefits - are not targeted for Medium size airport and Concept 4 not expecting benefits in any other KPA, then Concept 4 would have no practical application. However, as CAP targets were also assigned for Medium airports sub-OE, a small group of 5 airports from this has been selected that theoretically could benefit from CAP increase (criteria: >100.000 movements, high utilization of available capacity). The list particularly does not include Gdańsk Airport where Concept 4 was validated in EXE.02-08.V3.008 – PANSA FTS, as the traffic sample used in the exercises (50-60 operations per hour) corresponds to a Number of IFR Flight Movements in Peak Hour in 2018 (DDR2) of Large airports, whereas Gdańsk Airport with its 43.000 movements of real traffic is not likely to benefit from CAP3 increase.

OE	Applicable sub-OE	Special characteristics	
Airport	Medium	LEMG	Malaga/Costa Del Sol
		EGGW	London Luton
		GCLP	Gran Canaria
		LIML	Milano/Linate
		EGBB	Birmingham

Table 26: Operating Environment - Concept 4.

3.5.4.2.2 Time horizon

CBA results will be calculated up to 2040. Although the deployment of the Operational Improvements of the Concept is not expected before 2026, the time horizon has been aligned with the Common assumptions for CBAs as maintained by PJ19 [5] and the time-horizon will cover a 21 years period from 2019 to 2040.

Deployment timeframe is based on Solution OI steps / Enablers:

a. Deployment Start date(s) – reflect the start of investments for the first deployment location

b. Deployment End date(s) – reflect the end of the investments for the final deployment location

c. Initial and Final Operating Capability (IOC/FOC dates) – reflect the ramp-up of benefits across ECAC as more locations deploy the Solution

	OI step	Deployment Start date (CBA)	Deployment End date (CBA)	Initial Operating Capability (CR)	Final Operating Capability (CR)
Concept 4	AO-0338	31-12-2026	31-12-2030	31-12-2026	31-12-2030

Table 27: Deployment timeframe – Concept 4

3.5.4.2.3 Traffic evolution and discount rate

The traffic evolution values will be taken from the Challenges of Growth 2018 traffic forecast which assumed a growth of traffic of approximately 53% from 10,6M flights in 2017 to 16.2M flights in 2040 [21].

A discount rate of 8% will be used for all stakeholder's segments in the NPV calculation in line with S2020 Common Assumptions [5].

If required, residual values will be calculated when an investment is made near the end of the CBA period and a significant proportion of the benefits are expected to be realised after the end of the CBA period.

3.5.4.3 Assumptions

Assumptions are captured in the following table. Additional assumptions are also captured when relevant to the CBA.

	Common assumptions	Description
1.	The deployment is ECAC	S2020 Common Assumptions
2.	Traffic evolution	European Aviation in 2040: Challenges of Growth 2018, Flight forecast to 2040
3.	Cost of fuel	SESAR Cost Benefit Analysis Single Solution s.6.3.2
4.	Cost of CO2	SESAR Cost Benefit Analysis Single Solution s.6.3.2
5.	Cost of strategic delay	Standard Inputs for EUROCONTROL Cost-Benefit Analyses vol. 7.0,
6.	Discount rate	S2020 Common Assumptions
7.	CBA time frame	S2020 Common Assumptions
8.	Unaccommodated demand	SESAR Cost Benefit Analysis Single Solution s.6.3.2

Table 28: Common assumptions – Concept 4

	Local Assumptions	Description
1.	Deployment locations	See 3.5.4.2.1
2.	Deployment period	See 3.5.4.2.2
3.	Traffic shares	Airports traffic shares were counted on base of traffic values in 2018 reported in Airport OE Dataset February 2019
4.	Peak hours traffic share	Peak hours traffic share was calculated on common assumptions data on medium density airports.
5.	ANSP costs	All costs managed by ANSP.

6.	Cost share	Operating cost were established as a portion of investment costs.
7.	Sensitivities	Sensitivity ranges were based on expert judgment.

Table 29: Local assumptions – Concept 4

Scenario feature		Year 2030	Year 2035	Year 2040	Source
ECAC traffic ('000 # flights) in line with [5]		13 846	15 174	16 200	CoG 2018
Applicability: Number of locations where Solution is deployed (# ROEs)	OI ZZ	5 airports	5 airports	5 airports	internal
Impacted traffic, i.e. experiencing the benefits from the Solution(s)	'000 # IFR flights per year	2 additional	3 additional	3 additional	internal
	'000 # IFR flight hours per year	N/A	N/A	N/A	

Table 30: Solution Scenario – Concept 4

Equipage rate is not applicable for this solution.

4 Benefits

This section describes the monetised benefits deriving from the implementation of the Concepts integrating Solution 08 based on the CBA Scenarios illustrated in the previous section. The benefits were calculated in a 2-stage process as presented in a graph below: first, the results of EXEs reported in VALR [14] were aggregated into KPIs in PAR [13], and second, the KPIs of PAR were translated into monetary values in the CBA. A complete and detailed process of transition of validations results into monetary benefits with all underlying step-by-step assumptions is to be followed in the embedded CBA spreadsheet file in Chapter 6.

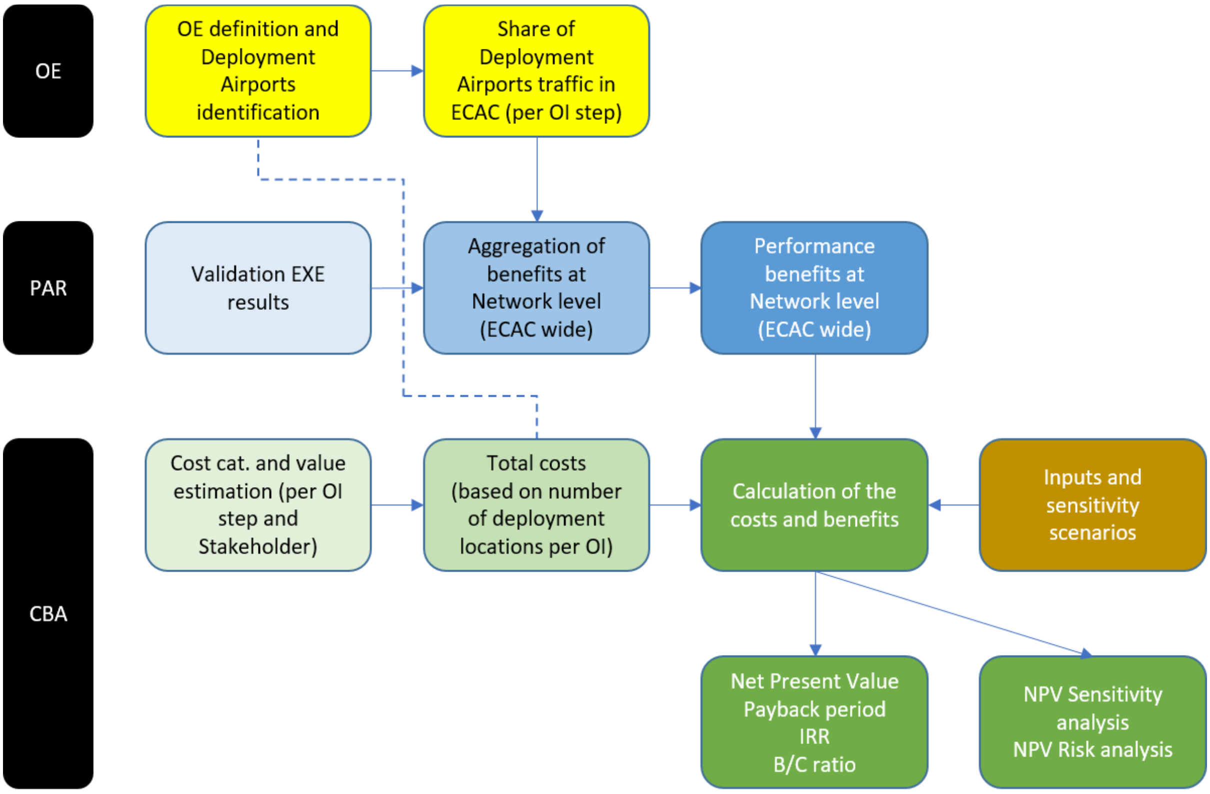

Figure 1: CBA calculation logic

The KPAs addressed by the Solution PJ02-08 are:

- For Concept 1: Airport Capacity, Predictability, Punctuality, Environmental sustainability, Human Performance and Safety.
- For Concept 2: Predictability, Punctuality and Environmental sustainability
- For Concept 3: Capacity, Safety and Human Performance.
- For Concept 4: Airport Capacity and Safety.

Neither Safety nor Human Performance have been monetized in the CBA. Safety level was confirmed by the exercises to be maintained, whereas for Human Performance only qualitative results are available.

Due to the different nature of the 4 Concepts addressed by the Solution, no aggregation of results can be done between them. This issue was already raised by the Solution at the beginning of the V3 phase and it was agreed with SJU that the Solution PAR would contain 4 Sub-PARs per each of the Concept and that the Solution CBA would contain 4 Sub-CBAs per concept as well.

The results of the validation exercises have been extrapolated to the ECAC level in the PJ02-08 V3 Performance Assessment Report [13] and compared to expected Validation Targets as defined PJ19.04.01 D4.5 Validation Targets (2019), Edition 00.01.00, February 2019 [9]. The table below summarises those results.

KPA	KPI / PI	Validation Target	Concept 1	Concept 2	Concept 3	Concept 4
Environment	FEFF1 Fuel Efficiency – Fuel burn per flight	8.5 kg	3.87 kg	1.04 kg	0	0
Capacity	CAP1: TMA Airspace Capacity – Throughput / airspace volume & time	3.599%	KPI not measured. Solution is not expected to bring benefits in TMA capacity. Validation Target to be corrected.			
	CAP2: En-Route Airspace Capacity – EN-route throughput, in challenging airspace, per unit time	0.000%	0			
	CAP3: Airport Capacity – Peak runway throughput (mixed mode) flights/hour	1.341%	5.1% and 90 flights/hour (LFV-COOPANS RTS with Stockholm-Arlanda Airport operating on independent parallel runways) 0.2% (ENAV FTS with Rome Fiumicino Airport operating on dependent runways)	0	0 (CAP3.2 7.5%)	1,9% for Gdańsk airport in Large airport traffic sample

Predictability and Punctuality	PRD1: Predictability – Flight duration variability, against RBT	5.030%	3.139%	0.60%	0	0
	PUN1: Punctuality – % AOBT within +/- 3 minutes of SOBT	0.000%	1.81%	0.86%	0	0
Cost Efficiency	CEF2: ATCO Productivity – Flights per ATCO hour	0.000%	0			
	CEF3: Technology Cost – Cost per flight	0.000%	0			
Safety	SAF1: Safety - Total number of fatal accidents and incidents with ATM Contribution per year	-0,45%	0%	0	0%	0

Table 31: PJ02-08 Validation Targets with Concepts results

4.1 Benefits (Concept 1)

A main assumption for the V3 validation has been that an Integrated Runway Sequence (TS-0301) is expected to bring benefits in Airport Capacity, Predictability, Punctuality, Environmental sustainability, Human Performance and Safety. As stated before, HP and SAF have not been analysed in the CBA. Despite having no validation target assigned for Punctuality KPA, validations did measure PUN1. However, due to lack of any formula for PUN1 monetisation this positive effect could not be reflected in the CBA in terms of economic values. The Benefit Impact Mechanism below followed by Benefit Monetisation Mechanism demonstrate the approach taken to monetise Concept 1 benefits.

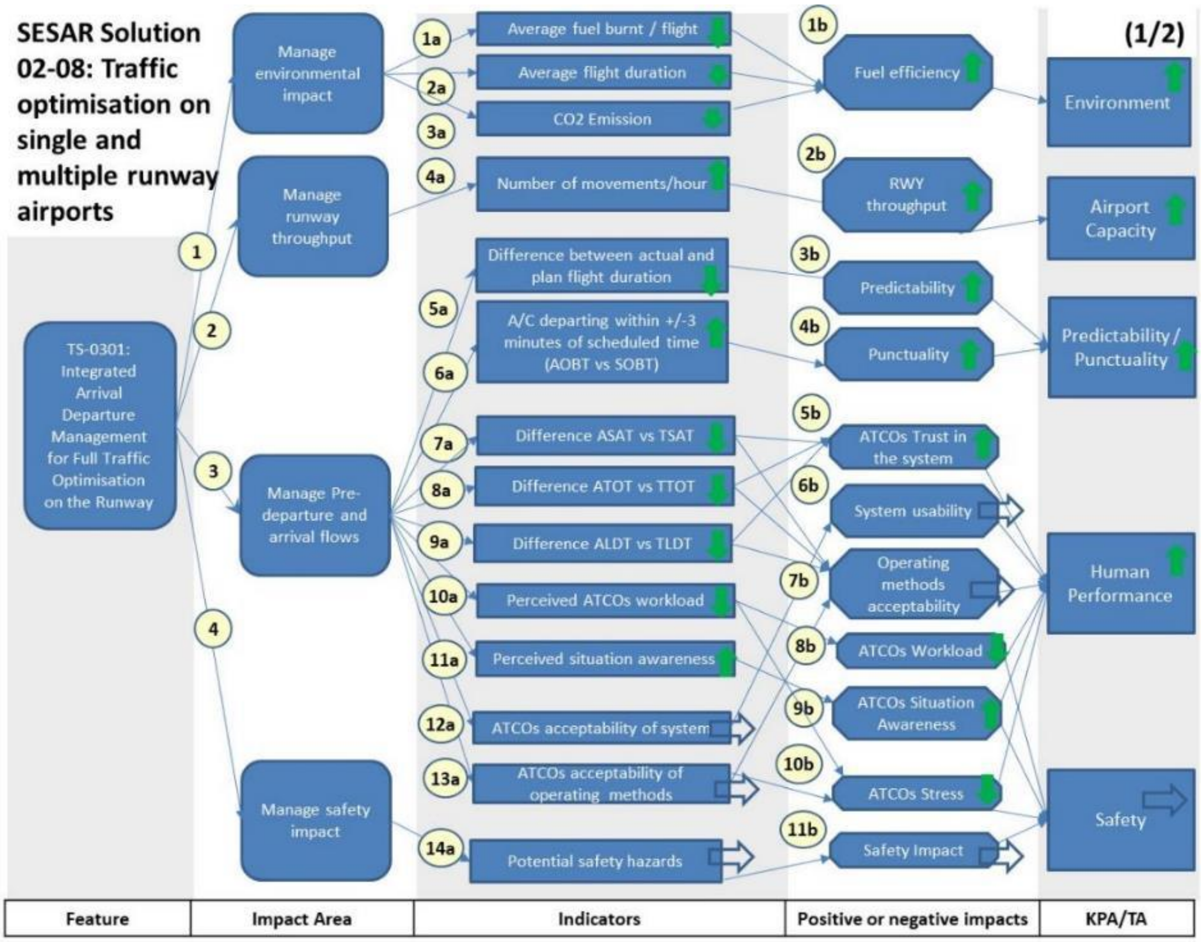

Figure 2: BIM Concept 1

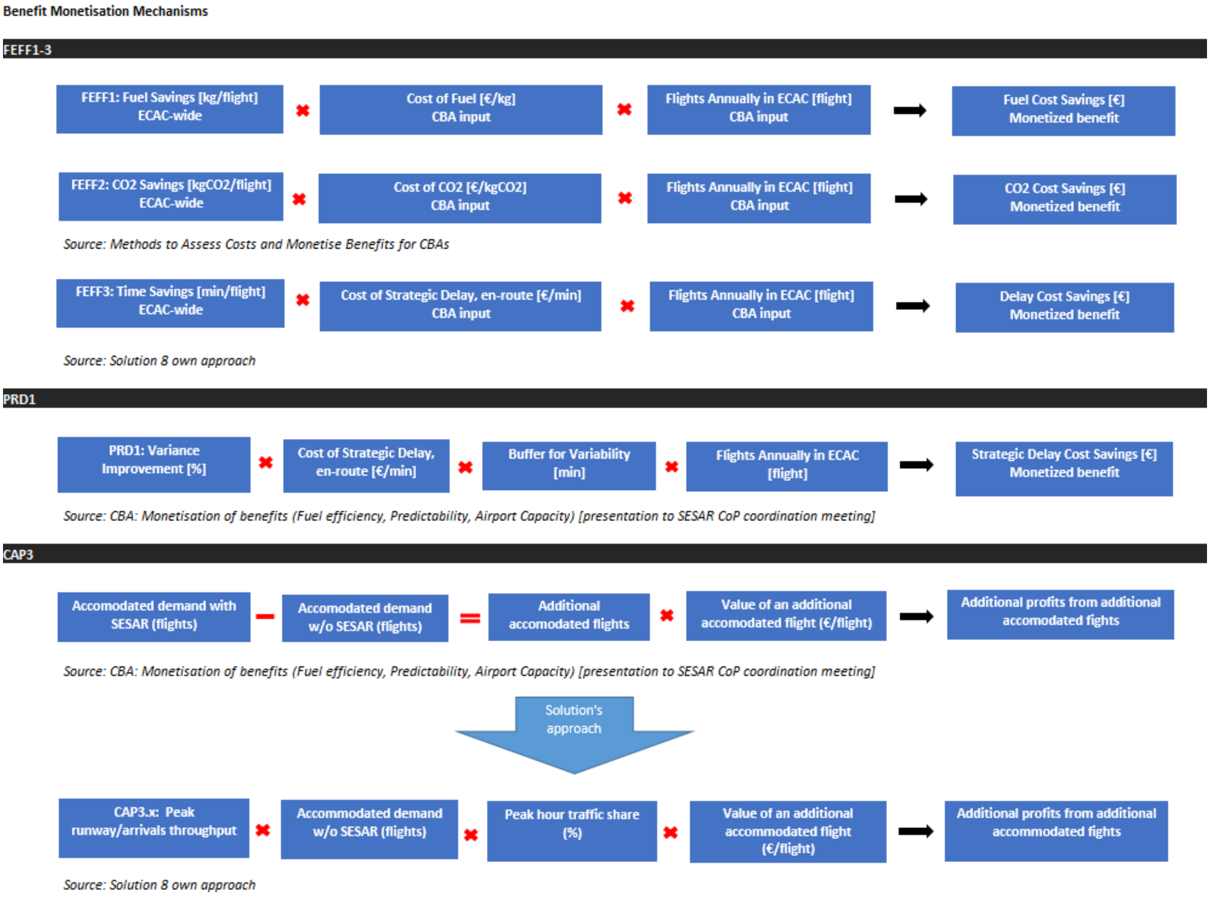

Figure 3: Benefit Monetisation Mechanism Concept 1

Performance Framework KPA[1]	Focus Area	KPI/PI from the Performance Framework	Unit	Metric for the CBA	Unit	2030	2035	2040
Capacity	Airport capacity	**CAP3** Peak Runway Throughput (Mixed mode)	% and # movements	Value of additional flights	€/year	132,318,142	144,998,115	154,807,449
Predictability and punctuality	Predictability	**PRD1** Variance of Difference in actual & Flight Plan or RBT durations	Minutes^2	Strategic delay cost (avoided-; additional +)	€/year	31,685,844	34,722,281	37,071,294
	Punctuality	**PUN1** % Departures < +/- 3 mins vs. schedule due to ATM causes	% (and # movements)	Tactical delay cost (avoided-; additional +)	€/year	N/A	N/A	N/A
Environment	Time Efficiency	**FEFF3** Reduction in average flight duration	% and minutes	Strategic delay: airborne: direct cost to an airline excl. Fuel (avoided-; additional +)	€/year	164,498,855	180,262,689	192,457,723
	Fuel Efficiency	**FEFF1** Average fuel burn per flight	Kg fuel per movement	Fuel Costs	€/year	50,058,664	58,966,943	67,318,881
	Fuel Efficiency	**FEFF2** CO2 Emissions	Kg CO2 per movement	CO2 Costs	€/year	3,207,297	4,074,443	5,042,941

Table 32: Results of the benefits monetisation per KPA for Concept 1

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

Reported results for Concept 1 demonstrate significant benefits both in absolute and relative to costs values. Interpretation of the results leads to the following conclusions:

1) Almost half of the value of benefits is attributed to a reduction in average flight duration – FEFF3, which is far more than the economic benefits reported to FEFF1 and FEFF2. The monetisation of this Mandatory PI, contrary to FEFF 1 and FEFF2, has not been exhaustively covered by SESAR 2020 documentation supporting CBA. However, CBA template imposes that FEFF is monetised through *Strategic delay: airborne: direct cost to an airline excl. Fuel (avoided-; additional +)*. In FEFF3 monetisation mechanism it was assumed that average flight duration reduction is equal to strategic delay reduction (defined as a buffer built into schedules in anticipation of delays) and monetised in the next step by the value from Standard Inputs for EUROCONTROL Cost-Benefit Analyses vol. 7.0 [16]. The same monetisation approach has been taken in recently released SESAR Cost Benefit Analysis Single Solution s6.3.2 [17].
2) The second major benefit's driver is the value of additional flights related to capacity increase. In the absence of an unambiguous definition or pre-defined categorisation of capacity constrained airports and confidentiality of airports' capacity data (see 3.5.4.2.1) a monetisation formula was applied that links: number of traffic at capacity constrained airports (selected by expert judgment), PAR results, peak-hour traffic share and estimated value of benefits for Airspace Users and Airport Operators for accommodating an additional flight. The final values are high; however, considering that Concept 1 targeted mainly Airport Capacity and the validations reported high capacity gains, they seem feasible.

4.2 Benefits (Concept 2)

The combination of the Integrated Runway Sequence with the use of an RMAN (Concept 2) is expected to bring additional gains in **Predictability and Punctuality** and **Fuel efficiency** compared to the use of Integrated Runway Sequence by suggesting an optimum runway configuration that feeds the building of an integrated sequence early in advance.

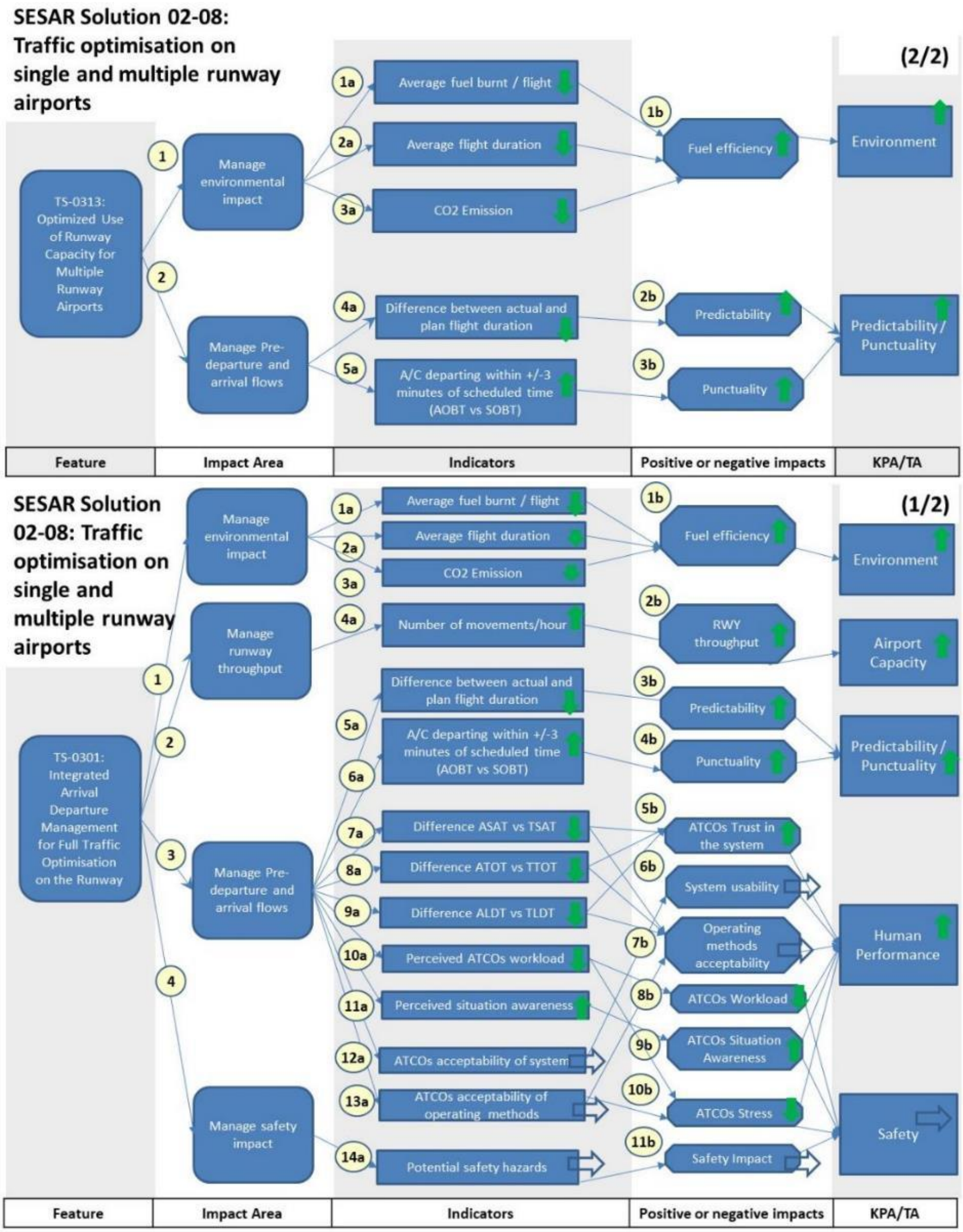

Figure 4: BIM 2

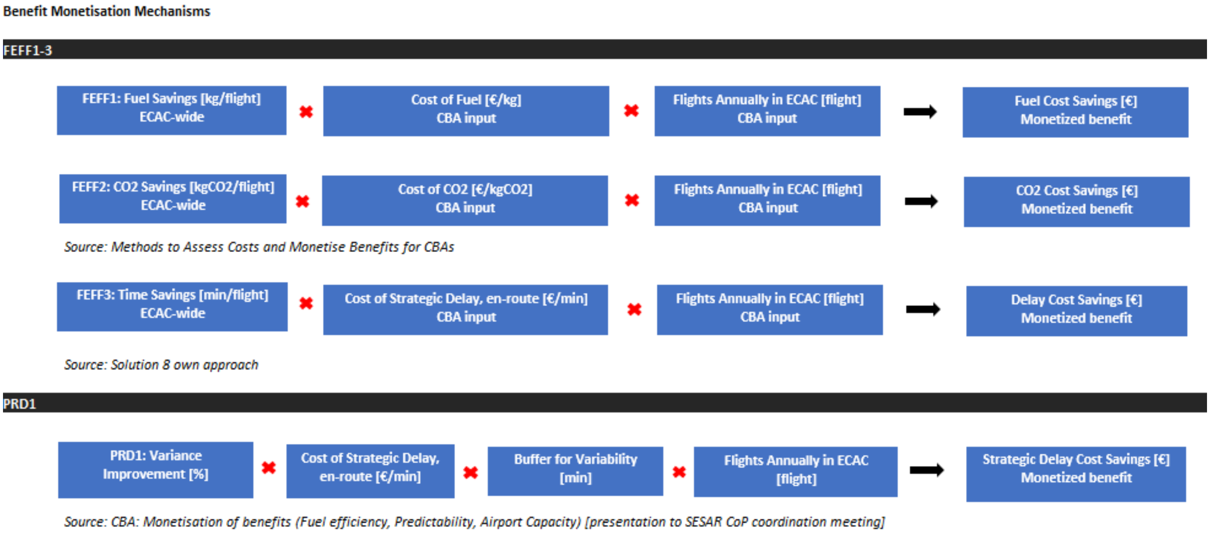

Figure 5: Benefit Monetisation Mechanism for Concept 2

Performance Framework KPA[1]	Focus Area	KPI/PI from the Performance Framework	Unit	Metric for the CBA	Unit	2030	2035	2040
Capacity	Airport capacity	**CAP3** Peak Runway Throughput (Mixed mode)	% and # movements	Value of additional flights	€/year	0	0	0
Predictability and punctuality	Predictability	**PRD1** Variance of Difference in actual & Flight Plan or RBT durations	Minutes^2	Strategic delay cost (avoided-; additional +)	€/year	8,681,053	9,512,954	10,156,519
	Punctuality	**PUN1** % Departures < +/- 3 mins vs. schedule due to ATM causes	% (and # movements)	Tactical delay cost (avoided-; additional +)	€/year	N/A	N/A	N/A
Environment	Time Efficiency	**FEFF3** Reduction in average flight duration	% and minutes	Strategic delay: airborne: direct cost to an airline excl. Fuel (avoided-; additional +)	€/year	149,544,414	163,875,172	174,961,566
	Fuel Efficiency	**FEFF1** Average fuel burn per flight	Kg fuel per movement	Fuel Costs	€/year	13,452,458	15,846,414	18,090,862
	Fuel Efficiency	**FEFF2** CO2 Emissions	Kg CO2 per movement	CO2 Costs	€/year	861,945	1,094,986	1,355,265

Table 33: Results of the benefits monetisation per KPA for Concept 2

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

Reported results for Concept 2, based on one RTS validation exercise extrapolated to ECAC, demonstrate significant benefits above all in terms of reduction in average flight duration – FEFF3. As stated in Section 4.2 in FEFF3 monetisation mechanism it was assumed that average flight duration reduction is equal to strategic delay reduction (defined as a buffer built into schedules in anticipation of delays) monetised in the next step by the value from Standard Inputs for EUROCONTROL Cost-Benefit Analyses vol. 7.0 [16]. The same monetisation approach has been taken in recently released SESAR Cost Benefit Analysis Single Solution s6.3.2 [17].

4.3 Benefits (Concept 3)

Concept 3, Increased Runway Throughput based on local ROT characterization (ROCAT), aims to bring an improvement in terms of **Airport Capacity**. Runway Occupancy Time is one major factor limiting the runway capacity: currently the AROT constraint of the leader aircraft to be considered for the separation minimum of its follower is taken into consideration in the applicable MRS. Then, for aircraft pairs where the MRS is the highest separation constraint, runway occupancy is very likely to be the limiting factor for runway throughput. For those aircraft types, better characterisation of AROT may allow reducing the separation minima and thus the runway capacity.

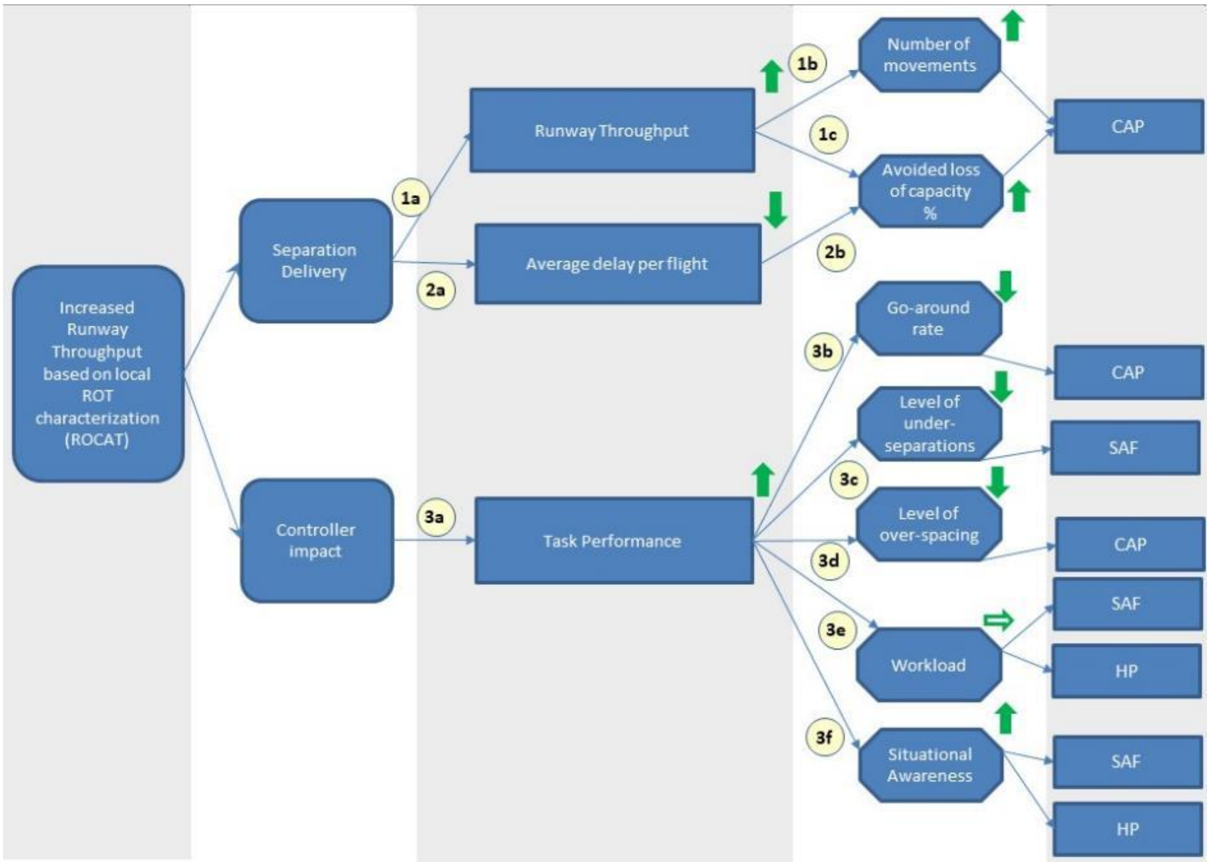

Figure 6: BIM Concept 3

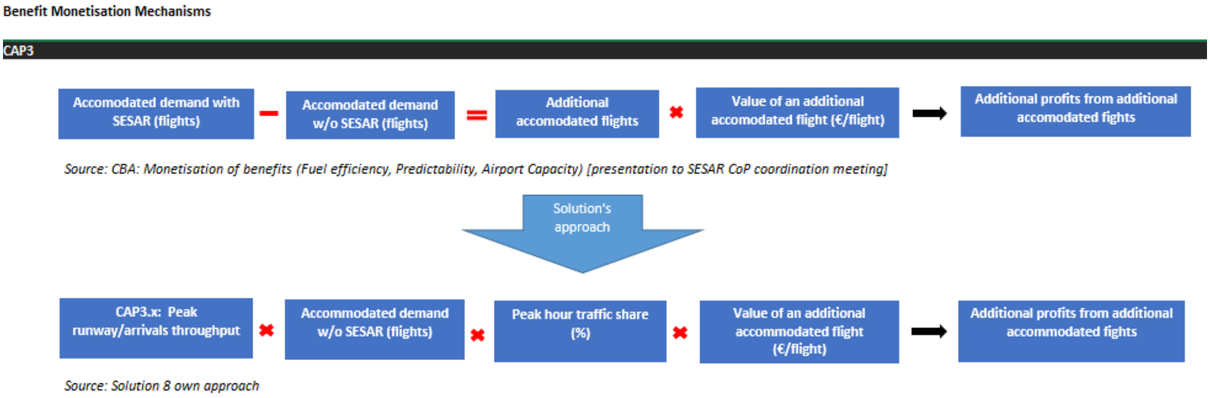

Figure 7: Benefit Monetisation Mechanism for Concept 3

Reported results for Concept 3, based on one joint with PJ.02-01 RTS validation exercise, extrapolated to Very Large and Large capacity constrained airports operating in segregated mode of operations, demonstrate significant expected benefits in terms of value of additional flights. High values are driven primarily by high CAP3.2 result reported in Concept 3 PAR for deployment of AO-0328 and AO-0337.

Performance Framework KPA[1]	Focus Area	KPI/PI from the Performance Framework	Unit	Metric for the CBA	Unit	2030	2035	2040
Capacity	Airport capacity	**CAP3** Peak Runway Throughput (Mixed mode)	% and # movements	Value of additional flights	€/year	262,527,074	287,848,175	307,321,524
Predictability and punctuality	Predictability	**PRD1** Variance of Difference in actual & Flight Plan or RBT durations	Minutes^2	Strategic delay cost (avoided-; additional +)	€/year	0	0	0
	Punctuality	**PUN1** % Departures < +/- 3 mins vs. schedule due to ATM causes	% (and # movements)	Tactical delay cost (avoided-; additional +)	€/year	N/A	N/A	N/A
Environment	Time Efficiency	**FEFF3** Reduction in average flight duration	% and minutes	Strategic delay: airborne: direct cost to an airline excl. Fuel (avoided-; additional +)	€/year	0	0	0
	Fuel Efficiency	**FEFF1** Average fuel burn per flight	Kg fuel per movement	Fuel Costs	€/year	0	0	0
	Fuel Efficiency	**FEFF2** CO2 Emissions	Kg CO2 per movement	CO2 Costs	€/year	0	0	0

Table 34: Results of the benefits monetisation per KPA for Concept 3

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

4.4 Benefits (Concept 4)

Concept 4, Optimised use of RWY capacity for medium airports with the use of enhanced prediction of Runway Occupancy Time (ROT), aims to bring an improvement in terms of **Airport Capacity** at Medium aerodromes: the reduction of separation and/or designation of optimal exit taxiway has a direct impact on runway throughput (and also in the efficiency of runway usage) and therefore runway capacity. This concept aims to increase capacity of medium airports in peak hours by allowing easier operations in reduced separation minima on final approach.

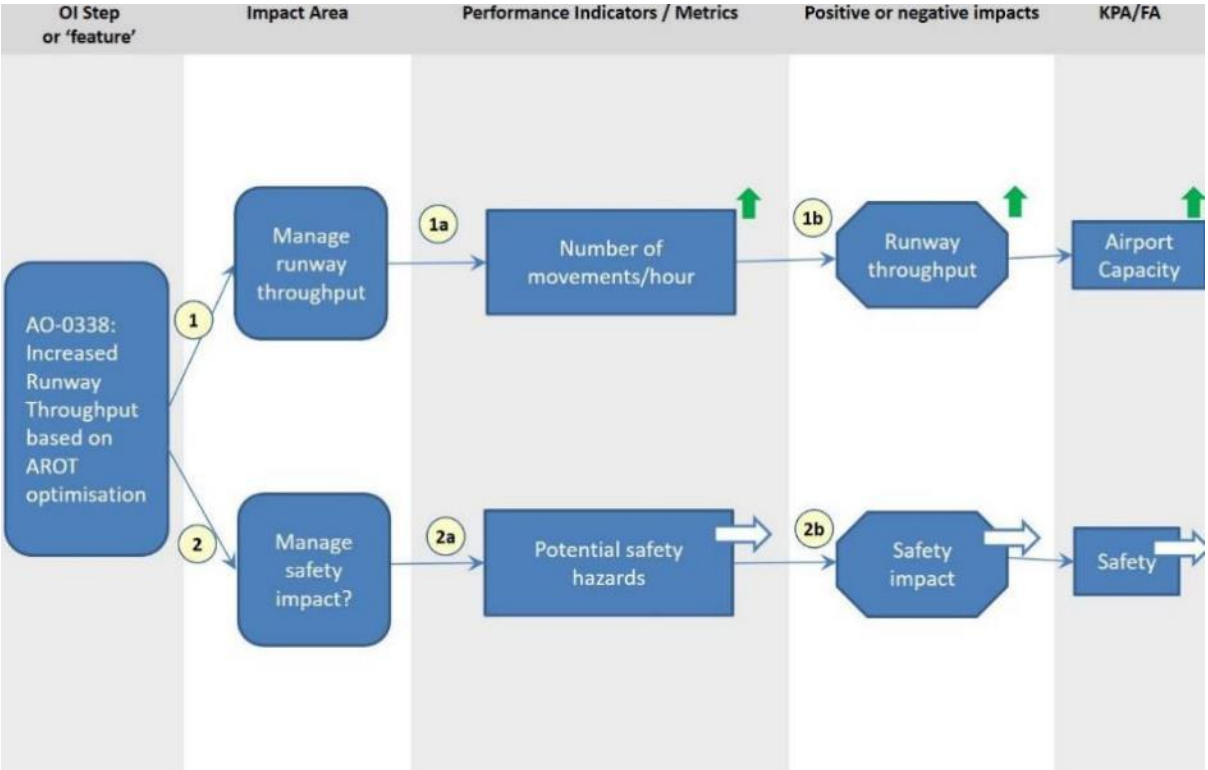

Figure 8: BIM Concept 4

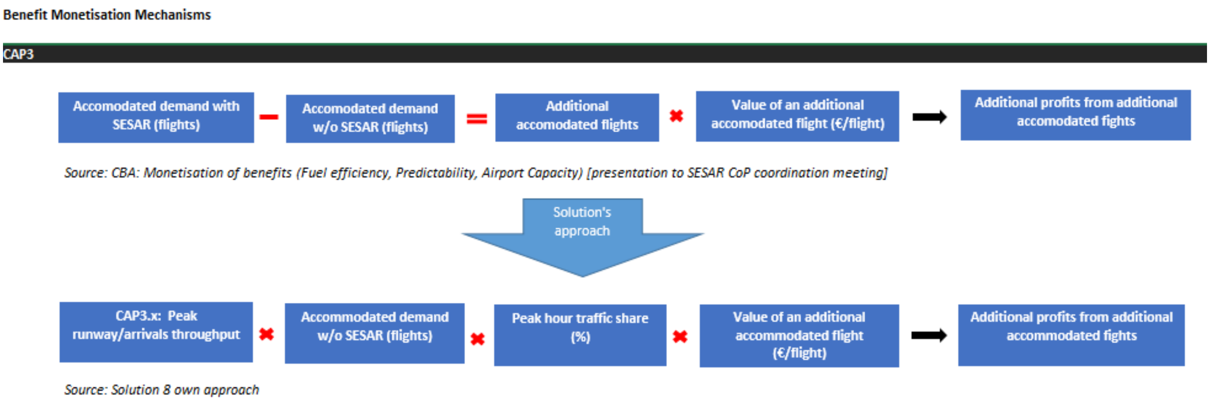

Figure 9: Benefit Monetisation Mechanism for Concept 4

In comparison to other Concepts, Concept 4 is expected to bring only small-scale benefits (if any, see: 3.5.4.2.1). The list of applicable locations has been limited to only a few Medium sized airports with considerably lower traffic than other concepts, lower peak hour traffic share and lower PAR results derived from one FTS validation covering Concept 4.

Performance Framework KPA[6]	Focus Area	KPI/PI from the Performance Framework	Unit	Metric for the CBA	Unit	2030	2035	2040
Capacity	Airport capacity	**CAP3** Peak Runway Throughput (Mixed mode)	% and # movements	Value of additional flights	€/year	3,290,536	3,605,866	3,849,808
Predictability and punctuality	Predictability	**PRD1** Variance of Difference in actual & Flight Plan or RBT durations	Minutes^2	Strategic delay cost (avoided-; additional +)	€/year	0	0	0
	Punctuality	**PUN1** % Departures < +/- 3 mins vs. schedule due to ATM causes	% (and # movements)	Tactical delay cost (avoided-; additional +)	€/year	N/A	N/A	N/A
Environment	Time Efficiency	**FEFF3** Reduction in average flight duration	% and minutes	Strategic delay: airborne: direct cost to an airline excl. Fuel (avoided-; additional +)	€/year	0	0	0
	Fuel Efficiency	**FEFF1** Average fuel burn per flight	Kg fuel per movement	Fuel Costs	€/year	0	0	0
	Fuel Efficiency	**FEFF2** CO2 Emissions	Kg CO2 per movement	CO2 Costs	€/year	0	0	0

Table 35: Results of the benefits monetisation per KPA for Concept 4

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

5 Cost assessment

This section describes and analyses all the costs stemming from implementing the four Concepts, based on the CBA Scenarios illustrated in Section 2. The analysis considers each Concept as a stand-alone solution, i.e. deployed independently from any other S2020 Solution or PJ02-08 Concept. Only the differential (or delta) value implied by the Solution Scenario over the Reference one is included in the analysis. Also, R&D and Pre-Industrialisation costs are already incurred in the SESAR Development Phase and therefore not included in the cost assessment.

The currency and all costs of the PJ02-08 CBA are provided in Euro (€).

5.1 Cost assessment (Concept 1)

5.1.1 ANSPs costs

SESAR 2020 cost fall into 3 main categories as follows:

1) Pre-implementation costs: R&D and pre-industrialization costs are already incurred in the SESAR Development Phase and therefore not included in the cost assessment.

2) Implementation costs:

    a. One-off implementation costs: one-off implementation costs incurred during the implementation period, such as training, program management.
    b. Capital costs of implementation: Cost incurred to implement the project. Mainly these are cost of equipment & systems and integrations costs related to the enablers listed in 3.2 SESAR solution description.
    c. Transition costs: Costs for maintaining current systems, during transition to a new system.

3) Operating costs:

    a. Personal & Training
    b. Maintenance & Repair
    c. Other

The following table includes deployment costs for Concept 1 “solution scenario”:

Enabler	One-off implementation cost (€)	Capital implementation cost (€)	Transition costs (€)	Total implementation cost	Operating costs (€ yearly)
AERODROME-	365 000	300 000	50 000	715 000	71 500

ATC-33 AERODROME-ATC-58 APP-ATC-164	Initial Training & Staffing Project Management Administrative cost Installation & Commissioning Validation & Certification	Equipment & System Integration costs	Maintaining current systems		Hardware & Software maintenance
AERODROME-ATC-27	optional enabler, not covered				
AERODROME-ATC-34	optional enabler, not covered				

Table 36: Concept 1-unit costs

5.1.1.1 ANSPs cost approach

The costs have been obtained by expert judgement during the dedicated sessions with Solution partners. Estimations of TS-0301 costs are based on previous implementation of AMAN and DMAN in Stockholm airport, with additional experiences of Integrated Runway Sequence Function linked to an AMAN and a DMAN. Due to the limitation of expert judgment approach method and the inherent R&D nature of the Solution, with no option to follow any real time examples, the cost estimates should be approached with a medium level of confidence.

5.1.1.2 ANSPs cost assumptions

Assumptions applied to the cost assessment:

- ANSP manage 100% of the cost.
- Operating costs represents 10% of implementation costs per OI.
- For the CBA only costs of Implementation Option 1 - validated in Concept 1 exercises - have been considered. When introducing an Integrated Runway Sequence Function there can be a variation of implementation costs depending on the airport complexity and linked operating procedures as well as design and maturity of existing systems at ATC and at the Airport.
- Low/High scenario -/+ 50%.

5.1.1.3 Number of investment instances (units)

Airport				TMA			ACC		
Very large	Large	Medium	Small	H	M	L	H	M	L
14	14	5	0	N/A			N/A		

Table 37: Number of investment instances – ANSPs

5.1.1.4 Cost per unit

Cost category	Airport				TMA			ACC		
	Very large	Large	Medium	Small	H	M	L	H	M	L
Pre-Implementation Costs (€)	N/A				N/A			N/A		
Implementation costs (€)	715 000	715 000	715 000	N/A	N/A			N/A		
Operating costs (€/year)	71 500	71 500	71 500	N/A	N/A			N/A		

Table 38: Cost per Unit – ANSP

5.2 Cost assessment (Concept 2)

5.2.1 ANSPs costs

The following table includes deployment costs for Concept 2 "solution scenario":

Enabler	One-off implementation cost (€)	Capital implementation cost (€)	Transition costs (€)	Total implementation cost	Operating costs (€ yearly)
APP-ATC-164	60 200	213 900	30 400	304 500	30 450
	Initial Training & Staffing Project Management Administrative cost Installation & Commissioning Validation & Certification	Equipment & System Integration costs Licences, patent Other capital costs	Maintaining current systems		Hardware & Software maintenance
AERODROME-ATC-74	73 500	261 400	37 200	372 100	37 210
	Initial Training & Staffing Project Management Administrative cost Installation & Commissioning Validation & Certification	Equipment & System Integration costs Licences, patent Other capital costs	Maintaining current systems		Hardware & Software maintenance
AERODROME-ATC-29	optional enabler, not covered				

Table 39: Concept 2-unit costs

5.2.1.1 ANSPs cost approach

The costs have been obtained by Indra expert judgement during the dedicated internal sessions. Estimations of TS-0313 costs are based on previous implementation of AMAN and DMAN in towers, with additional experiences of Integrated Runway Sequence function (AMAN/DMAN coupling). Cost of TS-0313 (Concept 2) has been estimated considering the cost of integrating RMAN tool with what has been developed in TS-0301 (Concept 1). Due to the limitation of Indra expert judgement approach method and the inherent R&D nature of the Solution, with no option to follow any real time examples, the cost estimates should be approached with a medium level of confidence.

5.2.1.2 ANSPs cost assumptions

Assumptions applied to the cost assessment:

- All the costs are applied to the ANSPs.
- Operating costs represents 10% of implementation costs per OI.
- Concept 2 (TS-0313) will be deployed at the same time as Concept 1 (TS-0310).

5.2.1.3 Number of investment instances (units)

A specified number of units has been defined for every airport category and for both OI steps.

The Solution 02-08 "The concept of Traffic Optimisation on single and multiple runway airports" is applicable in Very Large / Large / Medium Airports with runways operated in mixed mode or having other dependencies between arrivals and departures between the runways. Although, the OI step TS-0301 is applicable for all deployment locations, it has been assumed that multiple runway airports will simultaneously deploy the OI step TS-0313 with TS-0301, as TS-0301 is a pre-requirement for TS-0313.

OI step	Airport				TMA			ACC		
	Very large	Large	Medium	Small	H	M	L	H	M	L
TS-0313	14	13	4	0	N/A			N/A		

Table 40: Number of investment instances - ANSPs

5.2.1.4 Cost per unit

Cost category	Airport				TMA			ACC		
	Very large	Large	Medium	Small	H	M	L	H	M	L
Pre-Implementation Costs (€)	N/A				N/A			N/A		
Implementation costs (€)	676 600	676 600	676 600	0	N/A			N/A		
Operating costs (€/year)	67 660	67 660	67 660	0	N/A			N/A		

Table 41: Cost per Unit - ANSP

5.3 Cost assessment (Concept 3)

5.3.1 ANSPs costs

As stated in 3.5.3.2 due to the design of the exercise validating Concept 3 for the purpose of the CBA the costs of combined deployment of two OIs are taken into account, AO-0328 being a prerequisite for AO-0337 deployment:

- AO-0328 Optimised Runway Delivery on Final Approach
- AO-0337 Increased Runway Throughput based on local ROT characterization (ROCAT)
    - Enabler: AERODROME ATC-55 Airport ATC analyser tool for predicting ROT

The drawback of this approach is that firstly, AO-0328 with its set of enablers is to be validated by PJ.02-01 and secondly, PJ.02-01 project timeline is ahead of Solution's 8, hence up to date some data – such as cost of OI/enablers – is not yet available.

Enabler	One-off implementation cost (€)	Capital implementation cost (€)	Transition costs (€)	Total implementation cost	Operating costs (€ yearly)
AERODROME-ATC-55	0	100 000	0	100 000	10 000
		Integration costs			Hardware & Software maintenance
Prerequisite OI to be validated in PJ.02-01: AO-0328 — Optimised Runway Delivery on Final Approach;		15 000 000		15 000 000	1 500 000
	Initial Training & Staffing Project Management Administrative cost Installation & Commissioning Validation & Certification	Equipment & System Integration costs Licences, patent Other capital costs	Maintaining current systems		Hardware & Software maintenance Personal & Training

Table 42: Concept 3-unit costs

5.3.1.1 ANSPs cost approach

The cost figures for Concept 3 were based on expert judgment of ANSPs contributing to the project. In case of AO-0337 represented by a single enabler AERODROME-ATC-55 (R) Airport ATC analyser tool for predicting ROT its cost is considered low, as it is perceived as a fairly uncomplicated analysis of historical ground radar data which allows for characterization of ROT per aircraft type and per runway followed by a categorisation of Medium aircraft into 2 categories: of a short and long ROT.

As far as AO-0328 is concerned its costs categories, values and enablers are to be estimated by Solution 1. At this moment this data is not available, therefore Solution 8 resorts to an order of magnitude value of 15m € implementation cost. Once more accurate values are provided, they should be applied in the current CBA.

5.3.1.2 ANSPs cost assumptions

Assumptions applied to the cost assessment:

- ANSP manage 100% of the cost.
- Operating costs represents 10% of implementation costs per OI.
- Low/High scenario -/+ 50%.

5.3.1.3 Number of investment instances (units)

Airport				TMA			ACC		
Very large	Large	Medium	Small	H	M	L	H	M	L
10	4	0	0	N/A			N/A		

Table 43: Number of investment instances - ANSPs

5.3.1.4 Cost per unit

Cost category	Airport				TMA			ACC		
	Very large	Large	Medium	Small	H	M	L	H	M	L
Pre-Implementation Costs (€)	N/A				N/A			N/A		
Implementation costs (€)	15 100 000	15 100 000	0	0	N/A			N/A		
Operating costs (€/year)	1 510 000	1 510 000	0	0	N/A			N/A		

Table 44: Cost per Unit - ANSP

5.4 Cost assessment (Concept 4)

5.4.1 ANSPs costs

The following table includes deployment costs for Concept 4 solution scenario:

Enabler	One-off implementation cost (€)	Capital implementation cost (€)	Transition costs (€)	Total implementation cost	Operating costs (€ yearly)
AERODROME-ATC-55a	45 000	180 000	0	225 000	22 500
	Project Management Administrative cost Validation & Certification	Equipment & System Integration costs			Hardware & Software maintenance
AERODROME-ATC-32	optional enabler, not covered				

Table 45: Concept 4-unit costs

5.4.1.1 ANSPs cost approach

The costs have been obtained by University of Warsaw and PANSA expert judgement during the dedicated internal sessions. Due to the limitation of expert judgement approach method and the inherent R&D nature of the Solution, with no option to follow any real time examples, the cost estimates should be approached with a medium level of confidence.

5.4.1.2 ANSPs cost assumptions

Assumptions applied to the cost assessment:

- ANSP manage 100% of the cost.
- Operating costs represents 10% of implementation costs per OI.
- Low/High scenario -/+ 50%.

5.4.1.3 Number of investment instances (units)

Airport				TMA			ACC		
Very large	Large	Medium	Small	H	M	L	H	M	L
0	0	5	0	N/A			N/A		

Table 46: Number of investment instances - ANSPs

5.4.1.4 Cost per unit

Cost category	Airport				TMA			ACC		
	Very large	Large	Medium	Small	H	M	L	H	M	L
Pre-Implementation Costs (€)	N/A				N/A			N/A		
Implementation costs (€)	0	0	225 000	0	N/A			N/A		
Operating costs (€/year)	0	0	22 500	0	N/A			N/A		

Table 47: Cost per Unit - ANSP

6 CBA Model

Please find embedded the Excel file including the CBA Model below.

PJ02 Solution 02-08 V3 CBA 0.23.xlsx

6.1 Data sources

The model uses the following data sources:

- SESAR 2020 D6.1.203, PJ02-08 SPR-INTEROP/OSED for V3 – Part I, v00.01.01
- SESAR 2020 D6.1.203, PJ02-08 SPR-INTEROP/OSED for V3 – Part V, v00.01.00
- SESAR 2020 D6.1.132 - PJ02-08 VALR for SJU Quality Check, v00.01.00
- EATMA Dataset 19
- SESAR2020_Common_Assumptions_2019 (0_2) D4_0_30-PJ19
- PJ19 Common Assumptions: EUROCONTROL Performance Review Report (PRR 2013), May 2014
- Standard Inputs for EUROCONTROL Cost-Benefit Analyses vol. 8.0
- Standard Inputs for EUROCONTROL Cost-Benefit Analyses vol. 7.0
- SESAR Cost Benefit Analysis Single Solution s6.3.2
- IATA Economic Briefing September 2013 - Value of an Average Passenger Flight in the EU-27
- 2019 Airport Key Performance Indicators ACI
- Airport OE Dataset February 2019
- European Aviation in 2040: Challenges of Growth 2018, Flight forecast to 2040

7 CBA Results

7.1 CBA Results (Concept 1)

The table below summarises the main results of the Cost Benefit Analysis of the Concept 1.

Item	Discounted	Undiscounted
Investment costs (€)	**21,842,630**	**53,088,750**
ANSP	21,842,630	53,088,750
Airport Operators	0	0
Airspace Users	0	0
Benefits (€)	**1,640,693,760**	**5,178,026,074**
ANSP	0	0
Airport Operators	270,151,411	850,621,245
Airspace Users	1,370,542,349	4,327,404,828
Net Present Value (€)	**1,618,851,130**	
Payback period[7]	**2 years**	**2 years**
Internal rate of return (IRR)	**1501%**	
Benefit - Cost ratio (D/C ratio)	**75.1**	

Table 48: CBA Results for Concept 1 (in EUR)

[7] From Deployment Start Date

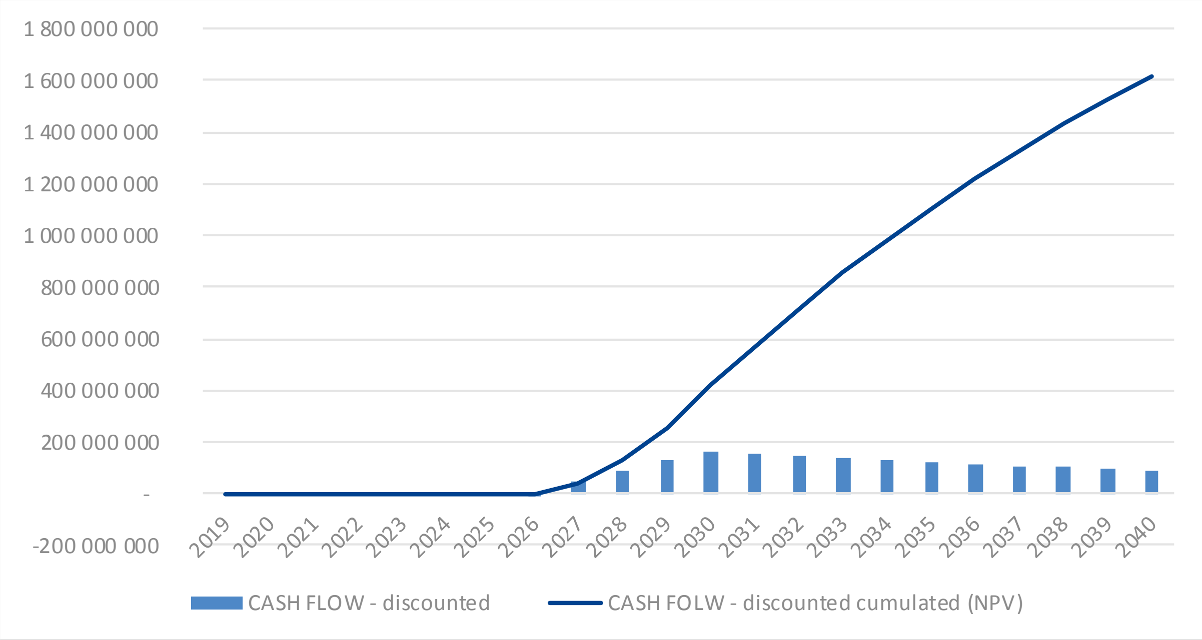

Figure 10: Cash flows for Concept 1 (in EUR; discounted)

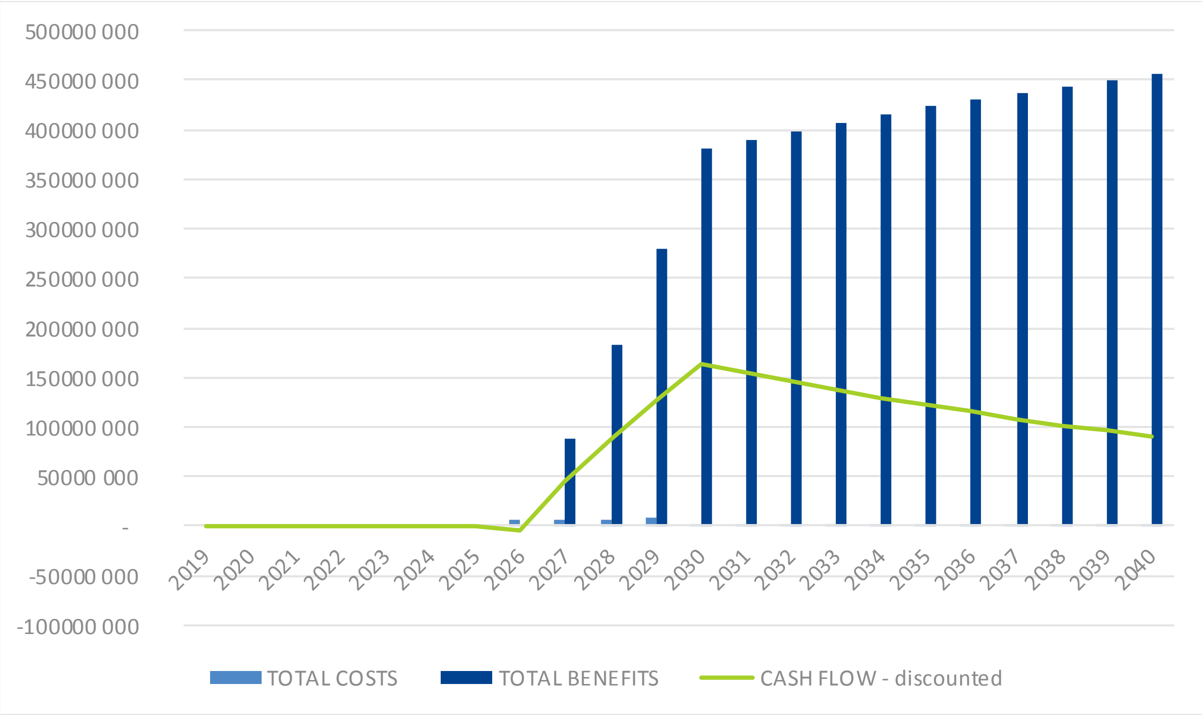

Figure 11: Total costs and benefits for Concept 1 (in EUR; undiscounted)

7.2 CBA Results (Concept 2)

The table below summarises the main results of the Cost Benefit Analysis of the Concept 2.

Item	Discounted	Undiscounted
Investment costs (€)	**19,416,844**	**47,192,850**
ANSP	19,416,844	47,192,850
Airport Operators	0	0
Airspace Users	0	0
Benefits (€)	**739,275,669**	**2,330,970,062**
ANSP	0	0
Airport Operators	0	0
Airspace Users	739,275,669	2,330,970,062
Net Present Value (€)	**719,858,825**	
Payback period[8]	**2 years**	**2 years**
Internal rate of return (IRR)	**763%**	
Benefit - Cost ratio (D/C ratio)	**38.1**	

Table 49: CBA Results for Concept 2 (in EUR)

[8] From Deployment Start Date

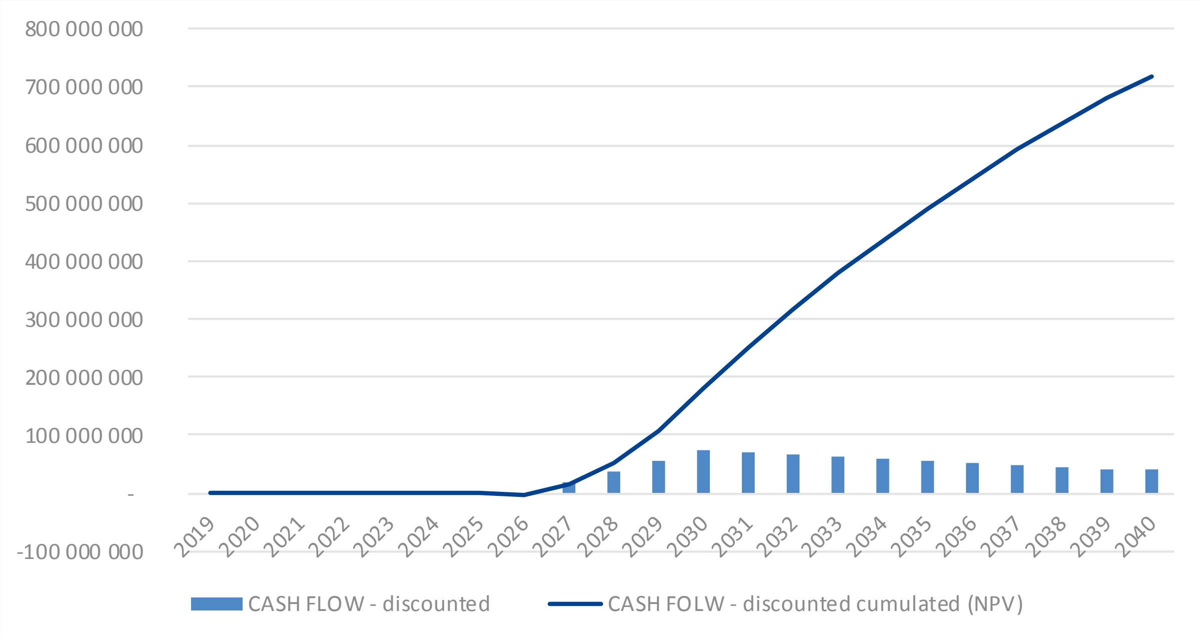

Figure 12: Cash flows for Concept 2 (in EUR; discounted)

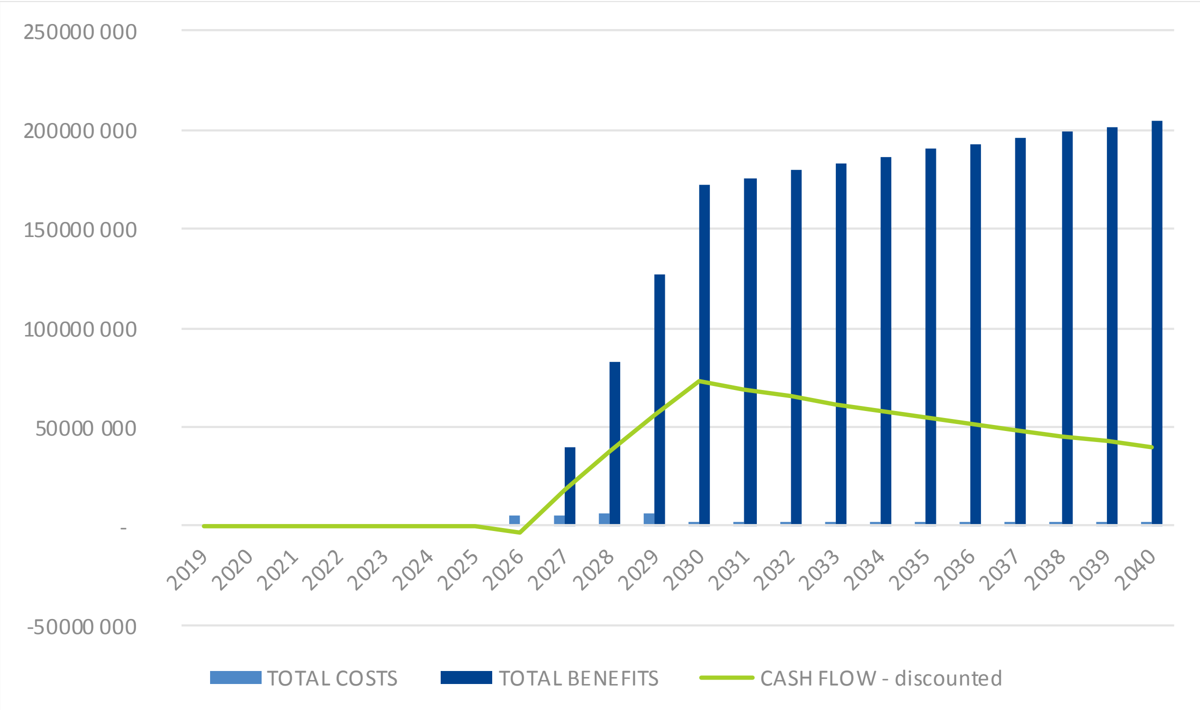

Figure 13: Total costs and benefits for Concept 2(in EUR; undiscounted)

7.3 CBA Results (Concept 3)

The table below summarises the main results of the Cost Benefit Analysis of the Concept 3.

Item	Discounted	Undiscounted
Investment costs (€)	**195,699,595**	**475,650,000**
ANSP	195,699,595	475,650,000
Airport Operators	0	0
Airspace Users	0	0
Benefits (€)	**1,120,491,543**	**3,528,073,046**
ANSP	0	0
Airport Operators	536,300,700	1,688,641,076
Airspace Users	584,190,843	1,839,431,970
Net Present Value (€)	**924,791,948**	
Payback period[9]	**3 years**	**2 years**
Internal rate of return (IRR)	**111%**	
Benefit - Cost ratio (D/C ratio)	**5.7**	

Table 50: CBA Results for Concept 3 (in EUR)

[9] From Deployment Start Date

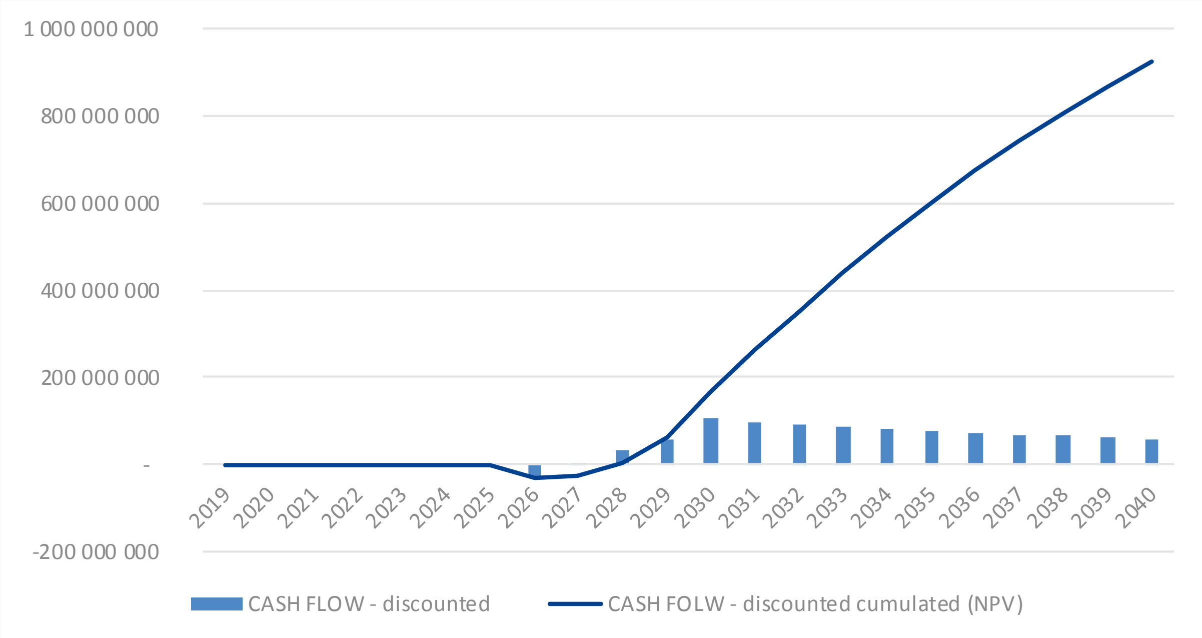

Figure 14: Cash flows for Concept 3 (in EUR; discounted)

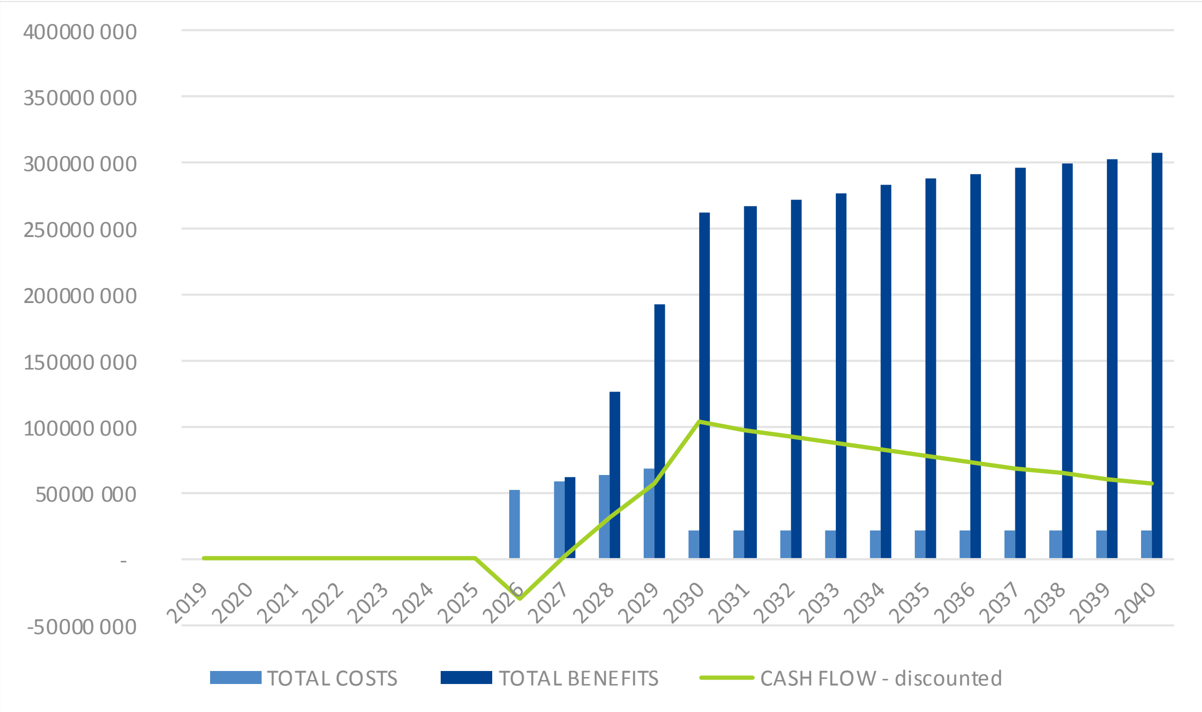

Figure 15: Total costs and benefits for Concept 3 (in EUR; undiscounted)

7.4 CBA Results (Concept 4)

The table below summarises the main results of the Cost Benefit Analysis of the Concept 4.

Item	Discounted	Undiscounted
Investment costs (€)	**1,041,448**	**2,531,250**
ANSP	1,041,448	2,531,250
Airport Operators	0	0
Airspace Users	0	0
Benefits (€)	**14,036,365**	**44,196,068**
ANSP	0	0
Airport Operators	6,718,223	21,153,558
Airspace Users	7,318,142	23,042,511
Net Present Value (€)	**12,994,917**	
Payback period[10]	**2 years**	**2 years**
Internal rate of return (IRR)	**269%**	
Benefit - Cost ratio (D/C ratio)	**13.5**	

Table 51: CBA Results for Concept 4 (in EUR)

[10] From Deployment Start Date

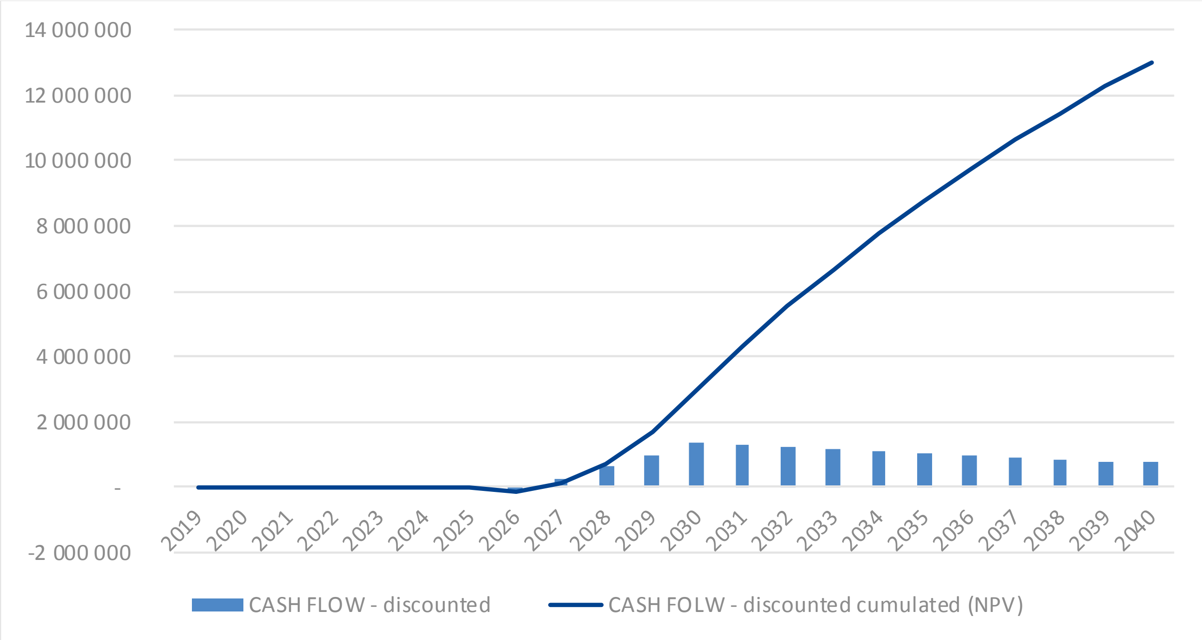

Figure 16: Cash flows for Concept 4 (in EUR; discounted)

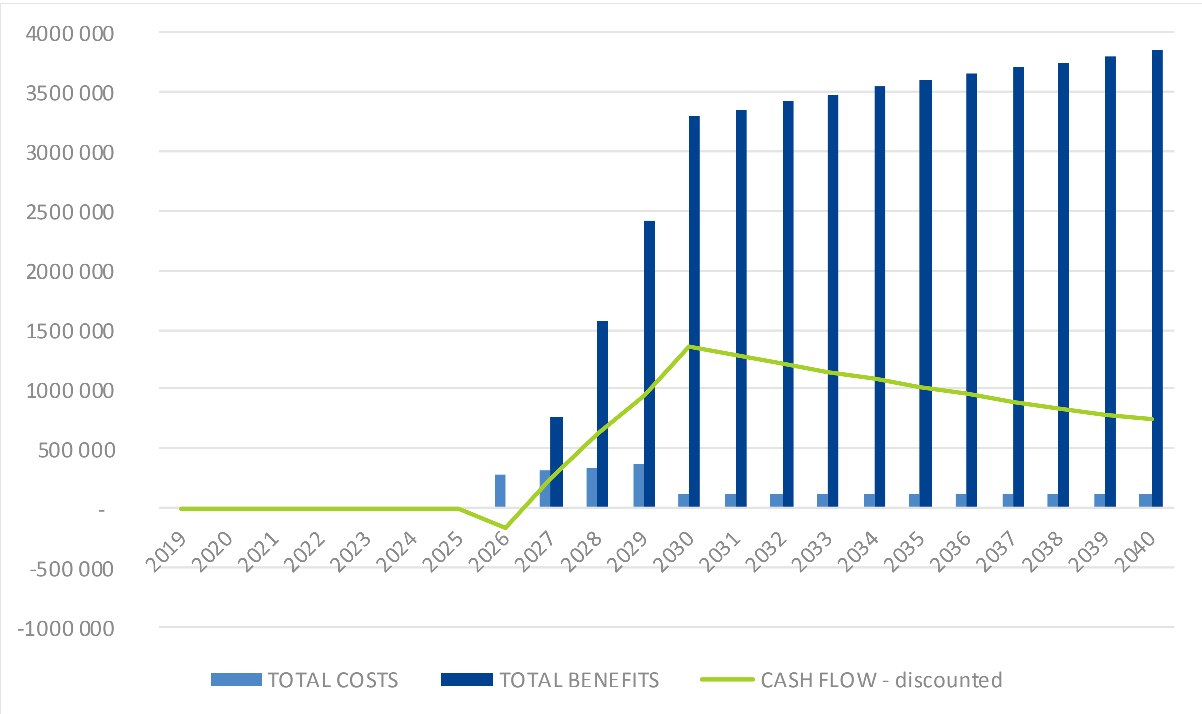

Figure 17: Total costs and benefits for Concept 4(in EUR; undiscounted)

8 Sensitivity and risk analysis

Sensitivity analysis

In order to measure the impact of risk which might affect the final result of the CBA a sensitivity analysis has been carried out. The tornado diagram presents the change of the NPV in high/low scenarios of the most influential parameters for each of the Concept:

- SESAR 1 factor - a default 50% factor has been added in sensitivity analysis emulating SESAR 1 approach for the results of the validation exercises that have not used a fully deployed reference baseline;
- Discount rate – since the Solution is to be deployed in a relatively far future with benefits throughout 30' a discount rate will have a considerable contribution to final NPV value;
- Traffic values – applied in line with CoG18 Fragmenting World (low) and Global Growth (high) scenarios [21];
- Strategic delay cost – parametrised as its value has been indirectly excerpted from EUROCONTROL Standard Inputs [15];
- Additional flight benefit – ranges of variability assigned due to possible global/ECAC-wide differences;
- Total costs – a wide range (-50%/+50%) of variability assigned due to the limitations of expert judgment approach;
- Operating costs – as above.

Risk analysis

A probabilistic risk analysis has been performed for each of the Concepts. This entails the simulation of a probability distribution for the CBA results - Net Present Value, starting from the specification of probability distributions that reflect the potential variability of the key project variables used in sensitivity analysis. For this purpose, Monte Carlo simulation has been run using the JASPERS spreadsheet model [11]. The JASPERS spreadsheet model enables the project promoter to run a "Monte Carlo" simulation of the CBA results only by making assumptions about the possible variability range (i.e. a minimum and a maximum value) of a given project variable. The variables that are modelled in the simulation are the Investment cost, Operating costs and the project Benefits; all in present values and for base case scenario.

It should be noted that the model employs a simplified method, where probability distributions are applied to aggregated elements of the NPV (e.g. benefits) and not to basic variables (e.g. demand volume, demand growth, various investment components, which may have very different risk profile, etc.). This simplification implicitly assumes that there is a linear and proportional relation between these basic variables and aggregated variables and that all project impacts (benefits) have the same variability.

8.1 Sensitivity and risk analysis (Concept 1)

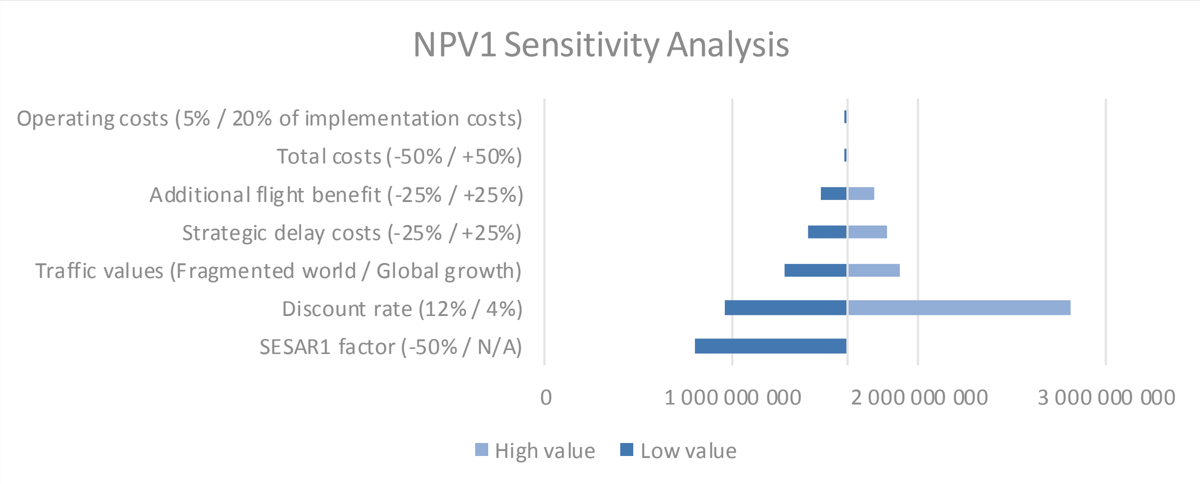

Figure 18: Tornado diagram for Concept 1 (in EUR)

Base-case NPV	***mEUR***	**1618.9**		
Variables		***Implementation***	***Operating***	***Benefits***
Base-case (Present Value)	*mEUR*	12.3	9.5	1640.7
Minimum	%	*50%*	*50%*	*50%*
Most Likely (Mode)	%	100%	100%	100%
Maximum	%	*150%*	*200%*	*120%*
Number of iterations	#	*10,000*		

Table 52: Risk Analysis Assumptions - Triangular Probability Distributions for Concept 1

	mEUR		**mEUR**
Mean (Expected NPV)	1,480.56	Minimum	809.72
Median	1,507.52	Maximum	2,021.54
Standard Deviation	255.07	Prob. {NPV>0}	100.0%

Table 53: Results of Monte Carlo Simulation – NPV for Concept 1

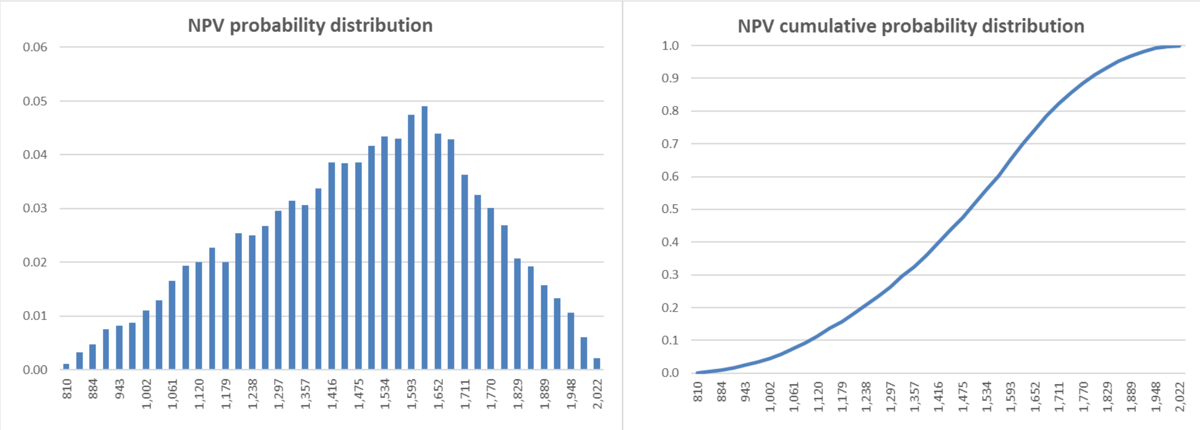

Figure 19: NPV probability distribution for Concept 1

8.2 Sensitivity and risk analysis (Concept 2)

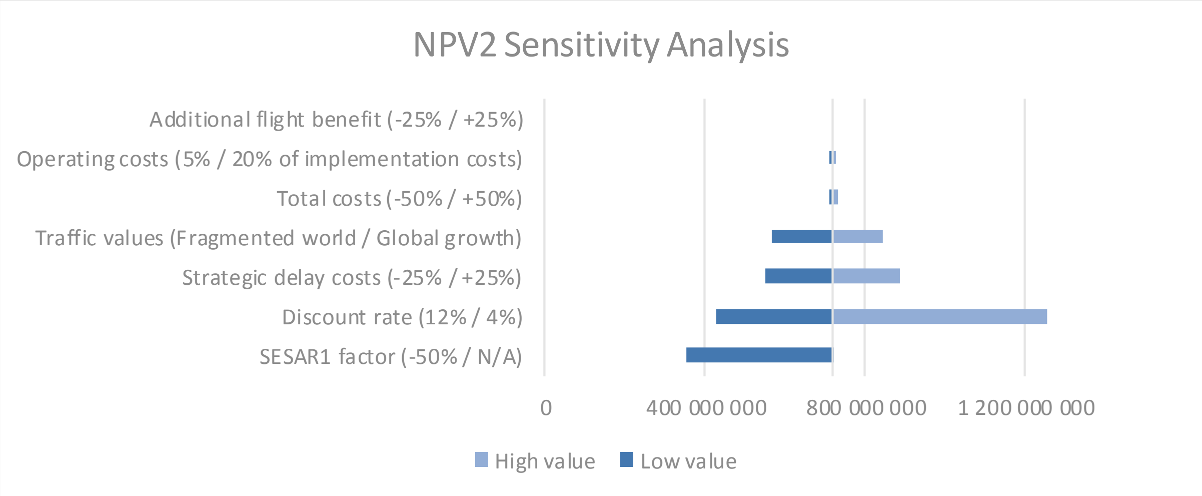

Figure 20: Tornado diagram for Concept 2 (in EUR)

Base-case NPV	***mEUR***	**719.9**		
Variables		***Implementation***	***Operating***	***Benefits***
Base-case (Present Value)	*mEUR*	10.9	8.5	739.3
Minimum	%	*50%*	*50%*	*50%*
Most Likely (Mode)	%	100%	100%	100%
Maximum	%	*150%*	*200%*	*125%*
Number of iterations	#	*10,000*		

Table 54: Risk Analysis Assumptions - Triangular Probability Distributions for Concept 2

	mEUR		**mEUR**
Mean (Expected NPV)	656.73	Minimum	353.39
Median	667.80	Maximum	904.17
Standard Deviation	116.28	Prob. {NPV>0}	100.0%

Table 55: Results of Monte Carlo Simulation – NPV for Concept 2

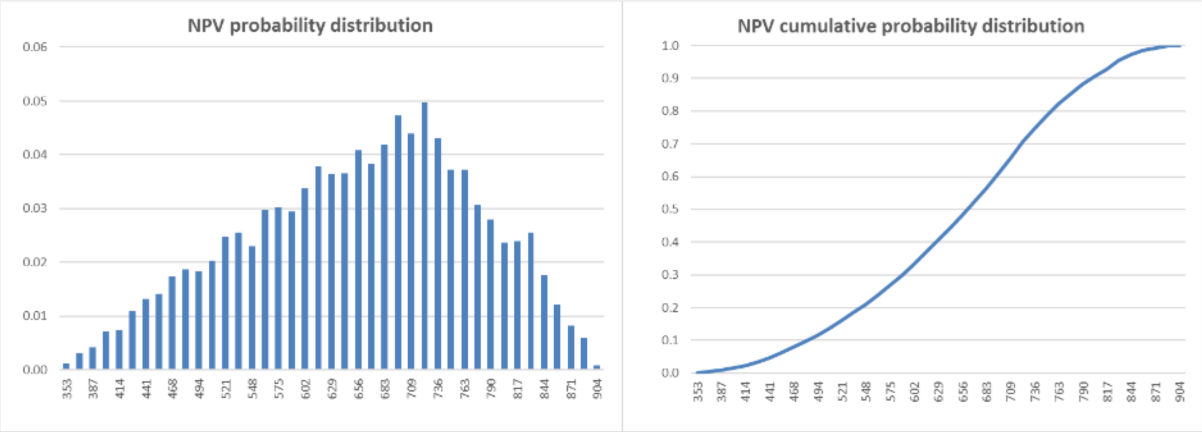

Figure 21: NPV probability distribution for Concept 2

8.3 Sensitivity and risk analysis (Concept 3)

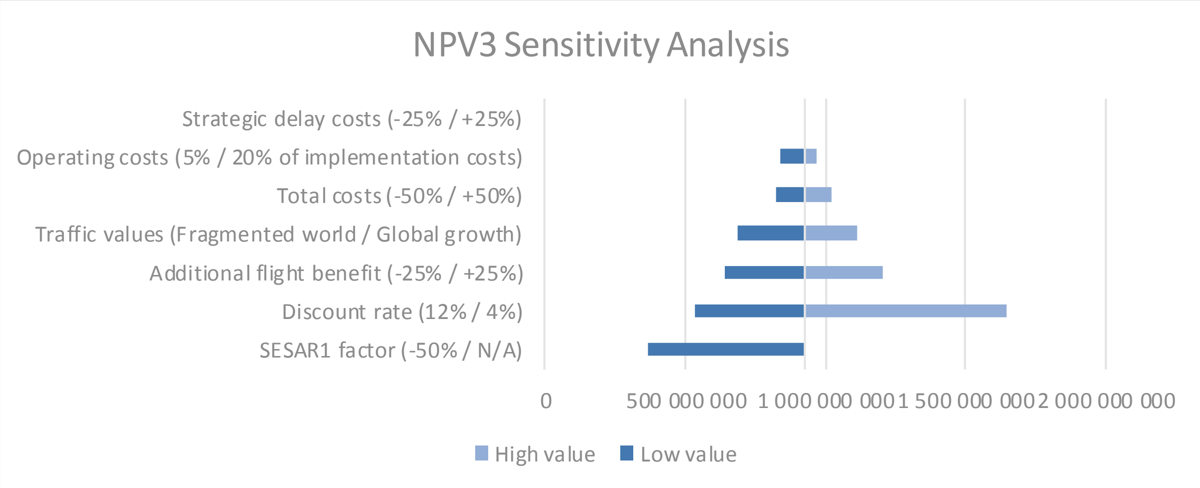

Figure 22: Tornado diagram for Concept 3 (in EUR)

Base-case NPV	***mEUR***	**924.8**		
Variables		***Implementation***	***Operating***	***Benefits***
Base-case (Present Value)	*mEUR*	110.3	85.4	1120.5
Minimum	%	*50%*	*50%*	*50%*
Most Likely (Mode)	%	100%	100%	100%
Maximum	%	*150%*	*200%*	*125%*
Number of iterations	#	*10,000*		

Table 56: Risk Analysis Assumptions - Triangular Probability Distributions for Concept 3

	mEUR		**mEUR**
Mean (Expected NPV)	817.06	Minimum	290.03
Median	836.39	Maximum	1,224.45
Standard Deviation	177.26	Prob. {NPV>0}	100.0%

Table 57: Results of Monte Carlo Simulation – NPV for Concept 3

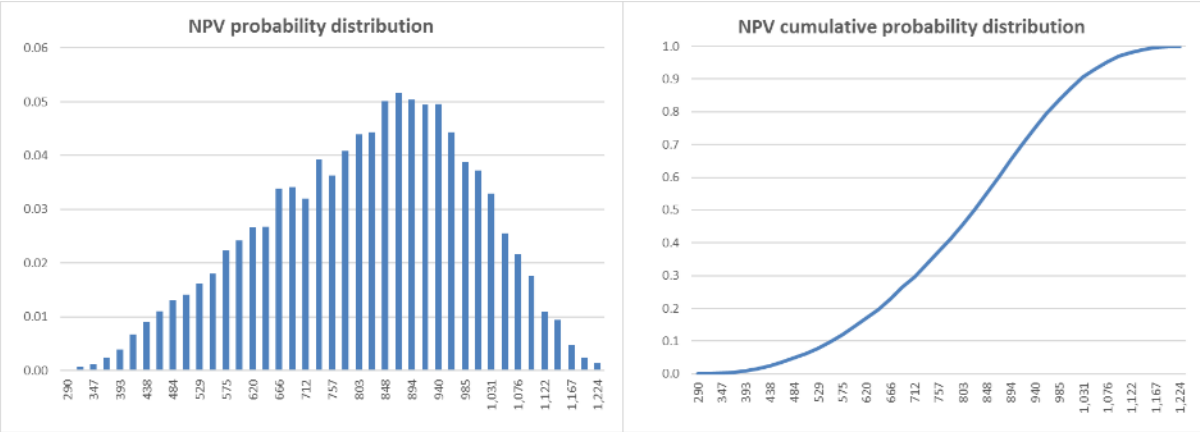

Figure 23: NPV probability distribution for Concept 3

8.4 Sensitivity and risk analysis (Concept 4)

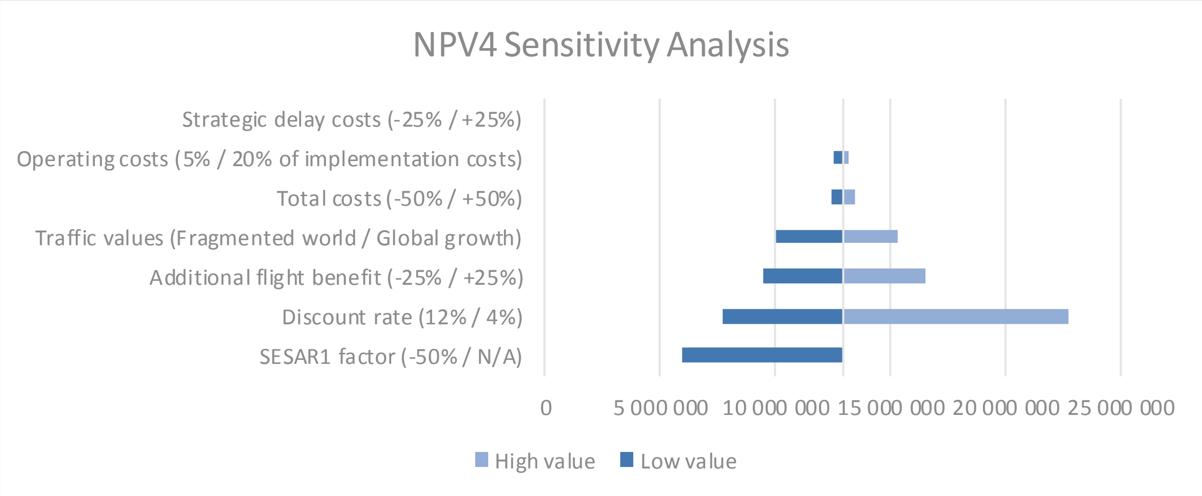

Figure 24: Tornado diagram for Concept 4 (in EUR)

Base-case NPV	***mEUR***	**13.0**		
Variables		***Implementation***	***Operating***	***Benefits***
Base-case (Present Value)	*mEUR*	0.6	0.5	14.0
Minimum	%	*50%*	*50%*	*50%*
Most Likely (Mode)	%	100%	100%	100%
Maximum	%	*150%*	*200%*	*125%*
Number of iterations	#	*10,000*		

Table 58: Risk Analysis Assumptions - Triangular Probability Distributions for Concept 4

	mEUR		**mEUR**
Mean (Expected NPV)	11.80	Minimum	5.76
Median	12.04	Maximum	16.52
Standard Deviation	2.19	Prob. {NPV>0}	100.0%

Table 59: Results of Monte Carlo Simulation – NPV for Concept 4

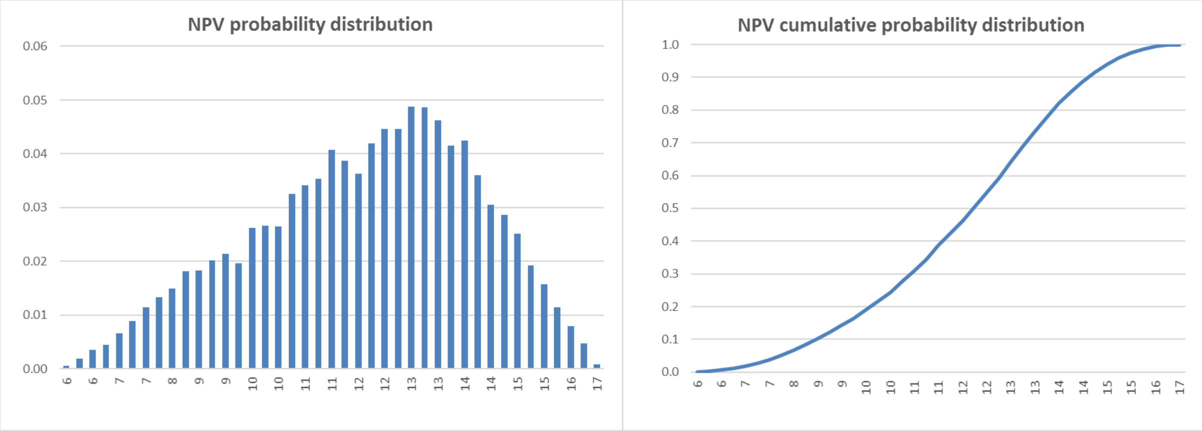

Figure 25: NPV probability distribution for Concept 4

9 Recommendations and next steps

The positive results of the V3 CBA of the Concepts integrating Solution 8 support the decision of proceeding with the Solution to V4 phase - Industrialisation. All Concepts have proven that the expected future benefits far outweigh the costs which confirms financial feasibility of the Concepts and the Solution as a whole. Significant benefits are expected stemming from increased capacity at capacity constrained airports as well as from reduction of an average flight duration, whereas the cost of implementing the Solution are perceived as low to moderate. From the financial point of view the Solution has reached the maturity level that gives a basis for its transition from research to operational environment.

In V4, Very Large Demonstration (VLD) activities will be executed where justified by Projects in order to bridge the gap between Pre-Industrial Development & Validation and Industrialisation & deployment. The results of this CBA shall serve as a reference in terms of costs and benefits for deployment of a Very Large Demonstration. A Very Large Demonstrator is expected to confirm in real environment that the costs incurred by ANSP for the development of its ATC systems which benefit Airspace Users and Airport Operators will pay off.

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

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

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

[4] SESAR 16.06.06-D26_01 ATM CBA for Beginners, Edition 01.02.00

10.2 Reference Documents

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

[5] Common assumptions for CBAs as maintained by PJ19 (provisionally the ones included in the 16.06.06- D68_Part 1, New CBA Model and Methods 2015, Edition 00.01.01 can be used)

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

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

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

[9] PJ19.04.01 D4.5 Validation Targets (2019), Edition 00.01.00, February 2019

[10]SESAR 2020 D86, Guidance on KPIs and Data Collection – Support to SESAR2020 transition

[11] JASPERS - Staff Working Papers: Monte Carlo simulation of Cost-Benefit Analysis results, Francesco Angelini and Marko Kristl, January 2013, Available at:

http://www.jaspersnetwork.org/plugins/servlet/documentRepository/displayDocumentDetails?documentId=223

[12] SESAR 2020 D6.1.203, PJ02-08 SPR-INTEROP/OSED for V3 – Part I, v00.01.03

[13] SESAR 2020 D6.1.203, PJ02-08 SPR-INTEROP/OSED for V3 – Part V, v00.01.00

[14] SESAR 2020 D6.1.132 - PJ02-08 VALR for SJU Quality Check, v00.01.00

[15] Standard Inputs for EUROCONTROL Cost-Benefit Analyses vol. 8.0

[16] Standard Inputs for EUROCONTROL Cost-Benefit Analyses vol. 7.0

[17] SESAR Cost Benefit Analysis Single Solution s6.3.2

[18] Airport OE Dataset February 2019

[19] IATA Economic Briefing September 2013

[20] 2019 Airport Key Performance Indicators ACI

[21] STATFOR European Aviation in 2040: Challenges of Growth 2018, Flight forecast to 2040

11 Appendix

Mapping between ATM Master Plan Performance Ambition KPAs and SESAR 2020 Performance Framework KPAs, Focus Areas and KPIs, source reference *[8]*

ATM Master Plan SESAR Performance Ambition KPA	ATM Master Plan SESAR Performance Ambition KPI	Performance Framework KPA	Focus Area	#KPI / (#PI) / <Design goal>	KPI definition
Cost efficiency	PA1 - 30-40% reduction in ANS costs per flight	Cost efficiency	ANS Cost efficiency	CEF2	Flights per ATCO hour on duty
				CEF3	Technology Cost per flight
Capacity	PA7 - System able to handle 80-100% more traffic	Capacity	Airspace capacity	CAP1	TMA throughput, in challenging airspace, per unit time
				CAP2	En-route throughput, in challenging airspace, per unit time
	PA6 - 5-10% additional flights at congested airports		Airport capacity	CAP3	Peak Runway Throughput (Mixed Mode)
			Capacity resilience	<RES1>	% Loss of airport capacity avoided
				<RES2>	% Loss of airspace capacity avoided
	PA4 - 10-30% reduction in departure delays	Predictability and punctuality	Departure punctuality	PUN1	% of Flights departing (Actual Off-Block Time) within +/- 3 minutes of Scheduled Off-Block Time after accounting for ATM and weather-related delay causes
Operational Efficiency	PA5 - Arrival predictability: 2-minute time window for 70% of flights actually arriving at gate		Variance of actual and reference business trajectories	PRD1	Variance of differences between actual and flight plan or Reference Business Trajectory (RBT) durations

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

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