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SESAR Solution 53B SPR-INTEROP/OSED for V3 - Part V – Performance Assessment Report (PAR)

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PJ18W2 4DSkyways

SOLUTION 53B: IMPROVED PERFORMANCE OF CD/R TOOLS ENABLED BY REDUCED TRAJECTORY PREDICTION UNCERTAINTY

This Performance Assessment Report (PAR) is part of a project that has received funding from the SESAR3 Joint Undertaking under grant agreement No 872320 under European Union's Horizon 2020 research and innovation programme.

Abstract

Solution 53B is part of the PJ18-W2 4DSkyways project. PJ18-W2 aims to continue the research undertaken in Wave 1, PJ.10-02a on Trajectory Management (TM) to enable the deployment of the SESAR Trajectory Based Operations (TBO). In particular, Solution 53 aims to improve existing Separation Management and Monitoring Tools (planned and tactical layers) in the en-route and TMA operational environments and, therefore, to increase the quality of separation management services, reducing controller workload per aircraft and separation buffers, and facilitating new controller team organisations.

This document contains the Performance Assessment Report (PAR) of Solution 53B. It consolidates the performance results obtained in different validation activities at SESAR Solution level and is part V of the SPR-INTEROP/OSED.

The expected benefits from Solution 53B are the following:

- More efficient management and monitoring of potential conflicts;
- An increase in the potential to detect true conflicts;
- Reduced workload per aircraft for ATCOs;
- Facilitated new controller team organisations.

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1 Executive Summary

This document provides the Performance Assessment Report (PAR) for SESAR Solution PJ.18-W2-53B.

The PAR is consolidating Solution performance validation results addressing KPIs/PIs and metrics from the SESAR2020 Performance Framework [3].

Description:

Solution 53B is part of the PJ18-W2 4DSkyways project. PJ18-W2 has continued the research undertaken in Wave 1, PJ10-02a on Trajectory Management (TM) to enable the deployment of the SESAR Trajectory Based Operations (TBO).

This Solution addresses two Operational Improvement steps (OI):

- CM-0209-B - Improved Separation Management with the use of Aircraft Data in Conflict Detection and Resolution Tools in En-Route Predefined and User Preferred Routes environments; and
- CM-0212 - Improved Separation Management with the use of Aircraft Data in Conflict Detection and Resolution Tools in the TMA.

Solution 53 aims to improve Separation Management and Monitoring Tools (planned and tactical layers) in the en-route and TMA operational environments and therefore to increase the quality of separation management services (including more efficient management and monitoring of potential conflicts and an increase in the potential to detect true conflicts), reducing controller workload per aircraft for ATCOs and separation buffers, and facilitating new controller team organisations.

The PAR of Solution 53B assesses the following KPAs:

- Human performance
- Capacity
- Operational efficiency and environment
- Cost efficiency
- Safety
- Predictability

Assessment Results Summary:

The following tables summarises the assessment outcomes per KPI (Table 1) and mandatory PI (Table 2) puts them side-by side against Validation Targets in case of KPI from PJ19 [7]. The impact of a Solution on the performances are described in Benefit Impact Mechanism. All the KPI and mandatory PI from the Benefit Mechanism were the Solution potentially impact have to be assessed via validation results, expert judgment etc.

There are three cases:

1. An assessment result of 0 with confidence level High, Medium or Low indicates that the Solution is expected to impact in a marginal way the KPI or mandatory PI.
2. An assessment result (positive or negative) different than 0 with confidence level High, Medium or Low indicates that the Solution is expected to impact the KPI or mandatory PI.
3. An assessment result of N/A (Not Applicable) with confidence level N/A indicates that the Solution is not expected to impact at all the KPI or mandatory PI consistently with the Benefit Mechanism.

KPI	Validation Targets – Network Level (ECAC Wide)	Performance Benefits at Network Level (ECAC Wide or Local depending on the KPI)[1]	Confidence in Results[2]
SAF1: Safety - Total number of estimated accidents with ATM Contribution per year	Safety Neutral with Traffic increase (SNwT)	Safety Neutral with Traffic increase (SNwT)	High
FEFF1: Fuel Efficiency - Actual average fuel burn per flight	4.19kg-14.87 kg/flight	11.34kg/flight	High
CAP1: TMA Airspace Capacity - TMA throughput, in challenging airspace, per unit time.	High	2. 75%	High
CAP2: En-Route Airspace Capacity - En-route throughput, in challenging airspace, per unit time	Medium	1.46%	Medium
CAP3: Airport Capacity – Peak Runway Throughput	N/A	N/A	N/A

[1] Negative impacts are indicated in red.

[2] High – the results might change by +/-10%
Medium – the results might change by +/-25%
Low – the results might change by +/-50% or greater
N/A – not applicable, i.e., the KPI cannot be influenced by the Solution

(Mixed mode).			
TEFF1: Gate-to-gate flight time	High	0.33 minutes	Low
PRD1: Predictability – Average of Difference in actual & Flight Plan or RBT durations	Low	No clear trends identified during assessment	N/A
PUN1: Punctuality – Average departure delay per flight	N/A	N/A	N/A
CEF2: ATCO Productivity – Flights per ATCO -Hour on duty	High	TMA: 2.41% ENR: 1.32%	High
CEF3: Technology Cost – Cost per flight	N/A	N/A	N/A

Table 1: KPI Assessment Results Summary

Mandatory PI	Performance Benefits Expectations at Network Level (ECAC Wide or Local depending on the KPI)[3]	Confidence in Results[4]
SAF1.X: Mid-air collision - En-Route	SNwT	High
SAF2.X: Mid-air collision - TMA	SNwT	High
SAF3.X: RWY-collision accident	N/A	N/A
SAF4.X: TWY-collision accident	N/A	N/A
SAF5.X: CFIT accident	N/A	N/A

[3] Negative impacts are indicated in red.

[4] High – the results might change by +/-10%
Medium – the results might change by +/-25%
Low – the results might change by +/-50% or greater
N/A – not applicable, i.e., the KPI cannot be influenced by the Solution

SAF6.X: Wake related accident	N/A	N/A
SAF7.X: RWY-excursion accident	N/A	N/A
SAF8.X ...: Other SAF Risks	N/A	N/A
SEC1: A security risk assessment has been carried out	No formal security risk assessment has been carried out.	N/A
SEC2: Risk Treatment has been carried out	No formal risk treatment has been carried out.	N/A
SEC3: Residual risk after treatment meets security objective.	N/A	N/A
ENV1: Actual Average CO2 Emission per flight	98.46kg	High
NOI1: Relative noise scale	N/A	N/A
NOI2: Size and location of noise contours	N/A	N/A
NOI4: Number of people exposed to noise levels exceeding a given threshold	N/A	N/A
LAQ1: Geographic distribution of pollutant concentrations	N/A	N/A
CAP3.1: Peak Departure throughput per hour (Segregated mode)	N/A	N/A
CAP3.2: Peak Arrival throughput per hour (segregated mode)	N/A	N/A
CAP4: Un-accommodated traffic reduction	N/A	N/A
RES1: Loss of Airport Capacity Avoided	N/A	N/A
RES1.1: Airport time to recover from non-nominal to nominal condition	N/A	N/A
RES2: Loss of Airspace Capacity Avoided.	N/A	N/A
RES2.1: Airspace time to recover from non-nominal to nominal condition.	N/A	N/A
RES4: Minutes of delays.	N/A	N/A
RES5: Number of cancellations.	N/A	N/A
TEFF2: Taxi in time	N/A	N/A

TEFF3: Taxi out time	N/A	N/A
TEFF4: TMA arrival time	N/A	N/A
TEFF5: TMA departure time	N/A	N/A
TEFF6: En-Route time	N/A	N/A
PRD2: Variance of Difference in actual & Flight Plan or RBT durations	1.30 minutes	High
PUN2: % Flights departing within +/- 3 minutes of scheduled departure time due to ATM and weather related delay causes	N/A	N/A
CEF1: Direct ANS Gate-to-gate cost per flight	N/A	N/A
AUC3: Direct operating costs for an airspace user	N/A	N/A
AUC4: Indirect operating costs for an airspace user	N/A	N/A
AUC5: Overhead costs for an airspace user	N/A	N/A
CMC1.1: Allocated vs. Requested ARES duration	N/A	N/A
CMC1.2: Allocated vs. Requested ARES dimension	N/A	N/A
CMC1.3: Deviation of Transit Time to/from airbase to ARES	N/A	N/A
CMC 1.3.1: Allocated ARES duration vs. total mission duration	N/A	N/A
CMC 1.3.2: Deviation of total mission duration by iOAT FPL validation	N/A	N/A
CMC 1.4.1: Rate of iOAT FPLs acceptance by NM systems	N/A	N/A
CMC 1.4.2: Rate of iOAT FPLs acceptance by ATC systems	N/A	N/A
CMC2.1: Fuel and Distance saved by GAT	N/A	N/A
HP1: Consistency of human role with respect to human capabilities and limitations	Positive impact on operating methods, considered clear and exhaustive. Performance has increased and workload has reduced.	High

HP2: Suitability of technical system in supporting the tasks of human actors	Positive impact on controllers' productivity and performance thanks to acceptable allocation of tasks.	High
HP3: Adequacy of team structure and team communication in supporting the human actors	Team situational awareness maintained.	High
HP4: Feasibility with regard to HP-related transition factors	Job satisfaction levels maintained.	High
FLX1: Average delay for scheduled civil/military flights with change request and non-scheduled or late flight plan request	N/A	N/A

Table 2 Mandatory PIs Assessment Summary

Additional Comments and Notes:

N/A

2 Introduction

2.1 Purpose of the document

The Performance Assessment covers the Key Performance Areas (KPAs) defined in the SESAR2020 Performance Framework [3]. Assessed are at least the Key Performance Indicators (KPIs) and the mandatory Performance Indicators (PIs), but also additional PIs as needed to capture the performance impacts of the Solution. It considers the guidance document on KPIs/PIs [3] for practical considerations, for example on metrics.

The purpose of this document is to present the performance assessment results from the validation exercises at SESAR Solution level. The KPA performance results are used for the performance assessment at strategy level and provide inputs to the SESAR3 Joint Undertaking (S3JU) for decisions on the SESAR2020 Programme.

In addition to the results, this document presents the assumptions and mechanisms (how the validation exercises results have been consolidated) used to achieve this performance assessment result.

One Performance Assessment Report shall be produced or iterated per Solution.

2.2 Intended readership

In general, this document provides the ATM stakeholders (e.g. airspace users, ANSPs, airports, airspace industry) and S3JU performance data for the Solution addressed.

Produced by the Solution project, the main recipient in the SESAR performance management process is PJ19, which will aggregate all the performance assessment results from the SESAR2020 solution projects PJ1-18, and provide the data to PJ20 for considering the performance data for the European ATM Master Plan. The aggregation will be done at higher levels suitable for use at Master Planning Level, such as deployment scenarios.

2.3 Inputs from other projects

The document includes information from the following SESAR 2020 Wave1 projects:

- PAGAR 2019 90[4]: Performance Assessment and Gap Analysis Report (2019), where are collected the final benefits from SESAR 2020 Wave1.

PJ19 will manage and provide:

- SESAR Performance Framework (2019) [3], guidance on KPIs and Data collection supports.
- S2020 Common Assumptions, used to aggregate results obtained during validation exercises (and captured into validation reports) into KPIs at the ECAC level, which will in turn be captured in Performance Assessment Reports and used as inputs to the CBAs produced by the Solution projects. Where are also included performance aggregation assumptions, with traffic data items.

- For guidance and support PJ19 have put in place the Community of Practice (CoP)[5] within STELLAR, gathering experts and providing best practices.

2.4 Glossary of terms

See the AIRM Glossary [1] [6] for a comprehensive glossary of terms.

2.5 Acronyms and Terminology

Term	Definition
ADS-C	Automatic Dependent Surveillance - Contract
ANS	Air Navigation Service
ANSP	Air Navigation Service Provider
ATCO	Air Traffic Controller
ATFM	Air Traffic Flow Management
ATM	Air Traffic Management
BAD	Benefits Assessment Date
BADA	Base of Aircraft Data
BAER	Benefit Assessment Equipment Rate
CBA	Cost Benefit Analysis
CAP	The KPI which measures Airspace capacity throughput in TMA
CD/R	Conflict detection and resolution
CEF	The KPI which measures cost efficiency
CRT	Criterion
CTA	Controlled Time of Arrival

[5] Go to "Advanced Portfolio Manager" on the left navigation menu, and select "Coordination Group – ATM Performance Assessment (APA)" in STELLAR:

https://stellar.sesarju.eu/?link=true&domainName=saas&redirectUrl=%2Fjsp%2Fproject%2Fproject.jsp%3FobjId%3Dxrn%3Aview%3Axrn%3Adatabase%3Aondb%2Ftable%2FSYS_MESSAGE%402333834.13%40xrn%3AprototypeView%3Adatabase.view.message.private.AllMyMessages

DCB	Demand Capacity Balancing
DCT	Direct route
DOD	Detailed Operational Description
E-ATMS	European Air Traffic Management System
ECAC	European Civil Aviation Conference
ENR	En-route
ENV	Environment
EPP	Extended Projected Profile
EXE	Validation exercise
FEFF	Fuel Efficiency
FOC	Final operation capability
GRIB	GRIded Binary
DB	Deployment Baseline
HC	High Complexity
HP	Human Performance
HPAR	Human Performance Assessment Report
ISA	Instantaneous self-assessment
KPA	Key Performance Area
KPI	Key Performance Indicator
MET	Meteorological
MC	Medium Complexity
N/A	Not Applicable
NM	Nautical Miles
OI	Operational Improvement
OE	Operational Environment
PAR	Performance Assessment Report
PC	Peak

PI	Performance Indicator
PJ	Project
PRD	The KPI which measures predictability
PRU	Performance Review Unit
QoS	Quality of Service
RBT	Reference Business / Mission Trajectory
Ref	Reference scenario
RTS	Real Time Simulation
SAC	Safety Criteria
SAR	Safety Assessment Report
Sec	Seconds
SESAR	Single European Sky ATM Research Programme
S3JU	SESAR3 Joint Undertaking (Agency of the European Commission)
SESAR2020 Programme	The programme which defines the Research and Development activities and Projects for the S3JU.
SNwT	Safety Neutral with Traffic increase
Sol	Solution scenario
Sub-OE	Sub operating environment
TEFF	Time Efficiency
TOD	Top of descent
TMA	Terminal Manoeuvring area
TP	Trajectory Prediction
VALP	Validation Assessment Plan
VALR	Validation Assessment Report
VHC	Very High Complexity
W2	Wave 2
WL	Workload

Table 3: Acronyms and terminology

The following is a list of the concepts, terms or definitions introduced or commonly referred to in this document.

Term	Definition	Source
Airport Capacity Focus Area	Capture the peak runway throughput in the most challenging (or constrained) environments at busy hours, i.e. the capacity at a "maximum observed throughput" airport.	PAGAR
Airspace Capacity Focus Area	Capture the capability of a challenging volume of airspace to handle an increasing number of movements per unit time – through changes to the operational concept and technology.	PAGAR
Airspace Reservation/ Restriction (ARES)	Airspace Reservation means a defined volume of airspace temporarily reserved for exclusive or specific use by categories of users (Temporary Segregated Area (TSA), Temporary Reserved Area (TRA), and Cross-Border Area (CBA)) wheras Airspace Restriction designates Danger, Restricted and Prohibited Areas.	EC Regulation No 2150/2005
Airspace User Cost-Efficiency Focus Area	Cost-Efficiency obtained by Airspace Users other than direct gate-to-gate ATS costs (CEF1) or AU cost improvements assessed through other KPIs: Fuel Efficiency, Punctuality, etc. Note: Benefits assessed through other KPIs should not be included in this focus area to avoid double counting of benefits. AU Cost-Efficiency includes reduction of direct (AUC3) and indirect (AUC4) operational costs of the AU, as well as overhead costs (AUC5). In addition there are two specific PIs, Strategic Delay (AUC1) and Sequence Optimisation Benefit (AUC2).	PAGAR
ARES Capacity	The ability of an ATM system to accommodate specific training events which require airspace reservations and/or restrictions during a specific period of time, taking into account the duration of the training events, ATM inefficiency, planning inefficiency and weather impact on training and operations.	Performance Framework 2017

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Term	Definition	Source
ATM Master Plan	The European ATM Master Plan is the agreed roadmap to bring ATM R&I to the deployment phase, introducing the agreed vision for the future European ATM system. It provides the main direction and principles for SESAR R&I, as well as the deployment planning and an implementation view with agreed deployment objectives. Through the SESAR Key Features, the ATM Master Plan identifies the Essential Operational Changes (both Essential Operational Changes featured in the Pilot Common Project and New Essential Operational Changes) and key R&I activities that support the identified performance ambition. The ATM Master Plan is updated on a regular basis in collaboration and consultation with the entire ATM community. Amendments are submitted to the S3JU Administrative Board for adoption. The content of the European ATM Master Plan is structured in three levels (Level 1 – Executive View, Level 2 – Planning and Architecture View, and Level 3 – Implementation View) to allow stakeholders to access the information at the level of detail that is most relevant to their area of interest. The intended readership for Level 1 is executive-level stakeholders. Levels 2 and 3 of the ATM Master Plan provide more detail on the operational changes and related elements and therefore the target audience is expert-level stakeholders.	SESAR2020 Project Handbook, European ATM Master Plan (9 Edition)
Civil-military coordination and cooperation	The coordination between the civil and military parties authorised to make decisions and agree a course of action.	Performance Framework 2017
Cost-Benefit Analysis	A Cost-Benefit Analysis is a process for quantifying in economic terms the costs and benefits of a project or a programme 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. This process 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 affecting the decision.	PAGAR
Deployment Scenario	Set of SESAR Solutions selected to satisfy the specific Performance Needs of operating environments in the European ATM System and based on the timescales in which their performance contribution is needed in the respective operating environments.	PAGAR
Flexibility KPA	The ability of the ATM System and airports to respond to changes in planned flights and missions. It covers late trajectory modification requests as well as ATFCM measures and departure slot swapping and it is applicable to military and civil airspace users covering both scheduled and unscheduled flights. In terms of specific military requirements, it also covers the ability of the ATM System to address military requirements related to the use of airspace and reaction to short-notice changes.	Performance Framework 2017

Term	Definition	Source
Focus Area	Within each KPA, a number of more specific "Focus Areas" are identified in which there are potential intentions to establish performance management. Focus Areas are typically needed where performance issues have been identified.	ICAO Doc 9883
Fuel Efficiency Focus Area	The SESAR performance Focus Area concerned with fuel efficiency. How much fuel is used by aviation or by extension "Fuel efficiency" (how much fuel can be saved?) is one of the performance aspects. Note: Policy places considerable focus on this. Fuel efficiency contributes to 3 of the 11 KPAs defined by ICAO: Cost-efficiency, Efficiency, and Environment.	PAGAR
Gap Analysis	Difference between the validation targets and the performance assessment. It is used to: 1. Anticipate any deviation from the design performance targets; 2. Identify the underlying reasons; 3. Derive the appropriate recommendations to be taken on board to redirect the R&D activities within the Programme towards the ultimate achievement of SESAR2020's performance ambitions.	PAGAR
G2G ANS Cost-Efficiency Focus Area	One of the SESAR performance Focus Areas concerned with Cost Efficiency. Direct G2G ANS costs are those costs that are charged to Airspace Users via unit rates, including ATM/CNS costs, regulatory costs, Met costs and EUROCONTROL Agency costs.	Performance Framework new
Human Performance (HP)	Human capabilities and limitations which have an impact on the safety, security and efficiency of aeronautical operations.	EUROCONTROL ATM Lexicon
Key Performance Area	A way of categorising performance subjects related to high level ambitions and expectations. ICAO Global ATM Concept sets out these expectations in general terms for each of the 11 ICAO defined KPAs.	EUROCONTROL ATM Lexicon

Term	Definition	Source
Key Performance Indicator	Current/past performance, expected future performance (estimated as part of forecasting and performance modelling), as well as actual progress in achieving performance objectives is quantitatively expressed by means of indicators (sometimes called Key Performance Indicators, or KPIs). To be relevant, indicators need to correctly express the intention of the associated performance objective. Since indicators support objectives, they should not be defined without having a specific performance objective in mind. Indicators are not often directly measured. They are calculated from supporting metrics according to clearly defined formulas, e.g. cost-per-flight-indicator = Sum (cost)/Sum (flights). Performance measurement is therefore carried out through the collection of data for the supporting metrics.” In SESAR2020 Performance Framework, Key Performance Indicators are those that have a validation target associated derived from the corresponding Performance Ambition.	ICAO Doc 9883 Performance Framework
Local Air Quality Focus Area	One of the SESAR performance Focus Areas concerned with Environment. Local air quality is a term commonly used to designate the state of the ambient air to which humans and the ecosystem are typically exposed at a specific location. In the case of aviation, local air quality studies are generally conducted near airports.	PAGAR
Noise Focus Area	One of the SESAR performance Focus Areas concerned with Environment. The term Noise is used in this document to designate noise pollution, which is defined as unwanted sound. The impact of unwanted sounds on the recipients (in this case, people living around airports) causes adverse effects.	PAGAR
Operational Environment (OE)	An environment with a consistent type of flight operations.	EUROCONTROL ATM Lexicon
Performance Ambitions	Performance capability that may be achieved if SESAR Solutions are made available through R&D activities, deployed in a timely and, when needed, synchronised way and used to their full potential.	EUROCONTROL ATM Lexicon
Performance assessment	This term relates to the quantitative estimate of the potential performance benefit of an operational improvement based on outputs from validation projects, collected and analysed by PJ19.04.02	ICAO Doc 9883 updated in PAGAR

Term	Definition	Source
Performance Framework	1) The overall performance-driven development approach that is applied within the SESAR development programme to ensure that the programme develops the operational concept and technology needed to meet long-term performance expectations. 2) The set of definitions and terminology describing the building blocks used by a group of ATM community members to collaborate on performance management activities. This set of definitions includes the levels in the global ATM performance hierarchy, the eleven Key Performance Areas, a set of process capability areas, focus areas, performance objectives, indicators, targets, supporting metrics, lists of dimension objects, their aggregation hierarchies and classification schemes.	EUROCONTROL ATM Lexicon
Performance Indicator	PIs are defined in the SESAR performance framework and relate to performance benefits in specific KPAs. However, no validation targets are assigned to PIs. SESAR Solutions projects use the results of validation exercises to report performance assessment in terms of the PIs, reporting the expected positive and negative impacts. Certain PIs are mandatory for measurement and reporting by Solution projects.	SESAR2020 Project Handbook
Performance metrics	Sometimes proxies may be used in a validation exercise when it is not possible to measure an impact directly using the specified KPIs and PIs. In these cases, other metrics may be used provided the solution project later converts the results into the reporting KPIs and PIs.	SESAR2020 Project Handbook
Predictability Focus Area	Predictability is focused on in-flight (i.e. off-block to on-block) variability of flight duration compared to the planned duration. It is expected that this area will be extended in the future to reflect the improvement derived from better planning in pre-tactical phase.	Performance Framework 2019
Punctuality Focus Area	Refers to "ATM Punctuality". It captures ATM issues as well as events related to ATM that cause a temporal perturbation to airspace user schedules.	PAGAR
Resilience Focus Area	Resilience focuses on the ability to withstand and recover from planned and unplanned events and conditions which cause a loss of nominal performance.	Performance Framework updated
Safety	The state to which the possibility of harm to persons or damage to property is reduced, and maintained at or below, an acceptable level through a continuing process of hazard identification and risk management.	EUROCONTROL ATM Lexicon

Term	Definition	Source
Security	(aviation) Safeguarding civil aviation against acts of unlawful interference. This objective is achieved by a combination of measures and human and material resources. Note: ATM Security is concerned with those threats that are aimed at the ATM System directly, such as attacks on ATM assets, or where ATM plays a key role in the prevention of or response to threats aimed at other parts of the aviation system (or national and international assets of high value). ATM security aims to limit the effects of a threats on the overall ATM Network. ATM Security is a subset of Aviation Security (as defined by ICAO in Annex 17).	EUROCONTROL ATM Lexicon, Note are from PAGAR
SESAR2020	The Programme for SESAR2020 was created with a clear and agreed need for continuing research and innovation in ATM beyond the SESAR 1 development phase. SESAR2020 is structured into three main research phases, starting with Exploratory Research, which is then further expanded within a Public-Private-Partnership (PPP) to conduct Industrial Research and Validation. Finally, it further exploits the benefits of the PPP in Demonstrating at Large Scale the concepts and technologies in representative environments to firmly establish the performance benefits and risks.	Performance Framework 2017
SESAR Programme	The programme which defines the Research and Development activities and Projects for the S3JU.	EUROCONTROL ATM Lexicon
SESAR Solution	A term used when referring to both SESAR ATM Solution and SESAR Technological Solution.	SESAR2020 Project Handbook
SESAR ATM Solution	SESAR Solutions relate to either an Operational Improvement (OI) step or a group of OI steps with associated Enablers (technical system, procedure or human), which have been designed, developed and validated in response to specific Validation Targets and that are expected deliver operational and/or performance improvements to European ATM, when translated into their effective realisation. SESAR Technological Solutions relate to verified technologies proven to be feasible and profitable, which may therefore be considered to enable future SESAR Solutions.	SESAR2020 Project Handbook
Single European Sky High Level Goals	The SES High Level Goals are political targets set by the European Commission. Their scope is the full ATM performance outcome resulting from the combined implementation of the SES pillars and instruments, as well as industry developments not driven directly by the EU.	SESAR2020 Project Handbook
Sub-OE	A subcategory of an Operating environment, classified according to its complexity (e.g. high complexity TMA, medium complexity TMA, low complexity TMA).	EUROCONTROL ATM Lexicon
Validation targets	Validation targets are the targets that focus on the development of enhanced capabilities by the SESAR Solutions. They aim to secure from R&D the required performance capability to contribute to the achievement of the Performance Ambitions and, thus, to the SES high-level goals. In SESAR2020 validation targets are associated with a KPI.	EUROCONTROL ATM Lexicon

Table 4: Terminology

3 Solution Scope

3.1 Detailed Description of the Solution

Solution PJ.18-W2-53B aims to improve Separation Management and Monitoring Tools (planned and tactical layers) in the En-route and TMA operational environments in order to increase the quality of separation management services, reducing controller workload per aircraft, reducing separation buffers and facilitating more efficient controller team organisations.

Originally the PJ.18-W2-53A and PJ.18-W2-53B Solutions were part of a single solution, which was then split in what was originally described as a single solution into the two sub-solutions 53A and 53B, taking advantage of concepts and technology that are more mature to enable earlier delivery of benefits:

- PJ.18-W2-53A – Increased Automation in Planning and Tactical Separation Management
- PJ.18-W2-53B – Improved Performance of CD/R Tools Enabled by Reduced Trajectory Prediction Uncertainty

Solution PJ.18-W2-53B includes the more mature separation management elements for which V3 maturity is targeted. This solution builds on the work performed in Wave 1 solutions PJ.10-02a2 and PJ.18-06a and addresses the improvement of conflict detection and resolution tools that are derived from the improvement of ground Trajectory Prediction (TP) with the use of advanced data from ATN B2 ADS-C reports messages as defined in the EUROCAE standards ED228A and ED75C and improved meteorological data.

This solution addresses two Operational Improvement steps (OI) recorded in the Data Set 22:

- CM-0209-b Improved Separation Management with the use of Aircraft Data in Conflict Detection and Resolution Tools in en-route Predefined and User Preferred Routes environments;
- CM-0212 Improved Separation Management with the use of Aircraft Data in Conflict Detection and Resolution Tools in the TMA.

The improvements of ground trajectory prediction (TP) in Solution PJ.18-W2-53B address the use of ADS-C data beyond the items that were studied in Wave 1 (gross mass, speed schedule, TOC and TOD altitudes, and the predicted speeds at route points) to address in particular:

- The use of the EPP profile to calibrate the BADA performance model;
- Improvements in the calculations of turning manoeuvres thanks to the use of turn radius and the turning strategy (overfly vs fly-by);
- The implementation of catch-up manoeuvres (not depending on EPP data).

In addition, the solution encompasses the handling of MET data and other surveillance data from aircraft (ADS-C reports, NOWCAST from Mode S enhanced surveillance data, ADS-B out reports).

3.2 Detailed Description of relationship with other Solutions

Solution Number	Solution Title	Relationship	Rational for the relationship
PJ.18-W2-53B with **PJ.01-W2-8A1**	Short-term DCB optimisation of TMA and extended TMA airspace with TMA management tools.	Independent with cross-effect	The solution enables departure flows to be managed in an integrated manner resulting in a more consistent and manageable delivery into the en-route phase of flight while ensuring an optimal usage of runway capacity. No quantitative impact has been assessed stemming from the relationship. It is expected to lead to improved TP.
PJ.18-W2-53B with **PJ.01-W2-8A2**	Automatic controlled time of arrival (CTA) for management of arrival in en-route and on the ground.	Independent with cross-effect	The candidate solution enables aircraft to fly more optimal trajectories and absorb delay on the ground instead or in the air, reducing fuel burn. It also improves queue management and results in more predictable landing times. No quantitative impact has been assessed stemming from the relationship.
PJ.18-W2-53B with **PJ.01-W2-8B2**	Air/Ground intention sharing to improve optimised descent operations.	Cross-effect	The solution increases the efficiency of descents through improved sharing of aircraft intentions and predictions with the ground, the use of this information by the ground to better consider the aircraft's optimal profile, improved awareness by the flight crew of the ATC intentions.
PJ.18-W2-53B with **PJ.18-W2-53A**	Increased automation in planning and tactical separation management.	Is prerequisite to	This solution sees enhanced assistance provided by conflict detection and resolution for planning and tactical controllers and provides enhanced resolution support information based upon predicted conflict detection and associated monitoring features. It also provides additional trajectory prediction based on ADS-C and known constraints and introduces machine learning and big data

			techniques to provide more accurate estimates. No quantitative impact has been assessed stemming from the relationship.
PJ.18-W2-53B with **PJ.18-W2-56**	Air/Ground Trajectory Synchronisation via lateral and vertical complex CPDLC clearances to support TBO.	Cross-effect	This solution makes use of enhanced operational procedures based on a more efficient use of CPDLC with lateral and vertical data link clearances. The solution aims to leverage the usage of the current ATS Baseline 2 mandate and paves the way for future automation levels, as outlined in the European ATM Master Plan. No quantitative impact has been assessed stemming from the relationship.
PJ.18-W2-53B with **PJ.10-73-FCA**	Flight centric air traffic control (ATC).	Positive cross-effect	The solution looks at procedures for conflict detection and resolution; exploring different team set-ups and traffic allocation strategies; defining tools and procedures for demand and capacity balancing; and quantifying expected benefits. The candidate solution is expected to increase of controller productivity owing to a better balance of the demand and increase flight efficiency by removing the sectors entry/exit conditions. It is also expected to improve TP.

Table 5: Relationships with other Solutions

4 Solution Performance Assessment

4.1 Assessment Sources and Summary of Validation Exercise Performance Results

Previous Validation Exercises (pre-SESAR2020 Wave 2, etc.) relevant for this assessment are listed below.

Organisation	Document Title	Publishing Date
SESAR	EXE-10.02a-V3-VALP-001 performed by DSNA: En-Route	15/10/2019
SESAR	EXE-10.02a-V3-VALP-002b performed by COOPANS and Thales: TMA	15/10/2019
SESAR	EXE-10.02a-V3-VALP-003 performed by ENAV and LEONARDO: En-Route	15/10/2019
SESAR	EXE-10.02a-V3-VALP-004 performed by Skyguide: En-Route	15/10/2019
SESAR	EXE-10.02a-V3-VALP-005 performed by ECTL, ANS-CR, Thales: En-Route	15/10/2019
SESAR	EXE-10.02a-V3-VALP-006 performed by BULATSA and Airbus: TMA	15/10/2019
SESAR	EXE-10.02a-V3-VALP-007 performed by Airbus D&S and BULATSA: TMA and transition to En-Route	15/10/2019

Table 6: Pre-SESAR2020 Exercises

SESAR Validation Exercises of this solution are listed below.

Exercise ID	Exercise Title	Release	Maturity	Status
PJ.18-W2-53B-V3-EXE-008	TP improvement and CD/R tools enhancements through multiple data sources (ADS-C, Mode S)	R12	V3	Completed
PJ.18-W2-53B-V3-EXE-009	TP improvement and CD/R tools enhancements through ADS-C data, improved weather information, and AWAs management	R12	V3	Completed
PJ.18-W2-53B-V3-EXE-010	TP and weather information improvement through ADS-C data	R12	V3	Completed

PJ.18-W2-53B-V3-EXE-011	TP improvement and CD/R tools enhancements through ADS-C data and improved tactical tools	R12	V3	Completed
PJ.18-W2-53B-V3-EXE-012	TP improvement and CD/R tools enhancements through ADS-C data	R12	V3	Completed

Table 7: SESAR2020 Validation Exercises

The following table provides a summary of information collected from available performance outcomes.

Exercise	OI Step	Exercise scenario & scope	Performance Results	Notes
PJ.18-W2-53B-V3-EXE-008: TP improvement and CD/R tools enhancements through multiple data sources (ADS-C, Mode S)	CM-0209-b CM-0212	EXE-008 is an RTS exercise which aims to further improve CD/R and Conformance monitoring tools with the use of multiple data resources and available weather information, enhancing TP.	Increased situational awareness; Reduced workload for ATCOS; 10% or more increase in capacity; Improved operational efficiency for TMA and ENR; Level of safety in maintained. Improved cost efficiency. Positive environmental impact.	
PJ.18-W2-53B-V3-EXE-009: TP improvement and CD/R tools enhancements through ADS-C data, improved weather	CM-0209-b	EXE-009 has focused on the development of additional TP improvements using further elements of Automatic Dependent Surveillance – Contract Extended Projected Profile (ADS-C EPP) and more recent weather information compared with the previous weather forecast message (GRIB	Positive contribution to: •Human Performance; •Safety; •Capacity; and •Cost Efficiency.	The expected results are a better alerting conflict detection performance, a higher situational awareness, a higher ATCO

information, and AWAs management		message) and adverse weather areas (AWAs), assessing also the impact on conflict tools and separation management.		trust, a lower ATCO workload and better adherence to the flight plan.
PJ.18-W2-53B-V3-EXE-010: TP and weather information improvement through ADS-C data	CM-0209-b	EXE-010 aims at the validation of planned trajectories TP and Meteorological (MET) data quality improvements based on the use of ADS-C/EPP opportunities.	Higher Predictability	
PJ.18-W2-53B-V3-EXE-011: TP improvement and CD/R tools enhancements through ADS-C data and improved tactical tools	CM-0209-b	EXE-011 builds on the outcomes of 18-06a activities and aims to further investigate TP improvements using EPP. It will also validate tactical separation tools improvements.	Improved CD/R with better TP	
PJ.18-W2-53B-V3-EXE-012: TP improvement and CD/R tools enhancements through ADS-C data	CM-0209-b	EXE-012 aims to validate the improvement of the TP to be used in either Planning or Tactical phases and CD/R tools enriched with downlinked airborne data (ADS-C data).	Acceptance and relevance of procedures and working methods with more accurate tools. Positive impact on situational awareness on ATCO side. Adequacy of CD/R tools accuracy and improved HMI functions. Positive impact on ATCOs workload and consequently on sector capacity / cost efficiency.	

			Positive impact on Safety. Increased flight efficiency and predictability at local level.	

Table 8: Summary of Validation Results.

4.2 Conditions / Assumptions for Applicability

The following Table 9 summarises the applicable operating environments.

OE	Applicable sub-OE	Special characteristics
En-route	Very high, High, Medium traffic density and complexity	The airspace considered by solution PJ.18-W2-53B is a managed airspace, where a separation service is provided by ATM services providers. The vertical scope extends from FL0 to FL660, comprising of upper and lower airspace, but excludes airspace dedicated to final approach and aerodrome vicinity. Separation minima are expected to continue to be based on guidance, regulations, and factors used in today's environment and the choice of separation standard is made on a case-by-case basis depending on both the pair of aircraft to assess and the airspace where the separation is assessed. Separation may not be homogeneous throughout the whole controlled sector. It is assumed that by 2035 50% of aircraft will be EPP equipped.
TMA	Very high, High, Medium traffic density and complexity	

Table 9: Applicable Operating Environments.

The traffic assumptions, taking into account the expected airspace characteristics of 2035, for the above-defined Applicable Sub-OEs are summarised in the table below.

Assumption	ID	Source	Value
Contribution to total En-Route traffic from the specific sub-OE of Very High Complexity	ER-VHC-2035	*SESAR2020_Common_Assumptions 2019_annex1*	31.33%
Contribution to total En-Route traffic from the specific sub-OE of High Complexity	ER-HC-2035	*SESAR2020_Common_Assumptions 2019_annex1*	27.98%

Contribution to total En-Route traffic from the specific sub-OE of Medium Complexity	ER-MC-2035	*SESAR2020_Common_Assumptions 2019_annex1*	37.89%
Contribution to total En-Route traffic from peak traffic in the specific sub-OE of Very High Complexity	ER-PC-VHC-2035	*SESAR2020_Common_Assumptions 2019_annex1*	12.61%
Contribution to total En-Route traffic from peak traffic in the specific sub-OE of High Complexity	ER-PC-HC-2035	*SESAR2020_Common_Assumptions 2019_annex1*	12.92%
Contribution to total En-Route traffic from peak traffic in the specific sub-OE of Medium Complexity	ER-PC-MC-2035	*SESAR2020_Common_Assumptions 2019_annex1*	18.96%

Table 10: Traffic share assumptions for the applicable Operating Environments

For the TMA traffic, the SESAR2020 Common Assumptions document states that the traffic contribution to total traffic handled per sub-OE category is the sum of annual movements at each specific sub-OE within the same category divided by the annual IFR ECAC movements, because the volume of arrival and departure traffic is best considered in number of movements. The unit provided is therefore movements/flights instead of percentage.

In order to extrapolate the performance benefits to ECAC level, the percentage value of traffic per sub-OE complexity level has been computed by comparing the total number of IFR movements and number of IFR movements per specific sub-OE from the *En-route and Terminal OEs 2017 dataset*. The TMA peak traffic (PC) has then been computed by comparing the movements / flights in TMA PC OE with the corresponding total traffic per sub-OE from the *SESAR2020 Common Assumptions Annex*.

Assumption	Source	Value
Contribution to total TMA traffic from the specific sub-OE (TMA VHC)	Own computation based on TMA data from *En-route and Terminal OEs 2017 dataset*	41.85%
Contribution to total TMA traffic from the specific sub-OE (TMA HC)	Own computation based on TMA data from *En-route and Terminal OEs 2017 dataset*	14.19%
Contribution to total TMA traffic from the specific sub-OE (TMA MC)	Own computation based on TMA data from *En-route and Terminal OEs 2017 dataset*	32.21%
Contribution to total TMA traffic from the specific sub-OE (TMA PC VHC)	Own computation based on TMA data from *En-route and Terminal OEs 2017 dataset*	23.20%

Contribution to total TMA traffic from the specific sub-OE (TMA PC HC)	Own computation based on TMA data from *En-route and Terminal OEs 2017 dataset*	12.19%
Contribution to total TMA traffic from the specific sub-OE (TMA PC MC)	Own computation based on TMA data from *En-route and Terminal OEs 2017 dataset*	16.08%

Table 11: Traffic share assumptions for the TMA Operating Environment

4.3 Safety

Solution 53B is expected to have a positive impact on Safety as it aims to improve Separation Management and Monitoring Tools (planned and tactical layers) in the en-route and TMA operational environments in order to increase the quality of separation management services, reducing controller workload per aircraft, reducing separation buffers and facilitating more efficient controller team organisations.

4.3.1 Safety Design drivers and Performance Mechanism

Solution PJ.18-W2-53B encapsulates the more mature separation management elements for which V3 maturity is targeted. This solution builds on the work performed in Wave 1 solutions PJ.10-02a and PJ.18-06a and addresses the improvement of conflict detection and resolution tools that are derived from the improvement of ground Trajectory Prediction (TP) with the use of advanced data from ATN B2 ADS-C reports messages as defined in the EUROCAE standards ED228A and ED75C and improved meteorological data.

As such, the solution's Safety Assessment report addresses the following OIs:

- CM-0209-b - Improved Separation Management with the use of Aircraft Data in Conflict Detection and Resolution Tools in en-Route Predefined and User Preferred Routes environments;
- CM-0212 - Improved Separation Management with the use of Aircraft Data in Conflict Detection and Resolution Tools in the TMA.

Furthermore, the design safety drivers are the Safety Criteria (SAC). The SAC define the acceptable level of safety (i.e. accident and incident risk level) to be achieved by the solution under assessment.

The SACs of Solution PJ18-W2-53B are associated with:

- **Plan Induced Conflict Management/Planning Conflicts** – There shall be no increase in the number of planned (tactical) conflicts arising from inadequate information for conflict management, ATCO failure to identify conflict in time and/or inadequate ATCO conflict management, taking into consideration increase in traffic.
- **ATC Induced Conflict Management/ATC Induced Tactical conflict** - There shall be no increase in ATC-induced tactical conflicts arising from inadequate resolution strategy taking into consideration increase in traffic.
- **Pre-tactical Conflicts/Inadequate Trajectory Info** - There shall be no increase in pre-tactical conflicts due to Inadequate Trajectory Info taking into consideration increase in traffic.

The rationale of the SACs is that due to improvement of TP, availability of downlinked trajectory data and more accurate MET information, and thanks to improved performance of the CD/R tools, the ATCO is able to timely identify relevant conflicts and to apply adequate resolution strategies.

4.3.2 Data collection and Assessment

Safety has been assessed in **OBJ-18-W2-53B-V3-VALP-005** and various success criteria during five validation exercises. A short summary of each exercise is provided below. More details on the results can be found in the VALR [21]and SAR [22].

EXE-008

This exercise assessed the increase in the number of imminent separation infringements and the implementation of CD/R support tools.

For the criteria on **increase in the number of imminent separation infringements**, the exercise collected quantitative data from TESLA and GENETICs log files. The number of separation infringements for both en-route and TMA is constantly zero for all solution scenarios. Therefore, the exercise did not show any degradations in the separation infringements and therefore it is assumed that the level of safety is maintained.

For the criteria on the **implementation of CD/R support tools not deteriorating human performance impacting safety** the results were taken from debriefing interviews with ATCOs after each run.

The majority of the TMA ATCOs replies indicate they feel neutral (42%) or it is unlikely (25%) for the human performance to be deteriorated if the CD/R tool is implemented. On the other hand, 33% of the results consider it likely. Whereas the opinion of the en-route ATCOs shows a much higher percentage (67%) of the replies are towards likely that the human performance will be deteriorated. Respectively 25% for neutral and 8% for unlikely. This is because for every new technology there is an adoption phase, which might take a long time. The CD/R functionalities cover core responsibilities of the ATCOs and as such they must be proven over time so the ATCOs can use them with confidence and trust. It is therefore to be expected that the ATCOs skills will deteriorate with the implementation of advanced automation. Therefore, more effort must be concentrated in regular refresh trainings for the ATCOs and high level of CD/R tool resilience. Despite this, the validation exercise considers the success criterion is also considered satisfied.

EXE-009

Direct measures of KPIs were not possible in this exercise.

On the **increase of the number of pre-tactical planned** and **planned tactical conflicts**, the improved TP reduces false alarms and reveals undetected conflicts. There is no evidence that additional pre-tactical conflicts are generated by this approach.

On the **implementation of CD/R support tools not deteriorating human performance impacting safety**, the reduction of false alerts and identification of undetected conflicts could potentially increase situational awareness while reducing the workload for unnecessary checking of false alerts. There is no indication that human performance is deteriorated by this observation, especially no negative effect on Safety.

It can therefore be concluded that even for difficult conditions with strong winds and real ATC interaction, the improved TP seems to be at least equal or better than pure BADA. It is assumed that the safety level is maintained.

EXE-011

Due to the limitation of the simulations' settings it was not possible to obtain specific log data for the pre-tactical planned conflicts, planned tactical conflicts, ATC-induced tactical conflicts and imminent separation infringements. Therefore, the impact of safety was assessed by the questionnaires and debriefing. The obtained results do not show any trends of decreasing safety, but in order to provide more certain conclusions, further investigation is recommended.

EXE-0012

Based on quantitative and qualitative results, such as data logs, the level of safety is maintained with the use of the enhanced CD/R tool while traffic has been increased by 10-15%. In fact, the impact of enhanced tools using aircraft data on safety is largely positive as despite very highly complex airspace and high traffic load, thanks to the tools and the better knowledge of performance and intentions, ATCOs managed traffic and conflicts without issues.

More details of the outcomes per Success Criterion can be found in the PJ18-W2-53B Validation Report (VALR) [21].

4.3.3 Extrapolation to ECAC wide

The six validation exercises performed in PJ18-W2-53B covered significant proportions of the ECAC area, focusing on TMA and en-route sectors with Medium, High and Very High complexity airspace. However, only four validation exercises addressed the safety KPI. There is no apparent element which would prevent the assessed Safety results from applying to all sub-operating environments.

4.3.4 Discussion of Assessment Result

The safety assessment conducted across the exercises had been shown to be comprehensive and relies on a range of data sources (Real-Time simulations, technical demonstration, gaming exercises and workshops). Overall, it has been concluded that the level of safety is maintained with the enhanced TP improvements feeding the CD/R tool. Based on quantitative and qualitative results (data logs) the level of safety is maintained with the use of the new functionalities while traffic has been increased.

The evidence derived from validation related to abnormal conditions (EXE-008 and EXE-012) demonstrated that although in some cases the number of conflicts increased, the safety was maintained. No specific negative effect on human performance, which would impact safety, was identified.

The validation did not explicitly address degraded modes of operation however, some technical issues occurred (loss of ADS-C EPP) in EXE-012. The CD/R tools were designed to dynamically revert to conventional functioning mode (flight data treating without ADS-C EPP) and ATCOs were informed with the appropriate warning (reverting to reference scenario CD/R tools performance). Although the ATCO reported that the degradation did not affect their working methods, further investigation of degraded modes was recommended.

4.3.5 Additional Comments and Notes

No additional comments.

4.4 Environment: Fuel Efficiency / CO2 emissions

Solution 53B is expected to increase fuel efficiency and reduce CO_2 emissions with the use of enhanced TP and CD/R tools. The exercises demonstrate an improvement in the fuel burn and CO_2 emissions for the TMA sector. In contrast, the results for en-route show negligible improvement.

4.4.1 Performance Mechanism

Fuel efficiency is measured via the FEFF1 KPI, which measures the actual average fuel burn per flight. Whereas CO_2 emissions are measured via the ENV1 KPI, which looks at the actual average CO_2 emissions per flight.

Solution 53B will enable a reduction in fuel burn and CO_2 emissions as aircraft are less likely to level-off at an intermediate altitude or to climb/descend at a non-optimal rate and flights descend closer to their TOD. This is due to conflicts being solved earlier and, therefore, having a more stable flown trajectory and adherence to flight plan than without the change.

4.4.2 Assessment Data (Exercises and Expectations)

4.4.2.1 Fuel efficiency

Validation targets

The FEFF1 validation target for the total solution is **12.56 kg/flight** (4.19kg-14.87 kg/flight). The values below represent the targets per sub-OE:

- Very High Complexity TMA Sub-OE 44% of total solution target
- High Complexity TMA Sub-OE 22% of total solution target
- Medium Complexity TMA Sub-OE 35% of total solution target
- Low Complexity TMA Sub-OE N/A

- Very High Complexity ENR Sub-OE 49% of total solution target
- High Complexity ENR Sub-OE 28% of total solution target
- Medium Complexity ER Sub-OE 23% of total solution target
- Low Complexity ENR Sub-OE N/A

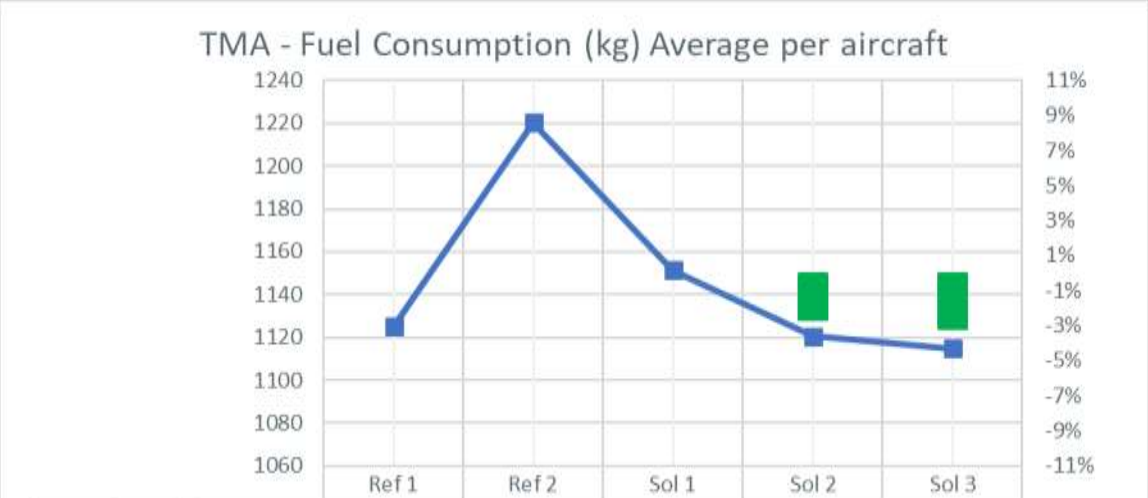
Validation results

Fuel consumption has been assessed in **OBJ-18-W2-53B-V3-VALP-002** via the success criterion **CRT-18-W2-53B-V3-VALP-002-001a** – *Average Fuel consumption per flight is decreased with the use of enhanced TP and CD/R tools in en-route.* Whilst **CRT-18-W2-53B-V3-VALP-002-001b** addresses *Average Fuel consumption per flight is decreased with the use of enhanced TP and CD/R tools in TMA*. This was measured in EXE-008 and EXE-012.

4.4.2.1.1 TMA

EXE-008

EXE-008 applied two reference scenarios (Ref 1 and Ref 2) and three solution scenarios (Sol 1, Sol 2 and Sol 3). The exercise has been undertaken in the Sofia TMA, which is a Medium Complexity sub-OE. The solution scenarios demonstrate an improvement in the fuel burn and CO_2 emissions for the TMA sector in the Medium Complexity sub-OE. In fact, the fuel consumption improvement during the exercise ranges between 2.68% per flight, in solution scenario 1, and 3.17% per flight, in solution scenario 3. This corresponds to an improvement between 31kg/flight and 36kg/flight.



	Ref 1	Ref 2	Sol 1	Sol 2	Sol 3
Change (%)			0.00%	-2.68%	-3.17%
Fuel Consumption (kg)	1125	1220	1151	1121	1115

Figure 1: EXE-008 – Fuel Consumption (kg/flight) Average per aircraft in TMA

4.4.2.1.2 En-route

EXE-008

Compared to TMA, the results for Sofia en-route sector, classified as a High Complexity sub-OE, show negligible improvements. For en-route, the solution scenarios demonstrate a small decrease in the fuel consumption, ranging between 0.08% per flight in solution scenario 2 and 0.06% per flight in solution scenario 1, or between 2.3kg/flight and 1.6kg/flight. This can be explained with the free route set up and the real flight data used. The aircraft have been flying on their preferred trajectories and there were not many intermediate fixes in the en-route sectors. Therefore, there were not many DCT instructions which ultimately resulted in rather constant values for fuel consumption in the en-route sector.

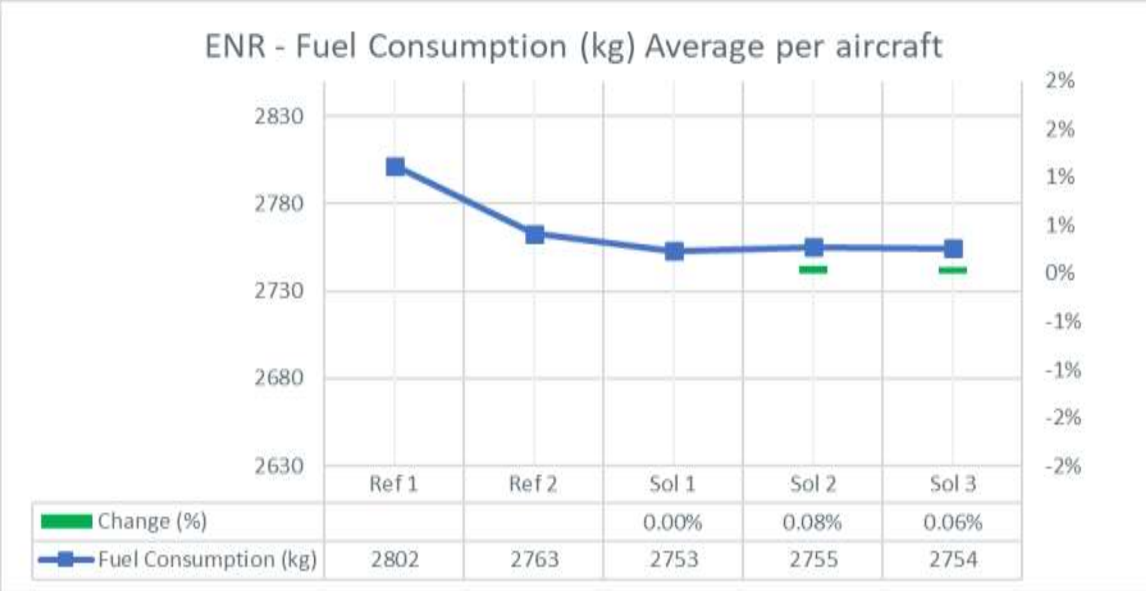


Figure 2: EXE-008 – Fuel Consumption (kg/flight) Average per aircraft in ENR

In future validations, more en-route sectors should be considered in order to get clear indication of the benefits that the tool brings regarding the fuel consumption. The success criterion is therefore considered partially satisfied.

EXE-012

EXE-012 is a shared exercise with Solution 56, which took place in Geneva and Zurich ACCs upper airspace, which are considered Very High Complexity sub-OE of en-route. The impact of Solution 53B on flight efficiency has been assessed using quantitative data (flight length measurement, adherence to optimised vertical optimized profiles) and qualitative data (ATCO assessments).

To summarise, there is no measured positive or negative impact regarding 2D efficiency from a quantitative perspective in the frame of this exercise (no clear trend). It must be noted that the traffic samples were set-up in a Free Route environment with optimised trajectories. This limited the impact of possible alterations of routes.

In parallel, 3D quantitative and qualitative gains are demonstrated with better flight profiles in climb, in cruise and descent, leading to potential fuel savings benefits.

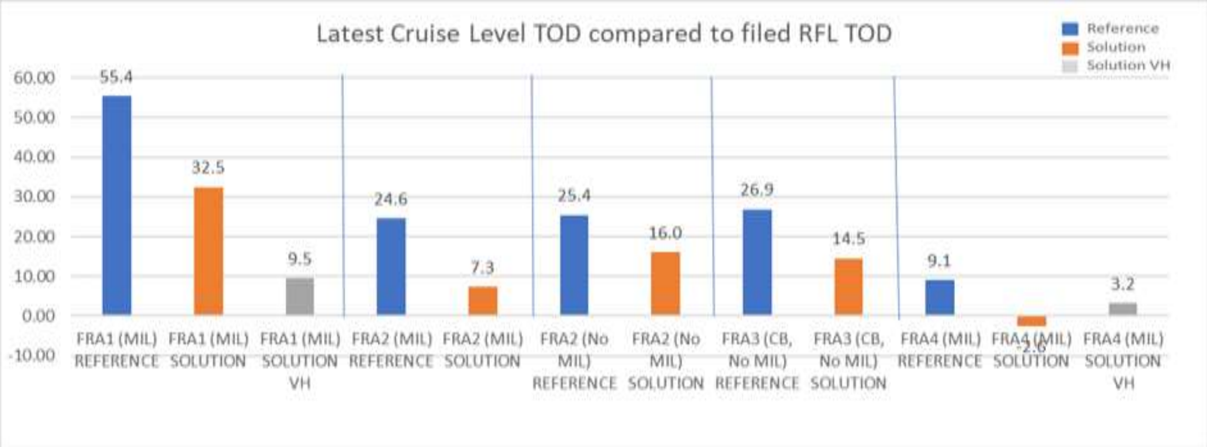


Figure 3: EXE-012 – 3D efficiency - Distance to destination airfield when starting descent from latest cleared cruise level (measured runs vs automated runs (ideal RFL TOD))

ATCOs therefore reported that the new solution tools contribute to a better flight efficiency. As such, the average fuel consumption per flight can be considered to be reduced with the use of enhanced TP and tools in en-route.

4.4.2.1.3 Summary

Exercise ID or Expert judgement	Benefits contribution to FEFF1 TMA	Benefits contribution to FEFF1 ENR
PJ.18-W2-53B-V3-EXE-008	2.68% (31kg/flight) – Solution scenario 1 3.17% (36kg/flight) – Solution scenario 3	0.28% (8kg/flight) – Solution scenario 2 and 0.37% (10kg/flight) – Solution scenario 1
PJ18-W2-53B-V3-EXE-012	N/A	No quantitative data

Table 12: Fuel efficiency benefits per Exercise

4.4.2.2 CO_2 emissions

Validation targets

No validation target has been set for ENV1.

Validation results

Fuel consumption has been assessed in **OBJ-18-W2-53B-V3-VALP-002** via the success criterion **CRT-18-W2-53B-V3-VALP-002-004a** – *The emission per flight is reduced with the use of enhanced TP and tools in en-route.* This KPI was measured in EXE-008 and EXE-012. While the TMA sector was addressed in **EX008-CRT-18-W2-53B-V3-VALP-002-004b** – *The emission per flight is reduced with the use of enhanced TP and CD/R tools in TMA.* This KPI was addressed in EXE-008 and EXE-012.

4.4.2.2.1 TMA

EXE-008

In EXE-008, there is a clear decrease in the emissions per flight in TMA. The fuel consumption, track distance (duration) and CO_2 emissions per flight are highly correlated. Thus, the results and rationale for emissions per flight are similar to the results for fuel consumption. For reference, please check criterion EX008-CRT-18-W2-53B-V3-VALP-002-001b.

The results show improvement in the CO_2 emissions per flight for TMA between 2.68% per flight in solution scenario 1 and 3.17% per flight in solution scenario 3, or an improvement between 100kg/flight and 118kg/flight.

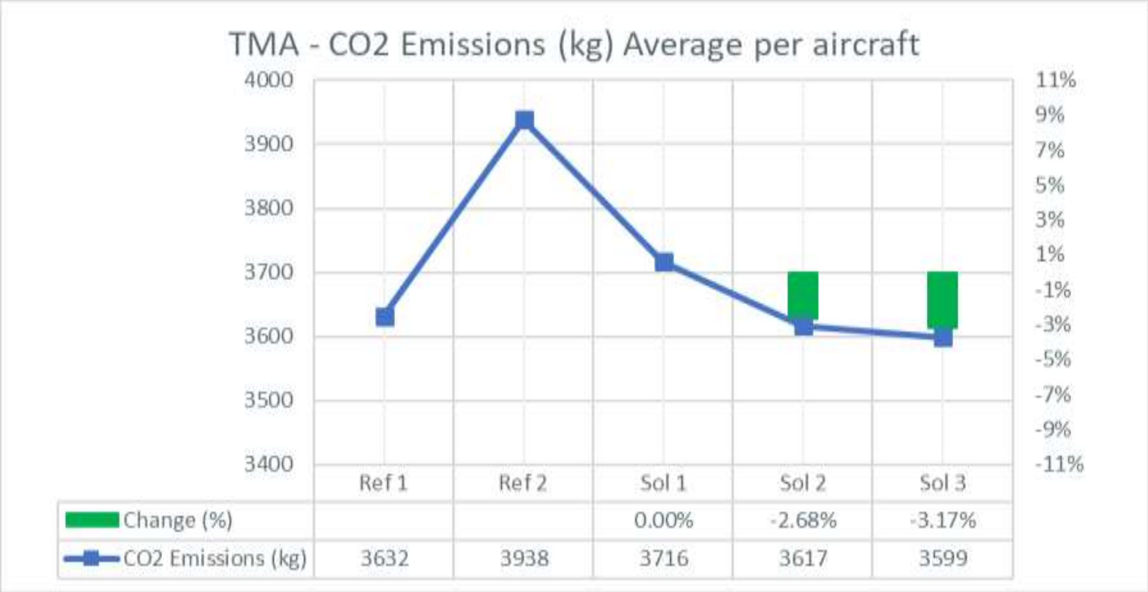


Figure 4: EXE-008 – CO2 emissions (kg/flight) Average per aircraft in TMA

4.4.2.2.2 En-route

EXE-008

EXE-008 demonstrates a small decrease of CO_2 emissions between 0.09% per flight, as per solution scenario 2, and 0.06% per flight, as per solution scenario 3, or an improvement between 7.7kg/flight and 5.4kg/flight. The results can be explained with the free route set up and the real flight data used. Thus, these values are negligible and do not present a clear trend line.

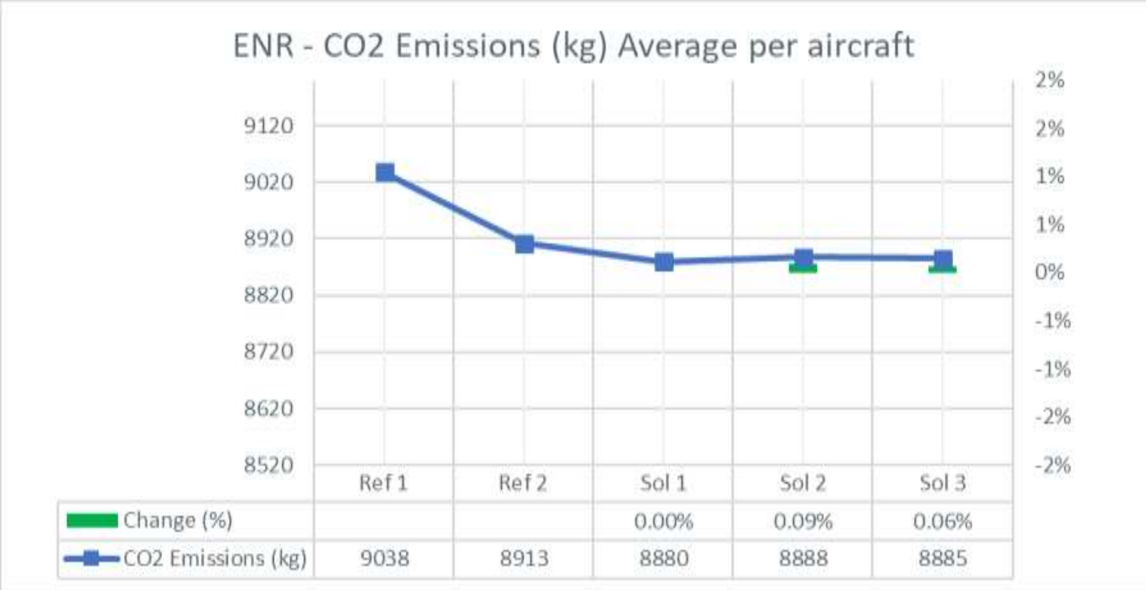


Figure 5: EXE-008 – CO_2 emissions (kg/flight) Average per aircraft in ENR

EXE-012

In EXE-012, CO_2 emissions have been computed as follows: Flight distance benefits are limited, the consequence on CO_2/NOx is also limited and linked to fuel saving, however, as for CRT-18-W2-53B-V3-VALP-002-001a the increase of the flight efficiency (optimal Flight Level more long time (until TOD), optimal descent from TOD, etc.), it is expected that the CO_2 emissions per flight are reduced with the use of enhanced TP and CD/R tools in en-route.

However, as there is no demonstrated positive or negative impact, the success criteria is considered partially achieved with no negative impact on validation objective. It has to be noted that the traffic samples were set-up in a Free Route Airspace environment with optimised trajectories. This limited the impact of possible alterations of routes.

4.4.2.2.3 Summary

Exercise ID or Expert judgement	Benefits contribution to ENV1 TMA	Benefits contribution to ENV1 ENR
PJ.18-W2-53B-V3-EXE-008	2.68% (100kg/flight) – Solution scenario 1 3.17% (118kg/flight) – Solution scenario 3	0.06% (5.4kg/flight) – Solution scenario 2 0.09% (7.7kg/flight) – Solution scenario 1 Negligible
PJ18-W2-53B-V3-EXE-012	N/A	No demonstrated impact

Table 13: CO_2 emissions benefits per Exercise

4.4.3 Extrapolation to ECAC wide

Whilst Solution 53B is applicable to all complexities (VHC, HC and MC), the extrapolation to ECAC level for FEFF1and ENV1 has been undertaken at Medium Complexity for TMA and High Complexity for en-route due to the data provided by the validation exercises. This does not exclude the possibility to extrapolate to all OEs. Additionally, we assume a 50% of equipage rate by 2035. As such, it is possible to expect higher benefits for both FEFF1 and ENV1.

4.4.3.1 Fuel efficiency

The extrapolation mechanism and applicable assumptions for TMA (see section 4.2 for details) are the following:

- Contribution to total TMA traffic in the specific sub-OE:
  - 41.85% (Very High Complexity)
  - 14.19% (High Complexity)
  - 32.21% (Medium Complexity)

The extrapolation of FEFF1 per Sub-OE is then as follows:

- MC TMA (kg): ((31kg+36kg)/2)*32.21% = 33.5 kg* 32.21% = 10.79kg (at ECAC level)

The extrapolation mechanism and applicable assumptions for en-route (see section 4.2 for details) are the following:

- Contribution to total ENR traffic in the specific sub-OE:
  - 31.33% (Very High Complexity)
  - 27.98% (High Complexity)
  - 37.89% (Medium Complexity)

The extrapolation of FEFF1 per Sub-OE is then as follows:

- HC ENR (kg): ((2.3kg+1.6kg)/2)*27.98% = 1.95 kg* 27.98% = 0.55 kg (at ECAC level)

To obtain the total benefit of FEFF1 of the Solution, the results of both en-route and TMA have been combined:

- Total (kg): 10.79 kg + 0.55 kg = 11.34 kg/flight

Therefore, 11.34 kg/flight is the final aggregated expected performance benefit for FEFF1 of Solution 53B, which represents 0.21% of the common assumption of average fuel burn per flight of 5280 kg.

4.4.3.2 CO_2 emissions

The extrapolation for CO_2 emissions follows the same approach and assumptions as for fuel efficiency.

Therefore, the extrapolation of ENV1 for the TMA Sub-OE is as follows:

- MC TMA (kg): ((100kg+118kg)/2)*32.21% = 109kg* 32.21% = 35.11 kg (at ECAC level)

Whereas the extrapolation of ENV1 for the en-route sub-OE is:

- HC ENR (kg): ((5.4kg+7.7kg)/2)*27.98% = 6.55kg* 27.98% = 1.83 kg (at ECAC level)

To obtain the total benefit of ENV1 of the Solution, the results of both en-route and TMA have been combined:

- Total (kg): 35.11kg + 1.83kg = 36.94kg/flight

The final aggregated results at ECAC level expected performance benefit for ENV1 of Solution 53B in SESAR2020 is 36.94kg/flight.

We obtain similar results also by applying the CO_2/fuel ratio:

- 36.94*3.15 = 35.70kg (at ECAC level)

4.4.3.3 Summary of extrapolation results

KPIs / PIs	Unit	Calculation	Mandatory	Absolute expected performance benefit in SESAR2020	% expected performance benefit in SESAR2020
FEFF1 Actual Average fuel burn per flight	Kg fuel per movement	Total amount of actual fuel burn divided by the number of movements	YES	11.34kg/flight	*0.21%*
ENV1 Actual Average CO2 Emission per flight	Kg CO2 per flight	Amount of fuel burnt x 3.15 (CO2 emission index) divided by the number of flights	YES	36.94kg/flight	*N/A*

Table 14: Fuel burn and CO_2 emissions saving for Mandatory KPIs /PIs

	Taxi out	TMA departure	En-route	TMA arrival	Taxi in
FEFF1 Actual Average fuel burn per flight	N/A	Not assessed	0.55kg of fuel savings	Not assessed	N/A
ENV1 Actual Average CO2 Emission per flight	N/A	Not assessed	1.83kg of CO2 savings	Not assessed	N/A

Table 15: Fuel burn and CO2 emissions saving per flight phase.

Results for TMA have not been included in Table 15 as no breakdown value for departure and arrival was provided.

4.4.4 Discussion of Assessment Result

The FEFF1 validation target for the total Solution is **12.56 kg/flight** (4.19kg-14.87 kg/flight).

For the combined TMA and en-route the assessed performance results is 11.34kg, which is in line with the assigned Validation Target being at the medium impact level (14.87kg-54.96kg). The target for FEFF1 has therefore been met.

Whilst Solution 53B is applicable to all complexities (VHC, HC and MC), the extrapolation to ECAC level for FEFF1 results have been undertaken only in the OEs in which the solution was validated (MC TMA and HC ENR). This does not exclude the possibility to extrapolate to all OEs. As such, it is possible to expect higher benefits for FEFF1.

4.4.5 Additional Comments and Notes

There are no additional comments.

4.5 Environment / Emissions, Noise and Local Air Quality

Solution PJ.18-W2-53B is not expected to impact these environment factors.

EUROPEAN PARTNERSHIP

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4.6 Airspace Capacity (Throughput / Airspace Volume & Time)

Airspace capacity, both for TMA and en-route, is increased due to the reduction of ATCO workload thanks to the introduction of EPP and MET data into TP and CD/R tools, which become optimized and more accurate.

4.6.1 Performance Mechanism

Airspace capacity is measured through two KPIs in this solution, CAP1 and CAP2. CAP1 measures TMA throughput, in challenging airspace, per unit time. Whereas CAP2 measures en-route throughput, in challenging airspace, per unit time.

For both en-route and TMA, the performance of the CD/R tool will be improved thanks to the introduction of EPP data and MET data into the TP and CD/R supporting tools. Consequently, these will be improved to solve conflicts by proposing improved solutions. By increasing the effectiveness of the conflict detection and resolution tool, there is a reduction of ATCO workload as the alerts and resolution proposals will be optimised and accurate. As a result, a reduction of ATCO workload will allow to further increase the number of flights per controller, increasing the airspace capacity.

4.6.2 Assessment Data (Exercises and Expectations)

Validation targets

The CAP1 Validation Target for the Solution is **3.77% (2.68%-4.86%).**

For CAP2, the Validation Target is **0.25% (0.13%-0.37%).**

Validation results

Airspace capacity has been assessed in **OBJ-18-W2-53B-V3-VALP-001**, in particular via the success criterion **CRT-18-W2-53B-V3-VALP-001-001** – *Airspace throughput is increased with the use of enhanced CD/R tools in en-route* as a result of the validation exercise design and results from situational awareness, workload and safety metrics. For CAP1, this was measured in EXE-008 for Medium Complexity, and for CAP2 this was measured in EXE-008, EXE-011 and EXE-012 for Very High and High Complexities.

Workload

As defined by the SESAR Performance Framework [3], **workload reduction** for both CAP1 and CAP2 is calculated as:

$$Increase\ in\ Airspace\ Capacity\ (\%) = \left(\frac{1}{\left(1 - \frac{Workload\ Reduction}{2}\right)} - 1\right) \times 100$$

The ISA scale rating was the chosen metric for workload reduction. During the exercise runs, each ATCO reported a rating between 1 (very low workload) and 5 (very high workload). The average of workload experienced in both Reference and Solution scenarios was then used for the calculation of the KPA results.

Traffic

The validation considers:

- 2019 traffic level, in order to assess the benefits of the Solution under validation by comparison with Reference scenario (same traffic samples),
- 2035-extrapolation traffic level (2035 being the Solution expected FOC date), which was the Solution scenario with increased traffic. It was used in order to better assess performance gains when the Solution would be widely deployed and to check that the Solution satisfies the needs (comparison Solution scenario 2019 vs. Solution scenario 2035).

The setup of the validation, the situational awareness, workload and separation infringement data indicate convincing results that we can expect meaningful capacity increase. A reduction of ATCO workload may increase the number of flights per controller, therefore increasing the airspace capacity.

4.6.2.1 TMA

EXE-008

This exercise was designed to assess the capacity objective by increasing the traffic level by 7.95% for a 30% EPP equipage rate (Sol 2) and by 9.04% for a 50% EPP equipage rate (Sol 3) compared to reference 1 scenario.

For TMA, the results of **EX008-CRT-18-W2-53B-V3-VALP-001-002** show that there is a clear improvement in the TMA ATCOs situational awareness and reduction of their workload in higher traffic level solutions while maintaining the same level of safety. **Therefore, we can conclude that the airspace capacity, with the use of the CD/R tool, in TMA is increased**.

The graph and table below show the results from ISA measurements for ATCOs:

Figure 6: EXE-008 – Instantaneous Self-Assessment (ISA)

There is 1% decrease in the workload of the TMA ATCOs when comparing Sol 1 to Ref 1. Respectively 18% reduction in Sol 2 compared to Ref 1 and 14 % decrease in Sol 3 compared to Ref 1. The spike in the last Sol 3 is due to relatively high values from one of the ATCOs in one of the runs played, compared to the feedback from the other TMA ATCOs in all Sol 3 runs. It is more an ATCO specific cause than general increase in the workload.

Results of WL reduction from ISA	
Sol1 – Ref1	1%
Sol2 – Ref1	18%
Sol3 – Ref1	13%
Sol1 – Ref2	10%
Sol2 – Ref2	26%
Sol3 – Ref2	21%

Table 16: EXE-008 – Results of workload reduction from ISA

Applying the equation used to calculate the TMA Airspace Capacity benefit through reduced controller workload, as defined in the SESAR Performance Framework, and using the average WL reduction per reference scenario, the CAP1 benefit obtained from EXE-008 is shown below.

Scenario	WL reduction TMA (%)	CAP1 benefit
	Calculated	*Calculated using Performance Framework formulae*
Ref 1 (2019 base traffic)	11.00%	5.82%
Ref 2 (2019 base traffic + 9.04% traffic increase)	18.70%	10.32%

Table 17: EXE-008 – Airspace Capacity (CAP1) benefits from WL reduction in TMA

When computing the deltas between reference scenarios and solution scenarios, the 9.04% traffic increase is not factored in the CAP1 benefits. As such, it is included for the final CAP1 benefit calculation:

Final CAP1 benefit	
Ref 1 (2019 base traffic)	5.82% +9.04%
Ref 2 (2019 base traffic + 9.04% traffic increase)	10.32%+9.04%
Average	**17.11%**

Table 18: EXE-008 – Final CAP1 benefits

Finally, the final CAP1 benefit resulting from EXE-008 performed for Sofia TMA, which is of Medium Complexity, is 17.11%.

4.6.2.2 En-route

EXE-008

The exercise focused on higher automation-level conflict detection and resolution tasks in pre-tactical and tactical-time horizon enabled by using improved TP. Traffic level is increased by 3.21% for a 30% EPP equipage rate (Sol 2) and by 5.11% for a 50% EPP equipage rate (Sol 3)

For en-route, the results of **EX008-CRT-18-W2-53B-V3-VALP-001-001** show that there is a clear improvement in the en-route ATCOs situational awareness and reduction of their workload in higher traffic level solutions while maintaining the same level of safety. Therefore, we can conclude that the airspace capacity, with the use of the CD/R tool, in en-route is increased.

The graph and table below show the results from ISA measurements for ATCOs:

Figure 7: EXE-008 – Instantaneous Self-Assessment (ISA)

The ISA results show that there is 7% increase in the workload for en-route ATCOs when comparing Sol 1 to Ref 1, 2% decrease between Sol 2 and Ref 1 and 3% increase comparing Sol 3 with Ref 1. More significant workload reduction can be observed when comparing Sol 1, 2 and 3 with Ref 2, where for the first time in the validation more traffic was introduced. Respectively the improvement in Sol 1 is 13%, in Sol 2 20% and Sol 3 16%. The reason for the increase in workload in Sol 3 compared to Sol 2 follows the same rationale as for the TMA.

Results of WL reduction from ISA[6]	
Sol1 – Ref1	-7%
Sol2 – Ref1	2%
Sol3 – Ref1	-3%
Sol1 – Ref2	13%
Sol2 – Ref2	20%
Sol3 – Ref2	16%

Table 19: EXE-008 – results of workload reduction from ISA

Applying the equation used for calculation of the en-route Airspace Capacity benefit through reduced controller workload, as defined in the SESAR Performance Framework, and using the average WL reduction per reference scenario, the CAP2 benefit obtained from EXE-008 is shown below.

Scenario	WL reduction ENR (%)	CAP2 benefit
	Calculated	*Calculated using Performance Framework formula*
Ref 1 (2019 base traffic)	-2.67%	-1.32%
Ref 2 (2019 base traffic + 5.11% traffic increase)	16.33%	8.89%

Table 20: EXE-008 Airspace Capacity (CAP2) benefits from WL reduction in ENR

When computing the deltas between reference scenarios and solution scenarios, the 5.11% traffic increase is not factored in the CAP1 benefits. As such, it is included in the final CAP2 benefit calculation:

Final CAP2 benefit	
Ref 1 (2019 base traffic)	-1.32% + 5.11%
Ref 2 (2019 base traffic + 5.11% traffic increase)	8.89% + 5.11%
Average	**8.90%**

Table 21: EXE-008 – Final CAP2 benefits

Finally, the final CAP2 benefit resulting from EXE-008 performed for Sofia en-route of High Complexity is 8.90%.

[6] Negative numbers show an increase in workload.

EXE-011

The exercise followed-up on the work undertaken in SESAR2020 Wave 1 PJ.10-02a2-V3-VALP-006, addressing three main threads: TP improvements, tactical separation tools improvements and CD/R tool improvements.

In this exercise, particularly **EX011-OBJ-18-W2-53B-V3-VALP-001,**questionnaires, debriefings and all workload measurements have been used to assess the impact in en-route. During the validation, in the opinion of ACTOs, the enhanced CD/R tools did not show usefulness nor a positive impact on airspace capacity. It might be related to a few false alerts that were observed during the exercises.

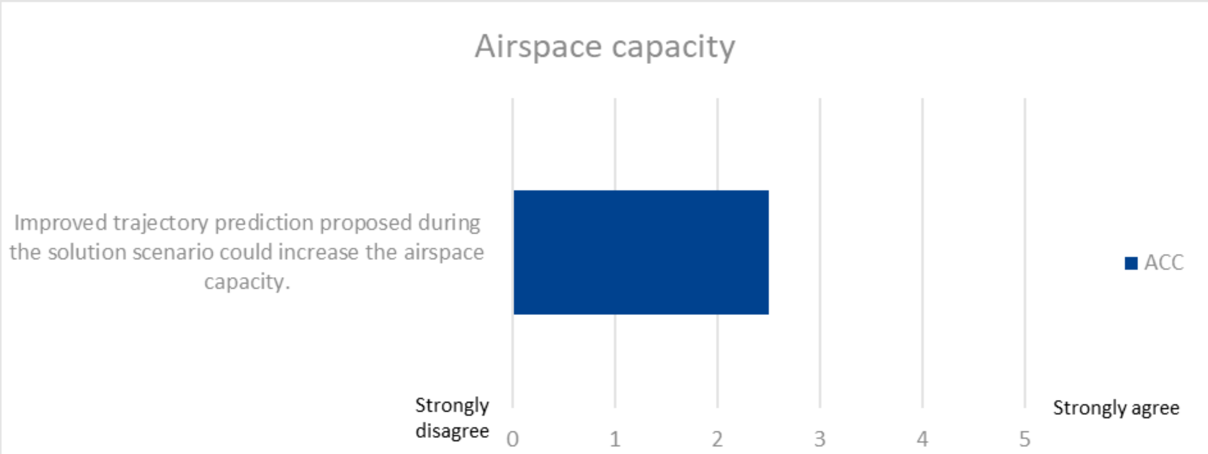

Figure 8: EXE-011 – Airspace capacity questionnaire results

Additionally, as airspace capacity is measured as function of workload, EX011-CRT-18-W2-53B-V3-HPAP-004-002 showed that **there is no significant change of workload predicted with the introduction of improved CD/R tools**. However, ATCOs noticed that EPP data might be operationally feasible and should be considered in the future CD/R tools improvements.

EXE-012

The exercise mainly measures the improvement in the TP tool in en-route thanks to the use of aircraft data (ADS-C EPP), improvement in CD/R from more accurate aircraft downlinked data and enhanced TP, and ATCO interaction and acceptability of the improved CD/R tools and HMI.

The exercise used two scenarios to assess performance: the reference scenario, with 2019 traffic level used as reference, and 2035-extrapolation traffic level to assess performance gains when the solution would be widely deployed. The result from 2035-extrapolation traffic level increase was a 10-15% traffic increase.

The following table shows the ISA measurements for both EC and PC ATCOs:

ATCO	**Validation scenario**	**ISA for FRA1**	**ISA for FRA2**	**ISA for FRA2 (No MIL)**	**ISA for FRA3**	**ISA for FRA4**	Average ISA score
EC+PC	Reference	2.6	2.4	2.9	2.9	2.7	**2.7**

	Solution	2.2	2.3	2.7	2.6	2.5	**2.46**

Table 22: EXE-012 – Workload self-assessment ratings – EC+PC

Due to the fact that workload reduction data were not available separately for EC, no quantitative impact on CAP2 stemming from workload reduction in EXE-012 has been assumed in calculation of final CAP2 benefits of EXE-012 and Solution 53B.

The ATCO workload reduction presented above, was based on the scenarios with a 2019 traffic demand. On top of these, other runs with 2035-extrapolation traffic levels were tested to better assess performance gains when the solution would be widely deployed and to check that this solution satisfies the needs (comparison solution scenario 2019 vs solution scenario 2035). With a 2035-extrapolation traffic demand, the workload is equivalent to ATCOs workload in reference runs. However, in these runs, number of controlled flights per ATCO and per peak hour increased by 10 to 15%.

As this validation exercise was common to Solutions PJ18.53 and PJ18.56, it has been asked to ATCOs to assess the ratio of Airspace Capacity gain per Solution. It is estimated that PJ18.56 Solution tools are the source of 80% of the gain whilst PJ18.53B Solution tools are the source of 20% of the gain.

Traffic		Average	Airspace Capacity increase (%), Sol 18.53B
Min	10%	12.5%	**2.50%**
Max	15%		

Table 23: Exe-012 – Airspace Capacity benefits from modelled traffic increase

The overview of CAP2 benefit stemming from EXE-012 performed for Geneva and Zurich ACCs of Very High Complexity is shown below:

Final CAP2 benefit	
From WL reduction	N/A
From traffic increase	2.50%
Average	**2.50%**

Table 24: EXE-012 – Final Airspace Capacity benefits

4.6.2.3 Summary

Exercise ID or Expert judgement	Benefits contribution to CAP1 (prior to extrapolation)	Benefits contribution to CAP2 (prior to extrapolation)
PJ.18-W2-53B-V3-EXE-008	17.11%	8.90%
PJ.18-W2-53B-V3-EXE-011	N/A	No quantitative results
PJ18-W2-53B-V3-EXE-012	N/A	2.50%

Table 25: Summary Airspace Capacity benefits per Exercise

OI step	Relative benefits contribution to CAP1	Relative benefits contribution to CAP2

CM-0209-B	0%	100%
CM-0212	100%	0%
TOTAL	100%	100%

Table 26: Airspace Capacity relative benefits per OI step

4.6.3 Extrapolation to ECAC wide

Whilst Solution 53B is applicable to all complexities (VHC, HC and MC), the extrapolation to ECAC level for CAP1 and CAP2 has been undertaken at Medium Complexity for TMA, and Very High Complexity and High Complexity for en-route due to the data provided by the validation exercises.

4.6.3.1 TMA

The extrapolation mechanism and applicable assumptions for TMA (see section 4.2 for details) are the following:

- Contribution to total TMA traffic in the specific sub-OE:
  - 41.85% (Very High Complexity)
  - 14.19% (High Complexity)
  - 32.21% (Medium Complexity)
- Contribution to total TMA traffic from peak traffic in the specific sub-OE:
  - 23.20% (Very High Complexity)
  - 12.19% (High Complexity)
  - 16.08% (Medium Complexity)

The extrapolation of CAP1 per Sub-OE is then as follows:

- MC TMA: 17.11% * 16.08% = 2.75% (at ECAC level)

2.75% (at ECAC level) is therefore the final aggregated expected performance benefit for CAP1 of the Solution 53B in SESAR2020.

4.6.3.2 En-route

The extrapolation mechanism and applicable assumptions for en-route (see section 4.2 for details) are the following:

- Contribution to total en-route traffic in the specific sub-OE:
  - 31.33% (Very High Complexity)
  - 27.98% (High Complexity)
  - 37.89% (Medium Complexity)
- Contribution to total en-route traffic from peak traffic in the specific sub-OE:
  - 12.61% (Very High Complexity)
  - 12.92% (High Complexity)
  - 18.96% (Medium Complexity)

The extrapolation of CAP2 per Sub-OE is then as follows:

- VHC ENR: 2.50% * 12.61% = 0.32% (at ECAC level)

- HC ENR: 8.90% * 12.92% = 1.15% (at ECAC level)

The final aggregated expected performance benefit for CAP2 of the Solution 53B in SESAR2020 is:

- **0.32% + 1. 15 % =1.46 % (at ECAC level)**

KPIs / PIs	Unit	Calculation	Mandatory	Absolute expected performance benefit in SESAR2020	% expected performance benefit in SESAR2020
CAP1 TMA throughput, in challenging airspace, per unit time	Relative change of movements (% and number of movement)	% and also total number of movements per volume of TMA airspace per hour for specific traffic mix and density, for High and Medium Complexity TMAs. TMA at peak demand hours.	YES	Not assessed	2.75% (ECAC level)
CAP2 En-route throughput, in challenging airspace, per unit time	Relative change of movements (% and number of movement)	% and also total number of movements, per volume of En-Route airspace per hour for specific traffic mix and density, for High and Medium Complexity TMAs. Airspace at peak demand hours.	YES	Not assessed	1.46% (ECAC level)

Table 27: Airspace benefits for Mandatory KPIs /PIs

4.6.4 Discussion of Assessment Result

For CAP1, the assessed performance results are 2.75%, which is in line with the assigned Validation Target being at the high impact level (2.68%-4.86%).

For CAP2, the assessed performance results are 1.46%, well above the assigned Validation Target being at medium impact level (0.13%-0.37%).

Whilst Solution 53B is applicable to all complexities (VHC, HC and MC), the extrapolation to ECAC level for CAP1 has been undertaken at Medium Complexity for TMA, whereas for CAP2 the results have been extrapolated at Very High and High Complexity. This is due to the data provided by the validation exercises and does not exclude the possibility to extrapolate to all OEs, where we expect higher benefits.

4.6.5 Additional Comments and Notes

No additional comments.

4.7 Airport Capacity (Runway Throughput Flights/Hour)

Solution PJ.18-W2-53B does not contribute to airport capacity benefits.

4.8 Resilience (% Loss of Airport & Airspace Capacity Avoided)

Solution PJ.18-W2-53B does not contribute to resilience benefits.

4.9 Flight Times

Solution 53B is expected to have impacts on flight times given that the flight time variability is reduced with the use of enhanced TP and CD/R tools in en-route. However, despite the targets being set, the validation does not demonstrate clear trends for flight times.

4.9.1 Performance Mechanism

Flight time in this solution is measured by the TEFF1 KPI under the SESAR Performance Framework 2019 [3]. TEFF1 measures the average of the distribution of actual gate-to-gate flight duration (min/flight) and is analysed in conjunction with FEFF1 (see section 4.4).

Flight time will be reduced as trajectory stability and adherence to flight plan are maintained by conflicts being solved earlier and flight plan adherence improving due to fewer trajectory changes from unnecessary interactions.

4.9.2 Assessment Data (Exercises and Expectations)

Validation targets

The TEFF1 Validation Target for the Solution is **0.12 min – 0.18 min.**

Validation results

The impact of enhanced CD/R tools using aircraft data on flight time has been assessed under **OBJ-18-W2-53B-V3-VALP-002**, in particular via the success criteria **CRT-18-W2-53B-V3-VALP-002-003a** – *The flight times variability is reduced with the use of enhanced TP and CD/R tools in en-route*. Whilst EXE-008 provides the track distance flown (NM), the success criterion **CRT-18-W2-53B-V3-VALP-002-003a** was not addressed by this exercise, therefore it has not been addressed in the assessment of flight times. Flight time has been assessed in EXE-008 and EXE-012.

4.9.2.1 TMA

EXE-008

Only EXE-008 addresses TEFF1 in TMA. In EXE-008, due to time limitations, only track distance was captured in the validation exercise log files. The validation exercise did not provide the duration in minutes to calculate TEFF1. However, the exercise leader has provided the results for TMA by converting the distance flown by the aircraft in different phases (en-route and TMA) in time, based on the average aircraft speeds that ATCOs used daily to build and execute their tactical plans.

EXE-008 concludes that there is a track distance improvement that ranges between 2.22% (3.3 NM) and 3.20% (4.8 NM), which corresponds to an average of 61 seconds (50 seconds and 72 seconds) according to expert judgement.

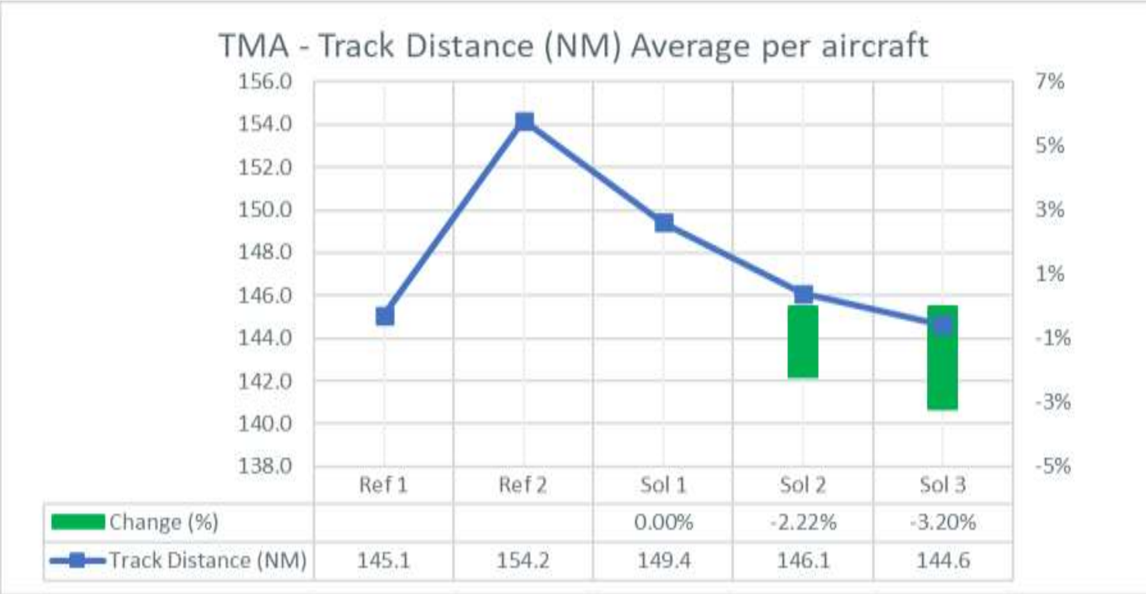

Figure 9: EXE-008 – Track Distance (NM) Average per aircraft in TMA

4.9.2.2 En-route

EXE-008

In EXE-008, due to time limitations, only track distance was captured in the validation exercise log files. However, the distance flown by the aircraft in different phases (en-route and TMA) can be easily converted in time, based on the average aircraft speeds that ATCOs used daily to build and execute their tactical plans.

For the Sofia en-route sector of High Complexity, the exercise shows a small increase of track distance (NM) 0.59% when comparing Sol 3 with Sol 1. The values are negligible and do not present a clear trend line (0%). With the free route set up and the real flight data used, the aircraft have been flying on their preferred trajectories and there were not many intermediate fixes in the en-route sectors. As a consequence, there were not many DCT instructions which ultimately resulted in rather constant values for track distance flown by the aircraft in the en-route sector.

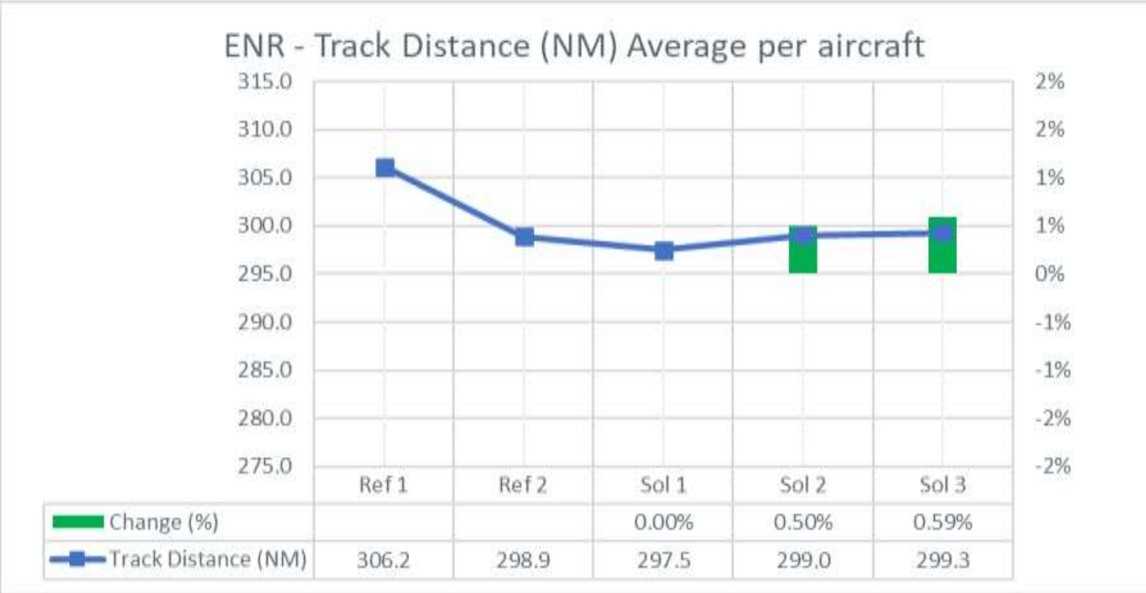

Figure 10: EXE-008 – Track Distance (NM) Average per aircraft

EXE-012

In EXE-012, with the use of enhanced TP and CD/R tools, flight optimal trajectory and profile are more easily facilitated and, therefore, the flight time is expected to be reduced. However, similar to previous criteria (CRT-18-W2-53B-V3-VALP-002-001a – CRT-18-W2-53B-V3-VALP-002-002a), it is difficult to draw true conclusion on the flight time variability in the measured sectors and due to the high level of traffic and complexity.

Thus, there is no clear trend identified during the assessment, no positive nor negative impact on flight duration in the frame of this exercise. It must be noted that the traffic samples were set-up in a Free Route environment with optimised trajectories. This limited the impact of possible alterations of routes.

4.9.2.3 Summary

Exercise ID or Expert judgement	Benefits contribution to TEFF1	Benefits contribution to TEFF2	Benefits contribution to TEFF3	Benefits contribution to TEFF4	Benefits contribution to TEFF5	Benefits contribution to TEFF6	Benefits contribution to EFF1
EXE-008	ENR: 0% TMA: 2.22% - Solution scenario 2 3.20 – Solution scenario 3 (Average of 61 seconds)						
EXE-012	No clear trends identified	N/A	N/A	N/A	N/A	N/A	N/A

	during assessment						

Table 28: Flight Times benefits per Exercise

OI step	Relative benefits contribution to TEFF1	Relative benefits contribution to TEFF2	Relative benefits contribution to TEFF3	Relative benefits contribution to TEFF4	Relative benefits contribution to TEFF5	Relative benefits contribution to TEFF6	Benefits contribution to EFF1
CM-0209-b	100%	N/A	N/A	N/A	N/A	N/A	N/A
CM-0212	0%	N/A	N/A	N/A	N/A	N/A	N/A
TOTAL	100%	N/A	N/A	N/A	N/A	N/A	N/A

Table 29: Flight Times relative benefits per OI step Extrapolation to ECAC wide

4.9.3 Extrapolation to ECAC wide

Given the benefits contribution results, the ECAC wide extrapolation was only undertaken for TMA.

The extrapolation mechanism and applicable assumptions for TMA (see section 4.2 for details) are the following:

- Contribution to total TMA traffic in the specific sub-OE:
  - 41.85% (Very High Complexity)
  - 14.19% (High Complexity)
  - 32.21% (Medium Complexity)

The extrapolation of TEFF1 per Sub-OE is then as follows:

- MC TMA (seconds): 61 * 32.21% = 19.65 seconds (at ECAC level) OR
- MC TMA (minutes): 19.65/60 = 0.33minutes

0.33 minutes are the final benefits for TEFF1, which represent 0.32% of the common assumption of flight time of 102 minutes.

KPIs / Pis	Unit	Calculation	Mandatory	Absolute expected performance benefit in SESAR2020	% expected performance benefit in SESAR2020
TEFF1 Gate-to gate flight time	Min/flight	Average of the distribution of actual gate-to-gate flight durations	YES	***0.33 minutes (19.65 seconds)***	***0.32***
TEFF2 Taxi in time	Min/flight	Average of the distribution of actual taxi-in (including ground queuing during taxi-in) durations	When relevant	*N/A*	*N/A*
TEFF3 Taxi out time	Min/flight	Average of the distribution of actual taxi-out (including ground queuing during taxi-out) durations	When relevant	*N/A*	*N/A*

KPIs / Pis	Unit	Calculation	Mandatory	Absolute expected performance benefit in SESAR2020	% expected performance benefit in SESAR2020
TEFF4 TMA arrival time	Min/flight	Average of the distribution of actual TMA arrival (including holdings) durations	When relevant	*N/A*	*N/A*
TEFF5[7] TMA departure time	Min/flight	Average of the distribution of actual TMA departure durations	When relevant	*N/A*	*N/A*
TEFF6 En-Route time	Min/flight	Average of the distribution of actual en-route durations	When relevant	*N/A*	*N/A*

Table 30: Flight Times benefits for Mandatory KPIs /Pis

Table 31 is showing the impact on flight phases (provided when it is possible).

	Taxi out	TMA departure	En-route	TMA arrival	Taxi in
TEFF1 Gate-to gate flight time	N/A	0.33 minutes	No clear trends identified during assessment	N/A	N/A
TEFF2 Taxi in time	N/A	N/A	N/A	N/A	N/A
TEFF3 Taxi out time	N/A	N/A	N/A	N/A	N/A
TEFF4 TMA arrival time	N/A	N/A	N/A	N/A	N/A
TEFF5 TMA departure time	N/A	N/A	N/A	N/A	N/A
TEFF6 En-Route time	N/A	N/A	N/A	N/A	N/A

Table 31: Flight times benefit per flight phase.

4.9.4 Discussion of Assessment Result

[7]Although no major time inefficiencies occur during climb, this phase has been included for consistency.

For TEFF1 the assessed performance results are 0.33 minutes, which is well above the assigned Validation Target for TEFF1 of 0.12 min – 0.18 min and represents 0.32% of the common assumption of flight time of 102 minutes.

Whilst Solution 53B is applicable to all complexities (VHC, HC and MC), the extrapolation to ECAC level for TEFF1 results have been undertaken only in the OEs in which the solution was validated (MC TMA). This does not exclude the possibility to extrapolate to all OEs. As such, it is possible to expect higher benefits for TEFF1.

4.9.5 Additional Comments and Notes

No additional comments.

4.10 Predictability

Solution 53B has a positive impact on predictability as the introduction of EPP data and MET data will improve CD/R tools. Due to fewer trajectory changes and early conflict resolution, the adherence to the flight plan is increased, thus improving predictability.

4.10.1 Performance Mechanism

Predictability in this solution is measured by the PRD1 KPI under the SESAR Performance Framework 2019 [3]. PRD1 measures the average of differences in actual and flight plan or RBT durations, while PRD2 measures the variance of difference in actual and flight plan or RBT durations. Both are expressed in minutes.

The performance of the CD/R tool will be improved thanks to the introduction of EPP data and MET data. As a consequence, the TP will be improved in order to solve tactical conflicts in the TMA and propose new and better solutions.

The application of the enhancements of the predictions due to the introduction of MET data is expected to improve the usability of the existing CD/R tools. The adherence to the Flight Plan is increased due to fewer trajectory changes as a consequence of unnecessary interactions. Hence, a more reliable and accurate trajectory prediction can lead to solve conflicts earlier, which can have a positive impact in predictability by reducing deviations from the planned profile.

4.10.2 Assessment Data (Exercises and Expectations)

Validation targets

The validation target for PRD1 is **0.14% (0%-0.28%).** The values below represent the targets per sub-OE:

- Very High Complexity TMA Sub-OE: 43.88% of total Solution target
- High Complexity TMA Sub-OE 21.58% of total Solution target
- Medium Complexity TMA Sub-OE 34.53% of total Solution target
- Low Complexity TMA Sub-OE N/A

- Very High Complexity ER Sub-OE: 48.98% of total Solution target
- High Complexity ER Sub-OE 27.55% of total Solution target
- Medium Complexity ER Sub-OE 23.47% of total Solution target
- Low Complexity ER Sub-OE N/A

No validation target has been set for PRD2.

Validation results

The impact of enhanced CD/R tools using aircraft data on predictability has been assessed using quantitative data (flight duration) and qualitative data (ATCOs assessment) under **OBJ-18-W2-53B-V3-VALP-002**, in particular via the success criteria **CRT-18-W2-53B-V3-VALP-002-002a** – *The flight duration with the use of enhanced TP and CD/R tools in en-route* and **CRT-18-W2-53B-V3-VALP-002-002b** – *The flight duration is reduced with the use of enhanced TP and CD/R tools in TMA.* EXE-012 addresses predictability.

Some relevant data that could be used for predictability has been provided by the exercise leader of EXE-008 in the context of time efficiency: EXE-008 concludes that there is a track distance improvement that ranges between 2.22% (3.3 NM) and 3.20% (4.8 NM), which corresponds to an average of 61 seconds (50 seconds and 72 seconds) according to expert judgement. However, in order not to double count the benefits results, the PRD1 benefits are not shown in this section, but are expected to be the same as TEFF1 (0.33minutes). With the data provided for Sol2 and Sol3, it is possible to compute the benefits of PRD2 for TMA which is of 242 seconds, or 4.03 minutes (0.03%). Whereas for en-route the PRD2 benefits have not been calculated as no data in minutes was provided.

EXE-012

In EXE-012, results do not show a clear trend regarding their impact of the solution on flight duration. Differences between solution and reference runs are really limited (few seconds) and results are sometimes better in solution runs and other times better in reference runs.

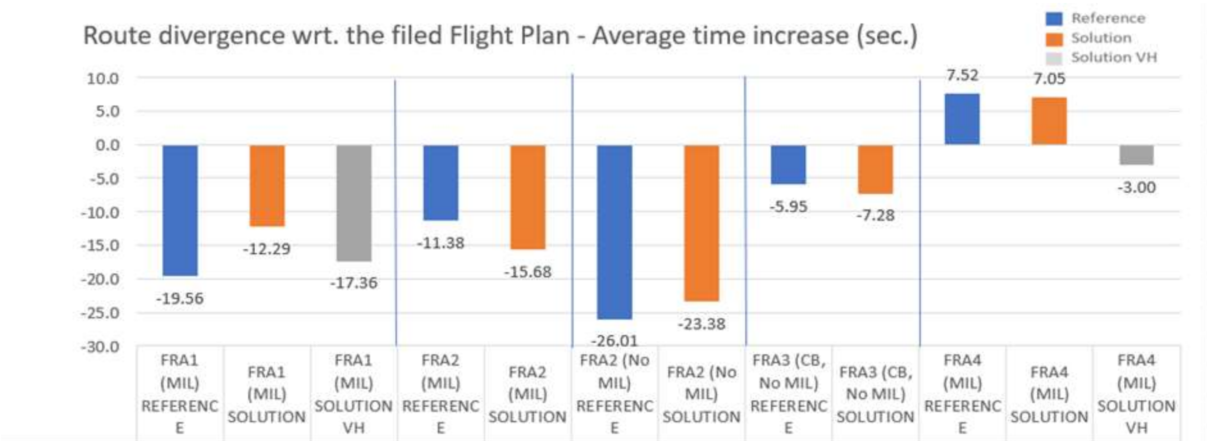

Figure 11: EXE-012 – Flight efficiency- average time increase

From a **quantitative** perspective, therefore, there is no clear trend on average and, when focusing on revised trajectories, results are alternatively better in solution and in reference runs, with very limited differences (less than 10 seconds). It must also be noted that there are no negative impacts either.

Qualitative benefits have been instead reported. In fact, the advanced knowledge of aircraft intentions and performances as well as the use of closed CPDLC clearances and automated discrepancy detection strongly contribute to better predictability.

During the debriefing sessions, ATCOs reported that the advanced knowledge of aircraft intentions and performance, as well as the use of closed CPDLC clearances and automated discrepancy detection, strongly contribute to improved predictability.

In a questionnaire regarding Flight Efficiency – impact of new tools on Predictability, the controllers were asked to rate the impact of improved knowledge of aircraft performance and intentions (enabled by better trajectory visualization and EPP reports) on Predictability. The impact of the use of ADS-C EPP data for Trajectory Prediction and CD/R Tools and the associated improved knowledge of aircraft performance and on Predictability are considered by ATCOs to be *very positive*.

This can be explained being able to anticipate the flights intent with better accuracy thanks to the better knowledge of aircraft performances. It also enables more optimal profiles of flights and therefore ensures a descent profile close to the optimal profile and in particular flights are initiating their descent much closer to the TOD. The flight duration in the measured sectors can then be a little increased.

4.10.2.1 Summary

Exercise ID or Expert judgement	Benefits contribution to PRD1	Benefits contribution to PRD2
EXE-008	ENR: 0%	ENR: N/A
	TMA : 2.22% - Solution scenario 2 3.20% – Solution scenario 3 (average of 61 seconds)	TMA: 0.03% or 4.03 minutes (242 seconds)
EXE-012	ENR: no clear quantitative results	N/A

Table 32: Predictability benefits per Exercise

OI step	Relative benefits contribution to PRD1	Relative benefits contribution to PRD2
CM-0209-b	0%	N/A
CM-212	100%	N/A
TOTAL	100%	N/A

Table 33: Predictability relative benefits per OI step

4.10.3 Extrapolation to ECAC wide

Given the lack of a clear trend, no ECAC wide extrapolation has been carried out for PRD1.

However, the extrapolation for PRD2 is as follow:

The extrapolation mechanism and applicable assumptions for TMA (see section 4.2 for details) are the following:

- Contribution to total TMA traffic in the specific sub-OE:
    - 41.85% (Very High Complexity)
    - 14.19% (High Complexity)
    - 32.21% (Medium Complexity)

The extrapolation of PRD2 per Sub-OE is as follows:

- MC TMA (%): 0.03%*32.21% = 0.01% (at ECAC level)
- MC TMA (seconds): 242*32.21% = 77.95 seconds (at ECAC level) OR
- MC TMA (minutes): 77.95/60 = 1.30 minutes

KPIs / Pis	Unit	Calculation	Mandatory	Absolute expected performance benefit in SESAR2020	% expected performance benefit in SESAR2020
PRD1 Average of Difference in actual & Flight Plan or RBT durations	Minutes	Average of the distribution of the differences between flown trajectories & Flight Plans or RBT durations	YES	Not assessed	Not assessed
PRD2 Variance[8] of Difference in actual & Flight Plan or RBT durations	$Minutes^2$	Variance of the distribution of the differences between flown trajectories & Flight Plans or RBT durations	YES	1.30 minutes (77.95 seconds)	0.01%

Table 34: Predictability benefits for Mandatory KPIs /Pis

4.10.4 Discussion of Assessment Result

In order not to double count the benefits results, the PRD1 benefits are not shown in this section, but are expected to be the same as TEFF1 (0.338 minutes). As such, no clear trend could be identified by the Solution validation exercises. The performance results therefore did not meet the assigned Validation Target for PRD1. For PRD2. The assessed performance results are 1.30 minutes (0.01%). No validation targets have been set for PRD2.

4.10.5 Additional Comments and Notes

No additional comments.

[8] Standard Deviation is also accepted (in minutes).

4.11 Punctuality

Solution PJ.18-W2-53B does not contribute to punctuality benefits.

4.12 Civil-Military Cooperation and Coordination (Distance and Fuel)

Solution PJ.18-W2-53B does not contribute to Civil-Military Cooperation and Coordination.

4.13 Flexibility

Solution PJ.18-W2-53B does not contribute to flexibility benefits.

4.14 Cost Efficiency

The Solution is expected to impact Cost Efficiency as improved trajectory prediction could increase airspace capacity via an improvement of ATCO productivity.

4.14.1 Performance Mechanism

The Cost Efficiency performance metric, CEF2, measures the ATCO Productivity improvement (%) by assessing the flights per ATCO-Hour on duty.

By increasing the effectiveness of the conflict detection tool, there will be a reduction of ATCO workload because the proposals will be optimised and accurate. The reduction of ATCO workload might improve ATCO productivity and thus possibly increasing the number of flights per ATCO hours on duty (G2G ANS Cost Efficiency).

To avoid double counting between CEF2 and CAP2 benefits, the ATCO Productivity gain **is only considered during non-peak hours.**

4.14.2 Assessment Data (Exercises and Expectations)

Validation target

The validation target for CEF2 is **0.98%-1.73%**. The values below represent the targets per sub-OE:

- Very High Complexity TMA Sub-OE 43.88% of total Solution target
- High Complexity TMA Sub-OE 21.58% of total Solution target
- Medium Complexity TMA Sub-OE 34.53% of total Solution target
- Low Complexity TMA Sub-OE N/A

- Very High Complexity ER Sub-OE 48.98% of total Solution target
- High Complexity ER Sub-OE 27.55% of total Solution target
- Medium Complexity ER Sub-OE 23.47% of total Solution target
- Low Complexity ER Sub-OE N/A

Validation results

The impact of enhanced CD/R tools using aircraft data on cost efficiency has been assessed using quantitative data (flight duration) and qualitative data (ATCOs assessment) under **OBJ-18-W2-53B-V3-VALP-003**, in particular via the success criteria CRT-18-W2-53B-V3-VALP-003-001– *To assess if the enhanced CD/R tools increase the number of controlled flights per controller in En-route* and EX008-OBJ-18-W2-53B-V3-VALP-003-002 – *To assess if the enhanced CD/R tools increase the number of controlled flights per controller in TMA*. It has been measured in EXE-008, EXE-011 and EXE-012 for Very High and High complexity environments.

Based on the expected increase in the capacity and the same number of sectors/ATCOs per different scenarios an improvement of the cost efficiency is expected. The same number of ATCOs can provide service to a larger number of aircraft.

Workload

The methodology in this section follows the approach taken to determine the change in Airspace Capacity. As defined in the SESAR Performance Framework [3], the following equation was used for calculation of a percentage increase in ATCO productivity through reduced controller workload:

$$Increase\ in\ ATCO\ productivity\ (\%) = \left(\frac{1}{\left(1 - 0.75 \times \frac{Workload\ reduction}{2}\right)} - 1 \right) \times 100$$

The ISA scale rating was the chosen metric for workload reduction. During the exercise runs, each ATCO reported a rating between 1 (very low workload) and 5 (very high workload). The average of workload experienced in both Reference and Solution scenarios was then used for the calculation of the KPA results.

4.14.2.1 TMA

EXE-008

The validation exercise includes Sofia's TMA sector of Medium Complexity and, based on the positive results for situational awareness, workload and safety, when 9.04% more traffic is introduced, we can conclude that one ATCO can control higher number of aircraft with the use of the CD/R tool.

The graph and table below show the results from ISA measurements for ATCOs:

Figure 12: EXE-008 – Instantaneous Self-Assessment (ISA)

As mentioned in the CAP1 section, there is 1% decrease in the workload of the TMA ATCOs when comparing Sol 1 to Ref 1. Respectively 18% reduction in Sol 2 compared to Ref 1 and 14 % decrease in Sol 3 compared to Ref 1. The spike in the last Sol 3 is due to relatively high values from one of the ATCOs in one of the runs played, compared to the feedback from the other TMA ATCOs in all Sol 3 runs. It is more an ATCO specific cause than general increase in the workload.

Results of WL reduction from ISA	
Sol1 – Ref1	1%
Sol2 – Ref1	18%
Sol3 – Ref1	13%
Sol1 – Ref2	10%
Sol2 – Ref2	26%
Sol3 – Ref2	21%

Table 35: EXE-008 – Results of workload reduction from ISA

Applying the equation used for calculating the TMA Cost Efficiency benefit through reduced controller workload, as defined in the SESAR Performance Framework, and using the average WL reduction per reference scenario, the CEF2 benefit for TMA obtained from EXE-008 is shown below.

Scenario	WL reduction TMA (%)	CEF2 benefit
	Calculated	*Calculated using Performance Framework formulae*
Ref 1 (2019 base traffic)	11.00%	4.30%
Ref 2 (2019 base traffic + 10% traffic increase)	18.70%	7.54%

Table 36: EXE-008 – Cost Efficiency (CEF2) benefits from WL reduction in TMA

When computing the deltas between reference scenarios and solution scenarios, the 9.04% traffic increase is not factored in the CEF2 benefits. As such, it is included for the final CEF2 benefit calculation:

Final CEF2 benefit in TMA	
Ref 1 (2019 base traffic)	4.30%+9.04%
Ref 2 (2019 base traffic + 9.04% traffic increase)	7.54% + 9.04%
Average	**14.96%**

Table 37: EXE-008 – Final CEF2 benefits TMA

Finally, the final CEF2 benefit resulting from EXE-008 performed for Sofia TMA of Medium Complexity is 14.96%.

4.14.2.2 En-route

EXE-008

The validation exercise includes Sofia's en-route sector, of High Complexity, and based on the positive results for situational awareness, workload and safety, when 5.11% more traffic is introduced, we can conclude that one ATCO can control higher number of aircraft with the use of the CD/R tool.

The graph and table below show the results from ISA measurements for ATCOs:

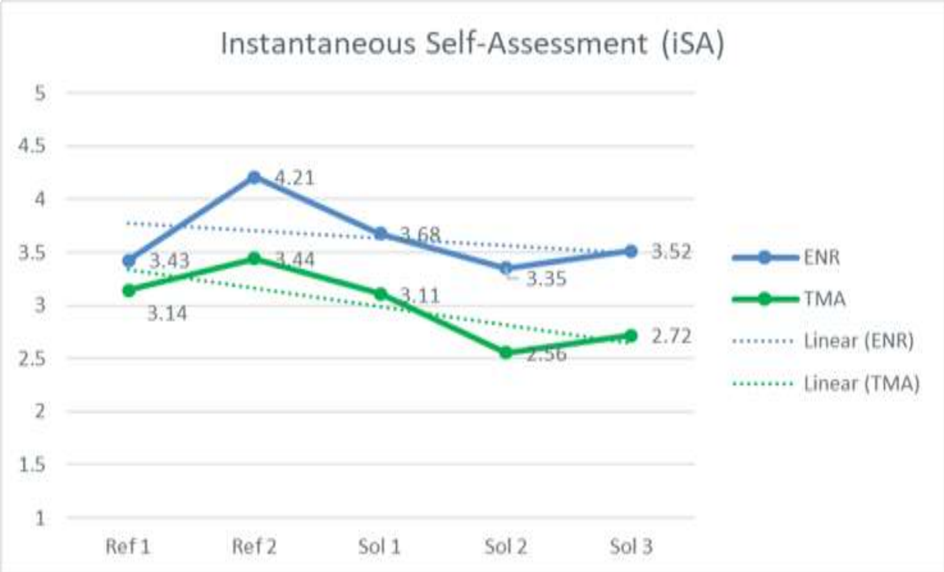

Figure 13: EXE-008 – Instantaneous Self-Assessment (ISA)

Applying the equation used for calculation of the en-route Cost Efficiency benefit through reduced controller workload, as defined in the SESAR Performance Framework, and using the average WL reduction per reference scenario, the CEF2 benefit for en-route obtained from EXE-008 is shown below.

Scenario	WL reduction ENR (%)	CEF2 benefit
	Calculated	*Calculated using Performance Framework formulae*
Ref 1 (2019 base traffic)	-2.67%	-0.99%
Ref 2 (2019 base traffic + 5.11% traffic increase)	16.33%	6.52%

Table 38: EXE-008 – Cost Efficiency (CEF2) benefits from WL reduction in ENR

When computing the deltas between reference scenarios and solution scenarios, the inherent 10% traffic increase is not factored in the CEF2 benefits. As such, it is included for the final CEF2 benefit calculation:

Final CEF2 benefit in ENR	
Ref 1 (2019 base traffic)	-0.99%+5.11%
Ref 2 (2019 base traffic + 5.11% traffic increase)	6.52% + 5.11%

Average	**7.88%**

Table 39: EXE-008 – Final CEF2 benefits ENR

Finally, the final CEF2 benefit resulting from EXE-008 performed for Sofia TMA of Medium Complexity is 7.88%.

EXE-011

In this validation exercise, ACC controllers had difficulties finding the use of the enhanced CD/R tools useful at the current stage. Depending on the run, one ACC EP during the reference scenario and one ACC PC during the solution scenario found the tool to be neutral while the for the other ATCOs the tool did not show usefulness during validation. Limited trust in the tools may be related to technical issues with the platform that are described in the Unexpected Behaviours section of the VALR [21]. During both reference and solution scenarios, a few false alerts were observed that decreased ATCO’s trust.

However, during the debriefing ATCOs state that EPP data might be operationally feasible and should be considered in CD/R tools. In the future, the enhanced CD/R tools that are fed with real aircraft data might increase the effort of ATCO, that in turn might increase the airspace capacity.

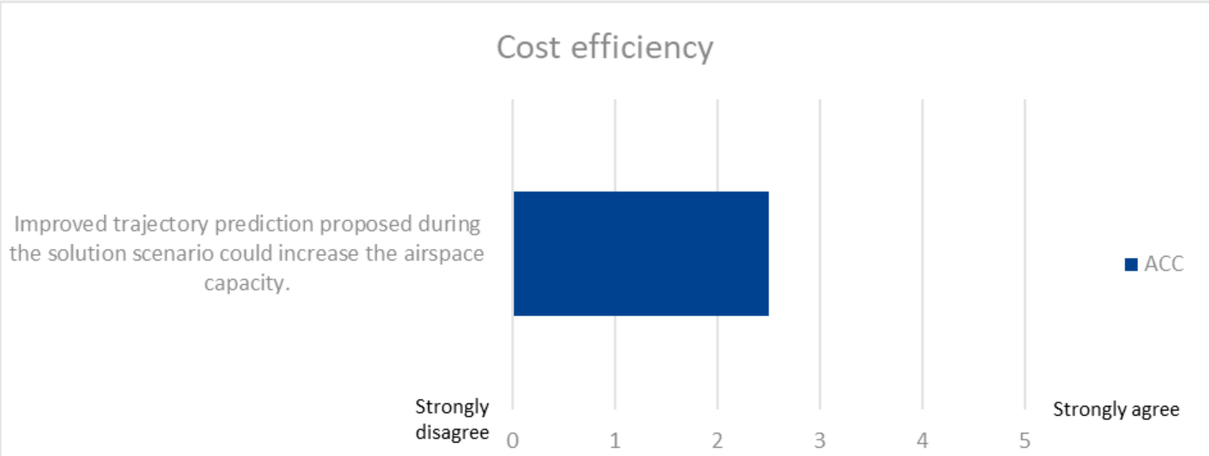

Figure 14: EXE-011 – Cost-efficiency questionnaire results

EXE-012

The enhanced tools increase the number of controlled flights per controller in en-route in this exercise, based on Geneva and Zurich’s ACCs of Very High Complexity, where the expected traffic level/complexity at horizon 2035 airspace capacity is manageable (based on 2035-extrapolation scenario traffic load).

The exercise mainly addresses the measuring the improvement in TP tool in en-route thanks to more aircraft data, improvement in CD/R thanks to more accurate aircraft downlinked data and enhanced TP, and ATCO interaction and acceptability of the improved CD/R tools and HMI.

The exercise used two scenarios to assess performance: the reference scenario, with 2019 traffic level used as reference, and 2035-extrapolation traffic level to assess performance gains when the solution would be widely deployed. The result from 2035-extrapolation traffic level increase was a 10-15% traffic increase.

The following graph shows the ISA measurements for both EC and PC ATCOs:

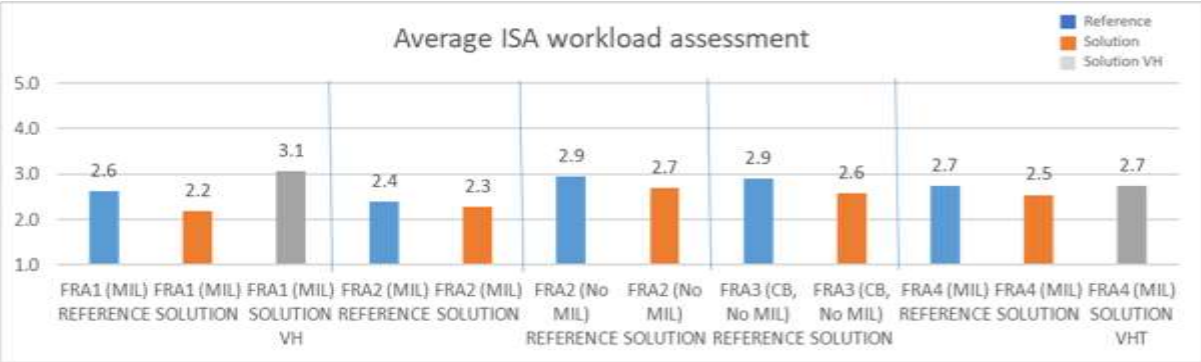

Figure 15: EXE-012 – Workload self-assessment

As defined in the SESAR Performance Framework, the equation for the calculation of ATCO productivity benefit is applied and the CEF2 benefit from EXE-012 obtained is the following:

ATCO	Baseline ISA	Solution ISA	WL reduction (%)	CEF2 benefit
	Input from EXE		*Calculated*	*Calculated using Performance Framework formulae*
EC + PC	2.70	2.46	8.89%	3.45%
			Sol 18.53 + 56	3.45%
			Sol 18.53B (23%)	**0.69%**

Table 40: EXE-012 - Cost efficiency (CEF2) benefits from WL reduction in ENR

As this validation exercise was common to Solutions PJ18.53 and PJ18.56, it ATCOs were asked to assess the ratio of Airspace Capacity gain per Solution. It is estimated that PJ18.53B Solution tools are the source of 20% of the gain (0.69%).

4.14.2.3 Summary

Exercise ID or Expert judgement	Benefits contribution to CEF2	Benefits contribution to CEF3	Benefits contribution to CEF1
PJ.18-W2-53B-V3-EXE-008	14.96% in TMA 7.88% in ENR	N/A	N/A
PJ.18-W2-53B-V3-EXE-011	No quantitative data	N/A	N/A
PJ.18-W2-53B-V3-EXE-012	0.69% in ENR	N/A	N/A

Table 41: Cost Efficiency benefit per Exercise

OI step	Relative benefits contribution to CEF2	Relative benefits contribution to CEF3	Relative benefits contribution to CEF1
CM-0209-b	50%	N/A	N/A
CM-212	50%	N/A	N/A
TOTAL	100%	0%	0%

Table 42: Cost Efficiency relative benefit per OI step

4.14.3 Extrapolation to ECAC wide

4.14.3.1 TMA

The extrapolation mechanism and applicable assumptions for TMA (see section 4.2 for details) are the following:

- Contribution to total TMA traffic in the specific sub-OE:
  - 41.85% (Very High Complexity)
  - 14.19% (High Complexity)
  - 32.21% (Medium Complexity)
- Contribution to total TMA traffic from peak traffic in the specific sub-OE:
  - 23.20% (Very High Complexity)
  - 12.19% (High Complexity)
  - 16.08% (Medium Complexity)
- Contribution to total TMA traffic from off-peak traffic in the specific sub-OE (calculation):
  - 41.85% - 23.20% = 18.65% (Very High Complexity)
  - 14.19% - 12.19% = 2.00% (High Complexity)
  - 32.21% - 16.08% = 16.13% (Medium Complexity)

The extrapolation of CEF2 in TMA per Sub-OE is then as follows:

- MC TMA: 14.96% * 16.13% = 2.41% (at ECAC level)

The final aggregated expected performance benefit for CEF2 in TMA for Solution 53B in SESAR2020 is 2.41% (at ECAC level).

4.14.3.2 En-route

The extrapolation mechanism and applicable assumptions for TMA (see section 4.2 for details) are the following:

- Contribution to total en-route traffic in the specific sub-OE:
  - 31.33% (Very High Complexity)
  - 27.98% (High Complexity)
  - 37.89% (Medium Complexity)
- Contribution to total ER traffic from peak traffic in the specific sub-OE:
  - 12.61% (Very High Complexity)
  - 12.92% (High Complexity)
  - 18.96% (Medium Complexity)
- Contribution to total ER traffic from off-peak traffic in the specific sub-OE (*calculation*):
  - 31.33% - 12.61% = 18.72% (Very High Complexity)
  - 27.98% - 12.92% = 15.06% (High Complexity)
  - 37.89% - 18.96% = 18.93% (Medium Complexity)

The extrapolation of CEF2 in en-route per Sub-OE is then as follows:

- VHC ER: 0.69% * 18.72% = 0.13% (at ECAC level)
- HC ER: 7.88% * 15.06% = 1.19% (at ECAC level)

The final expected performance benefit for CEF2 en-route is:

- 0.13% + 1.19% = 1.32% (at ECAC level)

The final aggregated expected performance benefit for CEF2 in en-route for Solution 53B in SESAR2020 is 1.32% (at ECAC level)

KPIs / Pis	Unit	Calculation	Mandatory	Absolute expected performance benefit in SESAR2020	% expected performance benefit in SESAR2020
CEF2[9] Flights per ATCO-Hour on duty	No	Count of Flights handled divided by the number of ATCO-Hours applied by ATCOs on duty.	YES	Not assessed	TMA: 2.41%ENR: 1.32%
CEF3 Technology cost per flight	EUR / flight	G2G ANS cost changes related to technology and equipment.	YES	N/A	N/A
CEF1 Direct ANS Gate-to-gate cost per flight	EUR / flight	Derived by PJ19, taking into account results for the other two KPIs as contributing factors.	Yes but derived from the other two KPIs above	*N/A*	*N/A*

Table 43: Cost Efficiency benefit for Mandatory KPIs /Pis

4.14.4 Discussion of Assessment Result

The assessed performance results for TMA is of 2.41% which is well above the Validation Target for CEF2 being at the highest impact level **(0.98%-1.73)**, while for en-route the benefit is of 1.32%%, which is in line with the Validation Target for CEF2 being at the highest impact level **(0.98%-1.73).**

4.14.5 Additional Comments and Notes

No additional comments.

[9] The benefits are determined by converting workload reduction to a productivity improvement, and then scale it to peak traffic in the applicable sub-OE category. It has to be peak traffic because there must be demand for the additional capacity (note that in this case the assumption is that the additional capacity is used for additional traffic).

4.15 Airspace User Cost Efficiency

Solution PJ.18-W2-53B does not contribute to Airspace User Cost Efficiency benefits.

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4.16 Security

Solution PJ.18-W2-53B does not contribute to security benefits. In addition, PJ.18-W2 Solutions have not performed formal security assessments.

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4.17 Human Performance

4.17.1 HP arguments, activities and metrics

The Human Performance (HP) assessment activities aimed to ensure that HP aspects related to SESAR technical and operational developments are systematically identified and managed. The assessment comprised of all five V3 validation exercises as they all cover the Human Performance aspects.

The HP activities conducted for Solution 53B were:

1. Initial Safety and HP scoping workshop;
2. Safety and HP metrics and indicators workshop;
3. Real Time Simulations (EXE-008, EXE-009, EXE-011, EXE-012) ;
4. HP results and requirements consolidation workshop.

The results collected have been used to draft recommendations and requirements to mitigate the identified issues or to ensure the identified benefits. For a detailed description of the HP results of the validation, please refer to the HP Assessment Report, Part IV of the OSED [23].

The HP assessment made use of HP arguments, which are used to help identify and capture changes to ATM actors' work and also screen and scope the HP assessment. They are essentially claims that need to be proven by the HP assessment. From the changes that would result from the introduction of the operational concept, it is identified that the following eight V3 level HP arguments need to be considered by the HP assessment.

Hence the arguments to be considered by the HP assessment process are:

- Argument 1.2: Operating methods (procedures) are exhaustive and support human performance.
- Argument 1.3: Human actors can achieve their tasks (in normal & abnormal conditions of the operational environment and degraded modes of operation).
- Argument 2.1: There is appropriate allocation of tasks between the human and the machine.
- Argument 2.2: The performance of the technical system supports the human in carrying out their tasks.
- Argument 2.3: The design of the HMI supports the human in carrying out their tasks.
- Argument 3.3: The communication between team members supports human performance.
- Argument 4.1: The proposed solution is acceptable to affected human actors.
- Argument 4.3: Staffing requirements & staffing levels.

The HP arguments are summarised in the table below in the form of four main HP performance indicators. In case at least one of the second level indicators have been covered per PI, that PI is considered to have been satisfied at the level of the Solution.

Pis	Activities & Metrics	Second level indicators	Covered
HP1		**HP1.1** Clarity and completeness of role and responsibilities of human actors	**N/A**

Pis	Activities & Metrics	Second level indicators	Covered
Consistency of human role with respect to human capabilities and limitations	Real Time Simulation, stakeholder workshop	**HP1.2** Adequacy of operating methods (procedures) in supporting human performance	**Open**
		HP1.3 Capability of human actors to achieve their tasks in a timely manner, with limited error rate and acceptable workload level	**Closed**
HP2 Suitability of technical system in supporting the tasks of human actors	Real Time Simulation	**HP2.1** Adequacy of allocation of tasks between the human and the machine (i.e. level of automation).	**Closed**
		HP2.2 Adequacy of technical systems in supporting Human Performance with respect to timeliness of system responses and accuracy of information provided	**Closed**
		HP2.3 Adequacy of the human machine interface in supporting the human in carrying out their tasks.	**Closed**
HP3 Adequacy of team structure and team communication in supporting the human actors	Real Time Simulation	**HP3.1** Adequacy of team composition in terms of identified roles	**N/A**
		HP3.2 Adequacy of task allocation among human actors	**N/A**
		HP3.3 Adequacy of team communication with regard to information type, technical enablers and impact on situation awareness/workload	**Closed**
HP4 Feasibility with regard to HP-related transition factors	Real Time Simulation	**HP4.1** User acceptability of the proposed solution	**Closed**
		HP4.2 Feasibility in relation to changes in competence requirements	**N/A**
		HP4.3 Feasibility in relation to changes in staffing levels, shift organization and workforce relocation.	**Closed**
		HP4.4 Feasibility in relation to changes in recruitment and selection requirements .	**N/A**
		HP4.5 Feasibility in terms of changes in training needs with regard to its contents, duration and modality.	**N/A**

Table 44: HP arguments, activities and metrics

4.17.2 Extrapolation to ECAC wide

There is no ECAC wide extrapolation required for this KPI. However, the six validation exercises performed in PJ18-W2-53B covered significant part of ECAC area, focusing on both en-route and TMA

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with Very High, High and Medium complexity. There is no apparent element which would prevent the extrapolation of the assessed Human Performance results from the achieved validation exercises to all the applicable TMA and en-route sub-operating environments.

4.17.3 Open HP issues/ recommendations and requirements

The table below is a summary of the number of HP issues that are still open and HP benefits identified following the Solution validation exercise, as well as number of recommendations and requirements defined. For the detailed description, please consult the HP Plan/HP Log and the HP Assessment Report, Part IV of the OSED [23].

Pis	Number of open issues/ benefits	Nr. Of recommendations	Number of requirements
HP1 Consistency of human role with respect to human capabilities and limitations	**1 (out of 10)**	**8**	**1**
HP2 Suitability of technical system in supporting the tasks of human actors	**0 (out of 10)**		**0**
HP3 Adequacy of team structure and team communication in supporting the human actors	**0 (out of 1)**		**0**
HP4 Feasibility with regard to HP-related transition factors	**0 (out of 2)**		**0**

Table 45: Open HP issues/ recommendations and requirements

4.17.4 Concept interaction

Solution 53B interacts with the following other SESAR2020 Solutions:

- PJ.18-W2-53A: Increased Automation in Planning and Tactical Separation ManagementPJ.18-W2-56: Air/Ground Trajectory Synchronisation via Lateral and Vertical Complex CPDLC Clearances to Support TBO.

Solution 53A sees enhanced assistance provided by CD/R for planning and tactical controllers and provides enhanced resolution support information based upon predicted conflict detection and associated monitoring features. It also provides additional trajectory prediction based on ADS-C and known constraints, and introduces machine learning and big data techniques to provide more accurate estimates. Controllers are assisted in their separation tasks by technical functionalities which use advanced data to improve the services provided.

Solution 56 explores the deployment of complex CPDLC clearances sent in advance of the lateral and vertical trajectory changes in order to enhance the synchronisation of the airborne trajectory with the ground trajectory. These new procedures are to be supported by data link standards (ATN B1 and B2), increased automation (e.g., ATC system proposing a CPDLC clearance) and enhanced 2D/3D conformance monitoring through the use of ADS-C EPP information.

4.17.5 Most important HP issues

The table below lists any important issues that might have a major impact on the performance of the Solution.

Pis	Most important issue of the solution	Most important issues due to solution interdependencies
HP1 Consistency of human role with respect to human capabilities and limitations	The operating methods for normal operating conditions for new functionality/ies of the CD&R tool need to be clear and consistent.	**N/A**
HP2 Suitability of technical system in supporting the tasks of human actors	The task allocation between the human and the machine brought by the introduction of CD&R tools is consistent with automation principles improving human performance in terms of controllers' productivity. It is also important that the user interface supports specific needs of controllers' tasks.	**N/A**
HP3 Adequacy of team structure and team communication in supporting the human actors	Due to availability of the CD&R tools for both EC and PC, it is expected that team situational awareness will increase.	**N/A**
HP4 Feasibility with regard to HP-related transition factors	It is expected that the benefits brought by the usage of the CD&R support tool will have a positive affective response of the controllers.	**N/A**

Table 46: Most important HP issues

4.17.6 Additional Comments and Notes

No additional comments.

4.18 Other PIs

Solution PJ.18-W2-53B is not expected to impact other Performance Indicators.

Gap Analysis

The gap analysis shows the comparison between the validation targets and the performance assessment. The table below summarises the comparison.

KPI	Validation Targets – Network Level (ECAC Wide)	Performance Benefits at Network Level (ECAC Wide or Local depending on the KPI)[10]	Rationale
SAF1: Safety – Total number of estimated accidents with ATM Contribution per year	Safety Neutral with Traffic increase (SNwT)	Safety Neutral with Traffic increase (SNwT)	In line with target.
FEFF1: Fuel Efficiency – Actual average fuel burn per flight	4.19kg-14.87 kg/flight	11.34kg/flight	In line with target.
CAP1: TMA Airspace Capacity - TMA throughput, in challenging airspace, per unit time.	High	2.75%	In line with the target of 2.68%-4.86%.
CAP2: En-Route Airspace Capacity - En-route throughput, in challenging airspace, per unit time	Medium	1.46%	Well above assigned target of 0.13%-0.37%.
CAP3: Airport Capacity – Peak Runway Throughput (Mixed mode).	N/A	N/A	N/A
TEFF1: Gate-to-gate flight time	High	0.33 minutes	Well above the assigned target of 0.12 min – 0.18 min.
PRD1: Predictability – Average of Difference	N/A	No trends	No benefits have been assessed as no clear trend

[10] Negative impacts are indicated in red.

in actual & Flight Plan or RBT durations			could be identified by the Solution validations.
PUN1: Punctuality – Average departure delay per flight	N/A	N/A	N/A
CEF2: ATCO Productivity – Flights per ATCO -Hour on duty	High	TMA: 2.41% ENR: 1.32%	TMA is well above the targets of 0.98%-1.73%, while ENR is in line with the targets.
CEF3: Technology Cost – Cost per flight	N/A	N/A	N/A

Table 47: Gap analysis Summary

Whilst Solution 53B is applicable to all complexities (VHC, HC and MC), the extrapolation to ECAC level for all results have been undertaken only in the OEs in which the solution was validated. This does not exclude the possibility to extrapolate to all OEs. As such, it is possible to expect higher benefits for each KPI.

5 References

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

[1] 08.01.03 D47: AIRM v4.1.0

[2] B05 Performance Assessment Methodology for Step 1 PJ19.04.01 Methodology for Performance Assessment Results Consolidation (2020)[11]

[3] SESAR Performance Framework (2019), Edition 01.00.01, Dec 2019

https://stellar.sesarju.eu/?link=true&domainName=saas&redirectUrl=%2Fjsp%2Fproject%2Fproject.jsp%3FobjId%3Dxrn%3Adatabase%3Aondb%2Frecord%2F16414675

[4] Performance Assessment and Gap Analysis Report (2019), Edition 00.01.02, Dec 2019

[5] Methodology for the Performance Planning and Master Plan Maintenance, Edition 0.13, Dec 2017

Content Integration

[6] SESAR ATM Lexicon

Performance Management

[7] PJ19.04 D4.1 Validation Targets - Wave 2 (2020)[12]

Validation

[8] European Operational Concept Validation Methodology (E-OCVM) - 3.0 [February 2010]

Safety

[9] SESAR, Safety Reference Material, Edition 4.0, April 2016

https://stellar.sesarju.eu/jsp/project/qproject.jsp?objId=1795089.13&resetHistory=true&statInfo=Ogp&domainName=saas

[10]SESAR, Guidance to Apply the Safety Reference Material, Edition 3.0, April 2016

https://stellar.sesarju.eu/jsp/project/qproject.jsp?objId=1795102.13&resetHistory=true&statInfo=Ogp&domainName=saas

[11]SESAR, Final Guidance Material to Execute Proof of Concept, Ed00.04.00, August 2015

[11] At the time of the creation of the PAR template, the Methodology (PJ19.04 Internal Document) is foreseen to be update in 2020.

[12] At the time of the creation of the PAR template the Validation Target is foreseen to be delivered in June 2020

[12]Accident Incident Models – AIM, release 2017

https://stellar.sesarju.eu/servlet/dl/ShowDocumentContent?doc_id=3658775.13&att=attachment&statEvent=Download

Human Performance

[13]16.06.05 D 27 HP Reference Material D27

[14]16.04.02 D04 e-HP Repository - Release note

Environment Assessment

[15]SESAR, Environment Assessment Process (2019), PJ19.4.2, Deliverable D4.0.080, Sep 2019.

https://stellar.sesarju.eu/servlet/dl/DownloadServlet?downloadKey=xrn%3Adatabase%3Aondb%2Frecord%2F14665451&resuming=true&zip=true&disposition=attachment&domainName=saas&domainName=saas

[16]ICAO CAEP – "Guidance on Environmental Assessment of Proposed Air Traffic Management Operational Changes" document, Doc 10031.

https://www.icao.int/publications/pages/publication.aspx?docnum=10031

Security

[17]16.06.02 D103 SESAR Security Ref Material Level

[18]16.06.02 D137 Minimum Set of Security Controls (MSSCs).

[19]16.06.02 D131 Security Database Application (CTRL_S)

Other documents

[20] SESAR Solution 53B SPR-INTEROP/OSED for V3 - Part I - ed 01_00_00

[21] SESAR Solution 53B VALR for V3 ed 01_01_00

[22] SESAR Solution 53B SPR-INTEROP/OSED for V3 – Part II – SAR ed 01_00_00

[23] SESAR Solution 53B SPR-INTEROP/OSED for V3 - Part IV - HPAR ed 01_00_00

Appendix A Detailed Description and Issues of the OI Steps

OI Step ID	Title	Consistency with latest Dataset
CM-0209-b	Improved Separation Management with the use of Aircraft Data in Conflict Detection and Resolution Tools in en-route Predefined and User Preferred Routes environments.	DS-22
CM-0212	Improved Separation Management with the use of Aircraft Data in Conflict Detection and Resolution Tools in the TMA.	DS-22

Table 48: OI Steps allocated to the Solution