

D1.5 - PJ.37-W3-DEMOR - Part V Performance Assessment Report, Track PJ.37-W3-01A

Deliverable ID:	D1.5
Dissemination Level:	PU
Project Acronym:	PJ37-W3-ITARO
Grant:	101017622
Call:	H2020-SESAR-2020-02
Topic:	SESAR-WAVE3-05-2020, SESAR-WAVE3-06-2020
Consortium coordinator:	NLR (AT-One)
Edition date:	25 May 2023
Edition:	01.00.00
Template Edition:	01.00.09

Authoring & Approval

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Rejected By – Representatives of beneficiaries involved in the project

Beneficiary	Date
None	

Document History

Edition	Date	Status	Beneficiary	Justification
00.00.01	04/07/2022	Draft	NLR (AT-One)	Initial population of document
00.00.02	02/02/2023	Draft	NLR (AT-One)	Update with RTS2 findings
00.00.03	17/02/2023	Draft	NLR (AT-One)	Updated edition number to align with Part I. No

				further changes. Version for internal review.
00.00.04	20/03/2023	Final Draft	NLR (AT-One)	Review comments addressed. Version for approval by project manager and PJ37 beneficiaries.
00.01.00	23/03/2023	Final	NLR (AT-One)	Approved version for delivery to S3JU.
00.02.00	17/05/2023	Final	NLR (AT-One)	No changes. Only aligned edition number with Part I.
01.00.00	25/05/2023	Approved	NLR (AT-One)	Approved by S3JU

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PJ37-W3-ITARO

INTEGRATED TMA, AIRPORT AND RUNWAY OPERATIONS

This Demonstration Report (DEMOR Part V – PAR) is part of a project that has received funding from the SESAR3 Joint Undertaking under grant agreement No 101017622 under European Union’s Horizon 2020 research and innovation programme.



Abstract

The present document constitutes Part V of the Demonstration Report (DEMOR), belonging to contractual deliverable (D1.5), of the SESAR2020 project PJ37-W3-ITARO. It overviews the results of the various exercises dealing with the Performance Assessment Report aspects of the integrated solutions addressed by ITARO. This project carries out ‘VLD-like’ exercise activities that focus on the integration of different SESAR solutions and (pre-) deployment items, already validated to high Technological Readiness Levels (TRLs) individually, but being combined and applied for the first time in an operational environment. This first-step integration cannot be performed directly in a real life ATC environment hence requires an integrated Real Time Simulation (RTS) step first, thereby explaining the ‘VLD-like’ in its IA-naming.

This DEMOR Part covers two exercises performed as part of the PJ.37-W3-01A solution track, relating to two Real Time Simulations (Arrival RTS1 and Arrival RTS2) performed by the NLR. NLR also performed a flight trial, however the flight trial findings are not included in this report as the objectives were aimed to assess the flight interval management system.

This report provides a synthesis of the research objectives that relate to KPIs described in the SESAR Performance Framework, as described in the Demonstration Plan. As the simulation runs performed in the RTS focused on the integration of the previously validated SESAR solutions, various scenarios to test the robustness of the integrated solution have been performed. This results in a limited number runs to extrapolate the potential impact to the ECAC region. Hence the assessment is mainly on local level.

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1 Executive Summary

This document provides the Performance Assessment Report (PAR) for SESAR2020 PJ37-W3-ITARO (Integrated TMA Airport and Runway Operations).

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

PJ.37-W3-01A ITARO Arrivals Solution track

- Two RTS exercises relate to the integration of RNP-based arrival and approach operations, Interval Management (IM), Continuous Descent Operations (CDOs). These exercises include furthermore the Optimised Runway Delivery (ORD) tool, RECAT-EU-Pairwise Separations (PWS) and Runway Occupancy Time (ROT) related separation impact. CDO and IM are generally initiated outside the TMA, CDOs preferably at the Top of Descent. Hence the further unification of arrival management will need an extended horizon, i.e., Extended-AMAN tool adaptation. Consequently, a precise delivery of aircraft into the terminal airspace is part of the exercises. In particular, controller aspects (e.g., Controller Working Position (CWP) HMI, working procedures, workload, acceptance) and ATC tool-integration will be looked at during both RTSs, as well as assessing the impact on the environment. The work combines the SESAR Solutions PJ.01-05, PJ.02-01-01, PJ.02-01-04, PJ.02-08.03 with CDOs and RNP-based operations, and the overall aim is to achieve the maturity level TRL7 ongoing for the Solutions PJ.02-01-01, PJ.02-01-04 and PJ.02.08-03.
- The previous mentioned RTSs are supported by a real-life flight demonstration that will combine Interval Management, Continuous Descent Operations and RNP-based TMA operations, in preferably a high-density TMA, but mainly addressed from the cockpit perspective. The work combines the SESAR Solution PJ.01-05 with CDOs and RNP-based operations, and the overall aim is to achieve the V3 ongoing maturity level for PJ.01-05.

No Validation Targets have been allocated to this solution track by PJ.19 and, therefore, the most relevant KPIs for the solution track have been identified and reported against.

More Information can be found in Chapter 2!

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 [8]. The impact of a Demo on the performances are described in Benefit Impact Mechanism. All the KPI and mandatory PI from the Benefit Mechanism where the Demo potentially impact have to be assessed via demonstration results, expert judgment etc.

There are three cases:

1. An assessment result of 0 with confidence level other level High, Medium or Low indicates that the Demo 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 Demo 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 Demo 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	NA	NA	NA, accident assessment requires Dynamic Risk Modelling
FEFF1: Fuel Efficiency - Actual average fuel burn per flight	NA	ECAC/Network wide: 5.5 kg saving per flight. 6.7% on local level for peak arrivals in the TMA for large and very large airports.	Low
CAP1: TMA Airspace Capacity - TMA throughput, in challenging airspace, per unit time.	NA	Traffic load in simulation was increased by 7.5%, however solution was not stressed to maximum traffic load (local).	Low
CAP2: En-Route Airspace Capacity - En-route throughput, in challenging airspace, per unit time	NA	NA	NA, en-route outside of scope
CAP3: Airport Capacity – Peak Runway Throughput	NA	NA	NA, no mixed mode operation in simulation. PI CAP3.2 is evaluated.

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

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
(Mixed mode).			
TEFF1: Gate-to-gate flight time	NA	NA	NA, ground ops outside of scope
PRD1: Predictability – Average of Difference in actual & Flight Plan or RBT durations	NA	In the order of seconds (local)	Low
PUN1: Punctuality – Average departure delay per flight	NA	NA	NA, focus on arrivals
CEF2: ATCO Productivity – Flights per ATCO -Hour on duty	NA	NA	NA, ATCO productivity not quantified
CEF3: Technology Cost – Cost per flight	NA	NA	NA, not evaluated

Table 1: KPI Assessment Results Summary

Mandatory PI	Performance Expectations at Network Level (ECAC Wide or Local depending on the KPI) ³	Confidence in Results ⁴
SAF1.X: Mid-air collision - En-Route	NA	NA, en-route outside of scope
SAF2.X: Mid-air collision - TMA	0%	Low

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

Mandatory PI	Performance Expectations at Network Level (ECAC Wide or Local depending on the KPI) ³	Benefits at Network Level	Confidence in Results ⁴
SAF3.X: RWY-collision accident	NA		NA, ground ops outside of scope
SAF4.X: TWY-collision accident	NA		NA, ground ops outside of scope
SAF5.X: CFIT accident	NA		NA, not ATM related hence out of scope
SAF6.X: Wake related accident	0%		Low
SAF7.X: RWY-excursion accident	NA		NA, ground ops outside of scope
SAF8.X ...: Other SAF Risks	NA		NA, no other SAF PIs evaluated
SEC1: A security risk assessment has been carried out	NA		NA, no security assessment performed
SEC2: Risk Treatment has been carried out	NA		NA, no security assessment performed
SEC3: Residual risk after treatment meets security objective.	NA		NA, no security assessment performed
ENV1: Actual Average CO2 Emission per flight	ECAC/Network wide: 17.3 kg CO2 saving per flight		Low
NOI1: Relative noise scale	NA		NA, only 1 PI evaluated
NOI2: Size and location of noise contours	Less than 1% decrease (local)		Low
NOI4: Number of people exposed to noise levels exceeding a given threshold	NA		NA, noise analysis performed using absolute noise levels
LAQ1: Geographic distribution of pollutant concentrations	NA		NA, no assessment of LAQ
CAP3.1: Peak Departure throughput per hour (Segregated mode)	NA		NA, focus on arrivals
CAP3.2: Peak Arrival throughput per hour (segregated mode)	Traffic load in simulation was increased by 7.5%, however solution was not stressed to maximum traffic load (local).		Low

Mandatory PI	Performance Expectations at Network Level (ECAC Wide or Local depending on the KPI) ³	Benefits at Network	Confidence in Results ⁴
CAP4: Un-accommodated traffic reduction	NA		NA
RES1: Loss of Airport Capacity Avoided	NA		NA
RES1.1: Airport time to recover from non-nominal to nominal condition	NA		NA
RES2: Loss of Airspace Capacity Avoided.	NA		NA
RES2.1: Airspace time to recover from non-nominal to nominal condition.	NA		NA
RES4: Minutes of delays.	NA		NA
RES5: Number of cancellations.	NA		NA
TEFF2: Taxi in time	NA		NA, ground ops outside scope
TEFF3: Taxi out time	NA		NA, ground ops outside scope
TEFF4: TMA arrival time	NA		NA, scripted
TEFF5: TMA departure time	NA		NA, focus on arrivals
TEFF6: En-Route time	NA		NA, en-route outside scope
PRD2: Variance of Difference in actual & Flight Plan or RBT durations	Order of 0.5 mins for 50% of the traffic (TMA arrival part)		Low
PUN2: % Flights departing within +/- 3 minutes of scheduled departure time due to ATM and weather related delay causes	NA		NA, focus on arrivals
CEF1: Direct ANS Gate-to-gate cost per flight	NA		NA, ground ops outside scope
AUC3: Direct operating costs for an airspace user	NA		NA
AUC4: Indirect operating costs for an airspace user	NA		NA
AUC5: Overhead costs for an airspace user	NA		NA
CMC1.1: Allocated vs. Requested ARES duration	NA		NA, outside scope
CMC1.2: Allocated vs. Requested ARES dimension	NA		NA, outside scope

Mandatory PI	Performance Expectations at Network Level (ECAC Wide or Local depending on the KPI) ³	Benefits at Network Level	Confidence in Results ⁴
CMC1.3: Deviation of Transit Time to/from airbase to ARES	NA		NA, outside scope
CMC 1.3.1: Allocated ARES duration vs. total mission duration	NA		NA, outside scope
CMC 1.3.2: Deviation of total mission duration by iOAT FPL validation	NA		NA, outside scope
CMC 1.4.1: Rate of iOAT FPLs acceptance by NM systems	NA		NA, outside scope
CMC 1.4.2: Rate of iOAT FPLs acceptance by ATC systems	NA		NA, outside scope
CMC2.1: Fuel and Distance saved by GAT	NA		NA, outside scope
HP1: Consistency of human role with respect to human capabilities and limitations	16 recommendations (8 closed), 4 open issues/benefits (local)		Medium
HP2: Suitability of technical system in supporting the tasks of human actors	4 recommendations (3 closed), 1 open issue/benefit (local)		Medium
HP3: Adequacy of team structure and team communication in supporting the human actors	NA		NA
HP4: Feasibility with regard to HP-related transition factors	NA		NA
FLX1: Average delay for scheduled civil/military flights with change request and non-scheduled or late flight plan request	NA		NA, outside scope

Table 2 Mandatory PIs Assessment Summary

Additional Comments and Notes:

No other PIs evaluated.

2 Introduction

2.1 Purpose of the document

The Performance Assessment covers the Key Performance Areas (KPA) 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 Demo. 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 demonstration exercises at SESAR Demo 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 demonstration exercises results have been consolidated) used to achieve this performance assessment result.

2.2 Intended readership

The intended readers of this document are the PJ.37 team members working on the demonstration exercises, PJ.37 management, and the SESAR3 Joint Undertaking.

2.3 Inputs from other projects

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

- PAGAR 2019 [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.

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

2.4 Glossary of terms

See the AIRM Glossary [1] [7] for a comprehensive glossary of terms.

2.5 Acronyms and Terminology

Term	Definition
ANS	Air Navigation Service
ANSP	Air Navigation Service Provider
ATFM	Air Traffic Flow Management
ATM	Air Traffic Management
BAD	Benefits Assessment Date
BAER	Benefit Assessment Equipment Rate
CBA	Cost Benefit Analysis
DOD	Detailed Operational Description
E-ATMS	European Air Traffic Management System
ECAC	European Civil Aviation Conference
DB	Deployment Baseline
KPA	Key Performance Area
KPI	Key Performance Indicator
N/A	Not Applicable
OI	Operational Improvement
PAR	Performance Assessment Report
PI	Performance Indicator
PRU	Performance Review Unit

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Term	Definition
QoS	Quality of Service
RBT	Reference Business / Mission Trajectory
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.

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)) whereas 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

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
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

Term	Definition	Source
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
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

Term	Definition	Source
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
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

Term	Definition	Source
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
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

Term	Definition	Source
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 Demo Scope

3.1 Detailed Description of the Demo

The PJ37-W3-ITARO project consist of three solution tracks, of which solution track PJ.37-W3-01 is divided into an A-part and B-part.

- Solution track PJ.37-W3-01A: Integrated Runway Throughput and Terminal Efficiency (VLD-like) - Arrival & Approach Operations
- Solution track PJ.37-W3-01B: Integrated Runway Throughput and Terminal Efficiency (VLD-like) – Departure Operations
- Solution-track PJ.37-W3-02: Complement of PJ.07-W2-39 Collaborative framework managing delay constraints on arrivals.
- Solution-track PJ.37-W3-03: Complement of PJ.01-W2-08B Dynamic E-TMA for Advanced Continuous Climb and Descent Operations

Solution track PJ.37-W3-02 and PJ.37-W3-03 are complementary to other SESAR projects, and thus these projects provide the associated Performance Assessment Report. Solution track PJ.37-W3-01 contains four different demonstration exercises. An overview of the PJ.37-W3-01 solution track , solutions, exercises, and coupling to external SESAR H2020 Wave 2 projects is provided in Table 5. The sections hereafter address the PJ.37-W3-01A - Arrival Operations.

Work Package (WP)	Solution to be validated	Exercise ID	Description	Ol's to be validated in exercise
WP02	PJ.37-W3-01A	EXE-PJ.37-W3-001	NLR real time simulation 1 for the integrated arrival management process solution, for the Schiphol TMA operations .	AO-0306 (S-PWS) AO-0328 (ORD) AO-0337 (ROT) TS-0108 (FIM)
		EXE-PJ.37-W3-002	NLR real time simulation 2 for the integrated arrival management process solution, for the Schiphol TMA operations .	AO-0306 (S-PWS) AO-0328 (ORD) AO-0337 (ROT) TS-0108 (FIM)
		EXE-PJ.37-W3-003	NLR flight trial to demonstrate interval management, combined with CDO and FAR	TS-0108 (FIM)
	PJ.37-W3-01B	EXE-PJ.37-W3-004	NATS real time simulation for the integrated departure management process solution	AO-0329 (OSD)

Table 5: PJ.37 exercises overview including relevant solutions per exercise.

Demonstration activity purpose

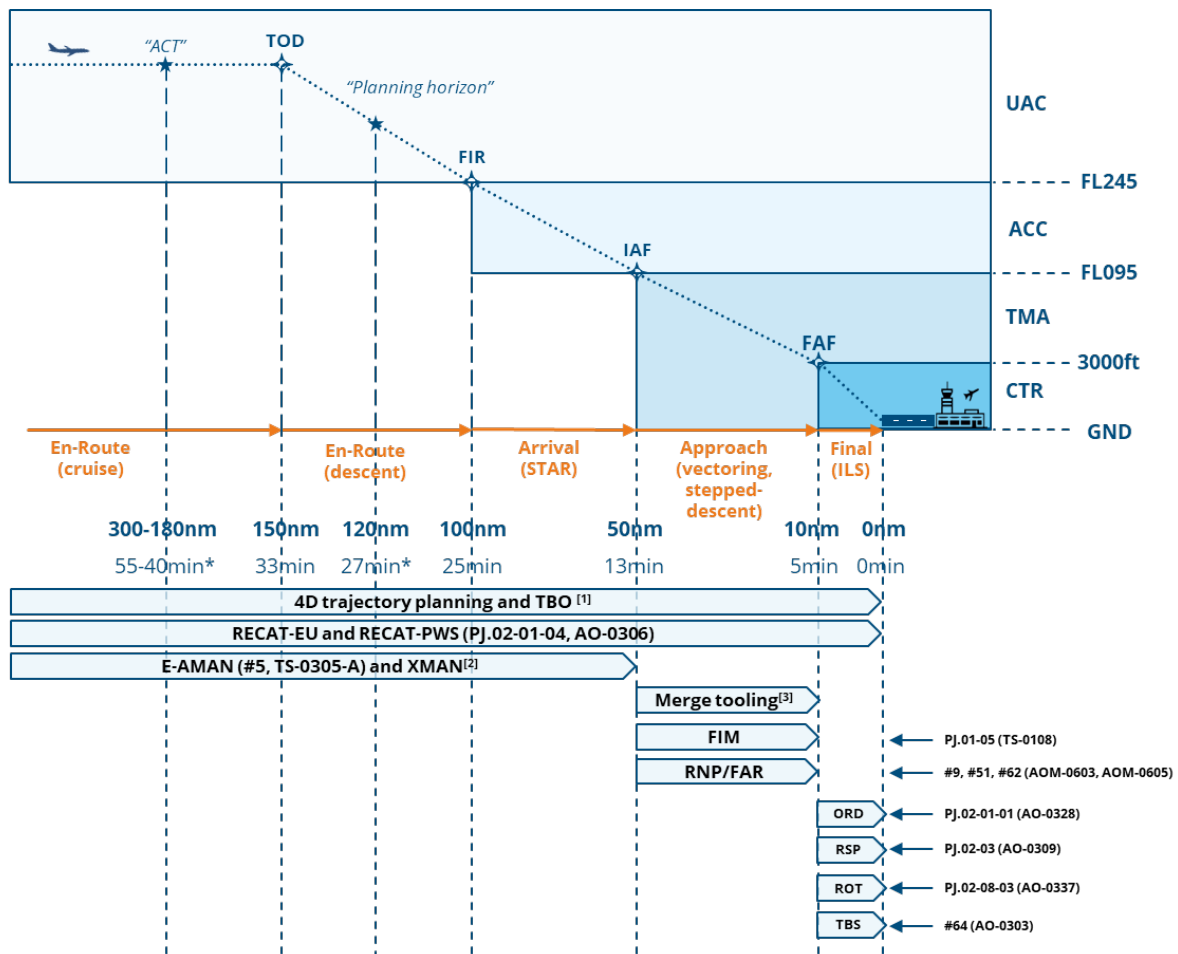
The purpose of solution track PJ.37-W3-01A is to demonstrate the benefits of integrated TMA and runway throughput solutions. This was demonstrated via three different exercises; two sets of Real-Time Simulation (RTS) activities and a flight trial (FT).

- EXE-PJ.37-W3-001 relates to RTS1 for PJ.37-W3-01A and aims to test the integrated applicable SESAR solutions within PJ.37-W3-01A for the Schiphol Terminal Manoeuvring Area (TMA).
- EXE-PJ.37-W3-002 relates to RTS2 for PJ.37-W3-01A. This exercise is based on EXE-PJ.37-W3-001 with improvements incorporated based on the findings during the performance of EXE-PJ.37-W3-001 and air traffic controller feedback. The aim of the exercise is to test the integrated applicable SESAR solutions within PJ.37-W3-01A for the Schiphol TMA. In addition, the evaluated solution scenarios are extended to more complex operational scenarios (e.g. IM mixed-mode operation and disruptions).
- EXE-PJ.37-W3-003 relates to the flight trial for PJ.37-W3-01A and aims to live-test the integrated applicable SESAR solutions within PJ.37-W3-01A with an in-flight aircraft pair. The flight trial was executed with research aircraft from NLR and DLR.

The Real-Time simulations were executed at the NLR premises in Amsterdam using the NLR's Air traffic management Real-time SIMulator (NARSIM) augmented with SESAR solution technologies. The flight trial was executed at Groningen Airport Eelde in the Netherlands.

Operating method description

Solution PJ.37-W3-01A focuses on the arrival management process of Amsterdam Schiphol Airport, which forms the reference scenario related to EXE-PJ.37-W3-001, EXE-PJ.37-W3-002, and EXE-PJ.37-W3-003. A schematic of the Schiphol arrival management process is provided in Figure 1, which includes an overview of the most relevant flight phases. The figure also includes an overview of the various SESAR solutions which form the integrated solution PJ.37-W3-01A, and in which part(s) of the Schiphol arrival management process they are active.



The following techniques will be embedded in the PJ.37-W3-01A Schiphol-RTS, however these are not part of a SESAR solution which will be validated within PJ.37-W3-ITARO:

[1] all simulated flights will have flight plan, which has the form of a 4D trajectory. Parts of the trajectory which are not actively monitored/controlled by humans-in-the-loop will adhere to this planned 4D trajectory, unless there is a disturbance in the ATM network.

[2] cross-border arrival management instructions are emulated in such a manner that it only affects the TMA-entry of the simulated flights.

[3] a merge tool will be provided to the ATCOs to facilitate the merging of FAR/RNP routes in the TMA

Figure 1: Relevant flight phases and airspace. All distances/times/altitudes are indicative and not to scale. ACC/TMA/CTR is controlled by the LVNL, UAC is controlled by a different ANSP. All SESAR solutions at the bottom of the figure, which form the integrated PJ.37-W3-01A solution track, indicate in which part(s) of the arrival management process they are active.

Since E-AMAN, TBS, RECAT-EU, RNP, ORD and FARs with a fixed profile descent are already part of the reference scenario, most of the required infrastructure for the solution scenario is already present in the reference scenario. As the implementation of Time Based Separation (TBS) and more sophisticated wake turbulence categories (RECAT-EU) compared to current operations, an Optimised Runway Delivery (ORD) tool, PJ.02-01-01, is implemented in the reference scenario. As the ORD tool also needs to consider Runway Occupancy Time (ROT), PJ.02-08-03 is included in the reference scenario.

The introduction of IM, combined with S-PWS, into the arrival management process in the solution scenario is likely to be one of the biggest changes in terms of operating method for the Air Traffic Controllers (ATCOs) and airspace users (AU).

3.2 Detailed Description of relationship with other Solutions

As the purpose of solution track PJ.37-W3-01A is to demonstrate the benefits of integrated TMA and runway throughput solutions, the SESAR solutions under evaluation in the demonstration exercise are in use at the same time or after each other i.e. they are compatible and dependent.

The OI steps and SESAR solutions under the scope of this exercise presented in Figure 1 and the solutions used in the solutions scenario are elaborated in Table 6 (extracted from dataset DS22 Draft).

SESAR Solutions to be validated	OI step
PJ.02-01-04 Wake Turbulence Separations (for Arrivals) based on Static Aircraft Characteristics	AO-0306 Static Pairwise Separations (S-PWS) for Arrivals
PJ.02-01-01 Optimised Runway Delivery (ORD) on Final Approach	AO-0328 Optimised Runway Delivery (ORD) on Final Approach
PJ.02-08-03 Increased Runway Throughput based on local runway occupancy time (ROT) categorisation	AO-0337 Increased Runway Throughput based on local ROT characterization
PJ.01-05 Airborne Spacing Flight-deck Interval Management (FIM)	TS-0108 Airborne Spacing Flight-deck Interval Management (FIM)

Table 6: Solutions to be demonstrated for EXE-PJ.37-W3-001. The solutions are extracted from DS22 Draft.

4 Demo 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.

None are listed, as previous Validation Exercises have analysed a specific SESAR solution and not an integrated set of SESAR solutions.

Organisation	Document Title	Publishing Date
N/A	N/A	N/A

Table 7: Pre-SESAR2020 Exercises

SESAR Demonstration Exercises of this Demo (completed ones and planned ones) are listed below.

Exercise ID	Exercise Title	Release	Maturity	Status
EXE.PJ.37-W3-001	Real time simulation 1 for the integrated arrival management process solution for the Schiphol TMA operations		TLR7 ongoing	Completed
EXE.PJ.37-W3-002	Real time simulation 2 for the integrated arrival management process solution for the Schiphol TMA operations		TRL7 ongoing	Completed

Table 8: SESAR2020 Demonstration Exercises

The SESAR 1 and SESAR2020 Wave 1 projects all have contributed to the integrated arrival concept exercises validated by this project. As not all of the previously performed exercises have made conversions to ECAC level, a realistic one-on-one comparison of the performance results is unreasonable. Furthermore, previous solutions have analysed their results against different references or using different metrics.

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

Exercise	OI Step	Exercise scenario & scope	Performance Results	Notes
N/A	TS-0305-A Arrival Management Extended to En-Route Airspace - single TMA	N/A	N/A	SESAR 1 Solution #5 Extended Arrival Management (E-AMAN) horizon
N/A	AO-0326 Optimisation of Separation Minima on Approach and Departure thanks to European Wake Turbulence Categorisation (RECAT EU)	N/A	N/A	- Re-CATegorisation (RECAT-EU) ⁶
N/A	AOM-0603 Enhanced Terminal Airspace for	N/A	N/A	SESAR 1 Solution #9, #51, #62

⁶ RECAT-EU and TBS are supported by functionalities of the ORD tool

Exercise	OI Step	Exercise scenario & scope	Performance Results	Notes
	RNP-based Operations			Enhanced Terminal Airspace using RNP-Based Operations
N/A	AOM-0605 Enhanced Terminal Operations with RNP ⁷ transition to ILS/GLS/LPV	N/A	N/A	SESAR 1 Solution #9, #51, #62 Enhanced Terminal Airspace using RNP-Based Operations
N/A	AO-0303 Time Based Separation for Final Approach - full concept	N/A	N/A	SESAR 1 Solution #64 Time Based Separation (TBS)
PJ.01-05 FTS#1 to FTS#3	TS-0108 Airborne Spacing Flight Deck Interval	The baseline scenario is a fixed route	Safety: N/A	Details presented in [9]

⁷ RNP refers as well to the usage of Fixed Approach Routes (FAR)

Exercise	OI Step	Exercise scenario & scope	Performance Results	Notes
PJ.01-05 RTS#1 to RTS#3	Management (FIM)	network with step-wise altitude profiles. The solution scenario is a fixed route network with continuously descending altitude profiles and IM operations. Noted that the results and conclusions about the noise contour areas depend on the traffic mix and number of flight operations and the defined approach procedures.	Fuel-efficiency: Fuel benefit of 1.65 to 2.05% for very high and high complexity TMAs in peak hours. Noise: Total noise contour area benefit of 14% (LA_{eq} 40 dB(A) and 400 arrival operations) and 46% (LA_{eq} 55 dB(A) and 400 arrival operations) and a total benefit regarding the number of people living inside the noise contours of 4% (LA_{eq} 40 dB(A), 400 Arrival Operation) and 70% (LA_{eq} 55 dB(A), 400 Arrival Operations). Airspace Capacity: In very high to high complexity TMA, capacity benefit is estimated to be 3.7% on average. Airport Capacity: For very large to large airports, on average 2.2% increase. For medium airports, 6.2% increase. Predictability: Flight duration variability improvement of 3.62% (standard deviation). Cost Efficiency: Related to Airspace Capacity and ATCO productivity. Estimated benefits of 0.84% for very high and high complexity TMAs, and 0.42% for medium complexity TMAs, in total 1.26%. Human Performance: No major human performance issues identified. The main human performance items for further discussion and/or investigation logged in HP log [10].	FTS results used for evaluation of fuel-efficiency, noise, airport capacity and predictability. RTS results used to evaluate airspace capacity, predictability and cost efficiency.
EXE- PJ02.01- VALP- RTS1,	AO-0328 Optimised Runway Delivery (ORD)	A generic environment derived from Vienna airport (Large airport with complex TMA),	Safety: Qualitative analysis. With the use of the target indicators, the accuracy of the spacing between aircraft is improved compared to what is achieved today (e.g. distance between pair of aircraft closer to separation minima) and will allow	Details presented in [11]

Exercise	Ol Step	Exercise scenario & scope	Performance Results	Notes
RTS2, RTS3a, RTS3b, RTS4a, RTS4b, RTS6, FTS9	on Final Approach	with according traffic mix. Reference Scenario- RECAT-EU TBS with FTD only. Solution Scenario- RECAT-EU TBS with ORD. The fuel burn savings is computed based on the comparison of the averaged flying time per flight.	controllers to deliver aircraft with greater accuracy than today. Improving spacing accuracy will reduce the number of aircraft that are under-separated. Controller reliance on target indicators may impact Task Performance (i.e. Workload, Situational Awareness and User Acceptance). Overall workload will not increase. It is expected that workload will increase for some tasks such as using the new Sequencing tool HMI. However the benefits of tool support (i.e. the target distance indicators) will reduce workload in other areas so no changes are expected to Safety. Reduced Situational Awareness (less aware of aircraft type), if below acceptable levels, could result in a decreased Safety. Fuel-efficiency: Fuel benefit of 0.59% to 1.6% for ORD tool with RECAT-EU TBS compared to TBS (AO-0303) FTD Indicator only tool support. Noise: N/A Airspace Capacity: N/A Airport Capacity: Increase in movements per hour of 0.8% to 2.3% for ORD tool with RECAT-EU TBS compared to TBS (AO-0303) FTD Indicator only tool support. Predictability: Reduction of 2.13% in standard deviation for ORD tool with RECAT-EU TBS compared to TBS (AO-0303) FTD Indicator only tool support. Human Performance: No major human performance issues identified.	FTS results used for evaluation of fuel efficiency and predictability. FTS and RTS results used for evaluation of Airport Capacity.

Exercise	OI Step	Exercise scenario & scope	Performance Results	Notes
EXE-PJ02.01-VALP-RTS2, RTS3a, RTS4b, RTS6, FTS9	AO-0306 Static Pairwise Separations (S-PWS) for Arrivals	A generic environment derived from Vienna airport (Large airport with complex TMA), with according traffic mix. Reference Scenario- RECAT-EU TBS with FTD only. Solution Scenario- RECAT-EU-PWS TBS with ORD. The fuel burn savings is computed based on the comparison of the averaged flying time per flight.	Safety: Qualitative analysis. With the use of the target indicators, the accuracy of the spacing between aircraft is improved compared to what is achieved today (e.g. distance between pair of aircraft closer to separation minima) and will allow controllers to deliver aircraft with greater accuracy than today. Improving spacing accuracy will reduce the number of aircraft that are under-separated. Controller reliance on target indicators may impact Task Performance (i.e. Workload, Situational Awareness and User Acceptance). Overall workload will not increase. It is expected that workload will increase for some tasks such as using the new Sequencing tool HMI. However the benefits of tool support (i.e. the target distance indicators) will reduce workload in other areas so no changes are expected to Safety. Reduced Situational Awareness (less aware of aircraft type), if below acceptable levels, could result in a decreased Safety. Fuel-efficiency: Fuel benefit of 1.1% to 3.33% for S-PWS and TBS (AO-0303) with ORD (AO-0328) tool compared to TBS (AO-0303) FTD Indicator only tool support. Noise: N/A Airspace Capacity: N/A Predictability: Reduction of 3.22% in standard deviation for S-PWS and TBS (AO-0303) with ORD (AO-0328) tool compared to TBS (AO-0303) FTD Indicator only tool support. Human Performance: No major human performance issues identified.	Details presented in [11] FTS results used for evaluation of fuel efficiency and predictability

Exercise	OI Step	Exercise scenario & scope	Performance Results	Notes
EXE.02-08.V3.005 (RTS)	AO-0337 Increased Runway Throughput based on local ROT characterization	Real Time Simulation of Zurich Airport and TMA environment with focus on Approach with application of the ROCAT concept	Safety: ROCAT does not increase the number of separation infringements and even reduces them mostly because of the use of the ORD tool (AO-0328- Solution 1) Fuel-efficiency: N/A Noise: N/A Airspace Capacity: N/A Airport Capacity: ROT increases the runway throughput Predictability: N/A Human Performance: ROT has no negative impact on the end users (air and ground) roles, tasks and human performance. Transition Factors relating to the ROT are identified and mitigation proposed	Details presented in [12] Focus on SAF and HUP, no % or numbers provided.

Table 9: Summary of Validation Results.

4.2 Conditions / Assumptions for Applicability

The following Table 10 summarises the applicable operating environments.

OE	Applicable sub-OE	Special characteristics
Schiphol TMA Airspace layout	Very high complexity, High complexity, Medium complexity	Representative large International Airport with congested airspace and mixed traffic. The simulated airspace is based on a realistic operational situation which represents the Dutch airspace in line with its national airspace redesign programme, which is derived from today's operational situation and to be implemented in 2030-2035. The routes consist of CDO on RNP routes for the main runway configurations, 4 IAFs and FARs with fixed speed profiles. All IAFs have entry flight level of FL100 as it is the most realistic procedure to have one fixed TMA entry altitude according to the local ANSP. Each FAR has a fixed descent angle. ATCOs are not familiar with the 4 IAF CDO procedure. Introduction of varied IAF entry FLs would increase the vertical spread along the FAR for each flight, resulting in more challenging simulations for the ATCO.
Airport	Very Large Airport, Large Airport, Medium Airport	Representative large International Airport with congested airspace and mixed traffic.
Airspace	Good weather conditions	The weather conditions such as wind, visibility and precipitation, are such that it does not negatively impact the operation with FAR, CDO and the integrated tool.
Aircraft Performance	Aircraft Performance Models	BADA 3.7 models are used to model aircraft performance and are controlled by pseudo pilots.

Table 10: Applicable Operating Environments.

The following solutions presented in Table 11 are part of the reference scenario.

SESAR Solution and/or OI which are part of the reference scenario in EXE-PJ.37-W3-001 / 002	OI step
PJ.02-01-01 Optimised Runway Delivery (ORD) on Final Approach	AO-0328 Optimised Runway Delivery (ORD) on Final Approach
PJ.02-08-03 Increased Runway Throughput based on local ROT characterization	AO-0337 Increased Runway Throughput based on local ROT characterization
#5 Extended Arrival Management (E-AMAN) horizon	TS-0305-A Arrival Management Extended to En-Route Airspace - single TMA

SESAR Solution and/or OI which are part of the reference scenario in EXE-PJ.37-W3-001 / 002	OI step
Re-CATegorisation (RECAT-EU) ⁸	AO-0326 Optimisation of Separation Minima on Approach and Departure thanks to European Wake Turbulence Categorisation (RECAT EU)
#9, #51, #62 Enhanced Terminal Airspace using RNP-Based Operations	AOM-0603 Enhanced Terminal Airspace for RNP-based Operations AOM-0605 Enhanced Terminal Operations with RNP ⁹ transition to ILS/GLS/LPV
#64 Time Based Separation (TBS)	AO-0303 Time Based Separation for Final Approach - full concept

Table 11: Reference scenario relevant for EXE-PJ.37-W3-001 and EXE-PJ.37-W3-002

Further detail of the demo is described in Chapter 3.

⁸ RECAT-EU and TBS are supported by functionalities of the ORD tool

⁹ RNP refers as well to the usage of Fixed Approach Routes (FAR)

4.3 Safety

Safety is impacted by the solution track. For more information please refer to Section 4.1 of the Demonstration Report Part II Safety Report.

4.3.1 Safety Design drivers and Performance Mechanism

The combined SESAR solutions that has been demonstrated in PJ.37-W3-01A (approach and arrival operations) and the respective operational improvement step are summarised below:

SESAR Solution ID and Title	SESAR Solution Description	OI Steps ref. (coming from EATMA)	Enablers ref. (coming from EATMA)
PJ.01-05 Airborne Spacing Flight-deck Interval Management	Airborne spacing flight-deck interval management refers to new Interval Management (IM) operations involving more complex geometries where a designated target aircraft may not be flying direct to the merge point.	TS-0108 Airborne Spacing Flight-deck Interval Management (ASPA FIM)	A/C-15b (Develop) Aircraft functions for Interval Management
			A/C-48a (Use) Air broadcast of aircraft position/vector (ADS-B OUT) compliant with DO260B
			A/C-67 (Use) ADS-B IN
			APP ATC 61 (Develop) Ground functions for Interval Management
			ASAS-STD-02 ICAO provisions for Interval Management
			HUM-002 (Develop) Human factors flight crew – Interval Management
			HUM-003 (Develop) Human factors ATCOs – Interval Management
PJ.02-01-01 Optimised Runway Delivery (ORD) on Final Approach	the solution is an ATC support tool to enable safe, consistent and efficient delivery of the required separation or spacing between arrival pairs on final approach to the runway landing threshold	AO-0328 Optimised Runway Delivery (ORD) on Final Approach	APP ATC 120 (Develop) Approach ATC System to support Optimised Runway Delivery on Final Approach
			APP ATC 156 (Optional) ATC System to Support Time-Based Separation in Final Approach

SESAR Solution ID and Title	SESAR Solution Description	OI Steps ref. (coming from EATMA)	Enablers ref. (coming from EATMA)
			APP ATC 169 (Optional) Approach ATC System to support Optimised Runway Delivery on Approach based on Aircraft ROT categorisation
			APP ATC 99 (Use) ATC System to use Real-Time Meteo Information Received From Met Systems
PJ.02-01-04 Wake Turbulence Separations (for Arrivals) based on Static Aircraft Characteristics	the solution consists of the efficient aircraft type pairwise wake separation rules for final approach. It consists of both the 103x103 aircraft type-based wake separation minima (for the most common aircraft in ECAC area) and the 20 wake category (20-CAT) based wake separation minima for arrival pairs involving all the remaining aircraft types	AO-0306 Static Pairwise Separations (S-PWS) for Arrivals	APP ATC 118 (Develop) ATC System to support static pair-wise wake separation (S-PWS) on approach
			REG-0523 (Develop) Regulatory provisions (AMC) for static pair-wise separation minima (S-PWS)
			AERODROME-ATC-42a (Develop) Airport ATC tool to support static pair-wise wake separation (S-PWS) in final approach
PJ.02-08-03 Increased Runway Throughput based on local ROT characterization.	the solution intends to reduce the in-trail separation on final approach with the aim of increasing runway throughput by taking into account the Runway Occupancy Time (ROT)	AO-0337 Increased Runway Throughput based on local ROT characterization	APP ATC 169 (Develop) Approach ATC System to support Optimised Runway Delivery on Approach based on Aircraft ROT categorisation
			AERODROME-ATC-55 (Use) Airport ATC analyser tool for predicting ROT

Even though the solutions are primarily aimed at increasing capacity and throughput, there are also safety benefits, which are related to:

- Fixed routes, providing a more predictable traffic picture.

- Tool to enable safe, consistent and efficient delivery of the required separation or spacing between aircraft pairs.
- Lower R/T workload for the air traffic controllers, making them better available for separation monitoring.

The Safety Report has identified four Safety Demonstration Objectives that are related to the new combination of tools considered in PJ37-W3-ITARO. These objectives are analysed in the following tables. For more information please refer to Section 4.1 of the Demonstration Report Part II Safety Report.

OBJ-37-W3-DEMOP-SAF1-0001		
Objective	The number of go arounds due to insufficient spacing shall not be greater than in the reference scenario	
Success Criterion	CRT-37-W3-DEMOP-SAF1-0001	The use of the integrated tool shall not increase the number of controller-instructed go arounds.
Results	Based on the data in RTS1, the fact that more go arounds occurred in solution runs than in reference runs cannot be related to the new combination of tools. The questionnaires did not reveal a concern regarding this objective either. Therefore, it was concluded that the number of go arounds due to insufficient spacing is not increased by the combination of tools. This conclusion was confirmed during RTS2, which did not include any go arounds due to insufficient spacing. Recommendations REC-37-W3-SAF-R1.1: For a more accurate representation of the safety objectives being studied, incorporate a runway controller in future simulations to manage traffic on the arrival segment and collaborate with the arrival controller in instances that may result in go-arounds	

Table 12: Results for OBJ-37-W3-DEMOP-SAF1-0001: The number of go arounds due to insufficient spacing shall not be greater than in the reference simulation

OBJ-37-W3-DEMOP-SAF1-0003		
Objective	The interoperability of the different tools in the integrated tool shall not introduce safety issues.	
Success Criterion	CRT-37-W3-DEMOP-SAF1-0003	Ensure that the functionalities of all solutions complement one another without negative interference.
Results	The FIM system's task is to create spacing between aircraft on fixed routes, but its efficiency depends on the accuracy of the EAT provided by E-AMAN. During a simulation, the actual flight sequence was sometimes different from the planned sequence, resulting in illogical pairings and unpredictable operation. This highlights the need for reliable EAT on the TMA boundary for the FIM system to work properly. However, the likelihood of the E-AMAN system	

providing unreliable EAT in real-life operations is small and the consequences are likely to be low as the ACC controller and flight crew may detect and resolve any issues before the aircraft arrives in the TMA. Nevertheless, ATCOs are not informed if the pairing is illogical, resulting in the safety objective not being fully met. The overall score for this system is "Partial OK."

Recommendations

REC-37-W3-SAF-R3.1: For future simulations or demonstrations, implement a safety mechanism to alert ATCOs in case of any compatibility issues between the FIM system/algorithm and the E-AMAN system/algorithm, such as illogical aircraft pairings.

REC-37-W3-SAF-R3.2: Consider expanding the coverage of the FIM system to include the ACC airspace, in addition to the TMA airspace. This could provide more time and space for the system to maintain appropriate spacing between aircraft and to create gaps in case an aircraft needs to re-sequenced.

REC-37-W3-SAF-R3.3: Enhance the realism of future simulations or demonstrations by incorporating more realistic speed profiles of aircraft. Refining the FIM algorithms and ensuring seamless transitions between them may be necessary to achieve this.

Table 13: Results for OBJ-37-W3-DEMOP-SAF1-0003: The interoperability of the different tools in the integrated tool shall not introduce safety issues

OBJ-37-W3-DEMOP-SAF1-0004		
Objective	There shall not be a negative impact on the number of losses of separation (wake turbulence separation, minimum radar separation infringements and tactical conflicts).	
Success Criterion	CRT-37-W3-DEMOP-SAF1-0004	The use of the integrated tool and the Airborne Spacing Flight Deck Interval Management does not lead to an increased number of separation losses in the nominal solution as compared against the reference scenario.
Results	The data of RTS1 showed that for both MRS and ROT, the solution runs did not seem to have more cases of LOS than the reference runs, and even showed much fewer. In the questionnaires and the debriefing the controllers did have a few concerns with wake turbulence separation losses, however. During RTS2, the number of LOSs during solution runs was similar to the number of LOSs in reference runs under comparable circumstances. The controllers did have a few concerns regarding LOSs, but these seemed to be mainly due to the high traffic density, the perceived controllability and the use	

of FIM, rather than due to the combination of tools. Therefore, the results of RTS2 appeared to confirm the RTS1 conclusion.

Recommendations

REC-37-W3-SAF-R4.1: To include a runway controller in the simulations, who controls the traffic on the arrival segment, and who can coordinate with the arrival controller regarding situations that may lead up to losses of separation due to WTS, MRS, and ROT. This would provide a more realistic picture regarding the safety objectives studied.

REC-37-W3-SAF-R4.2: The previous recommendation would also create the opportunity to study a safety objective that was omitted from the analysis in this report: OBJ-PJ.37-W3-001-SAF-002 and OBJ-PJ.37-W3-002-SAF-002 (The variability in Clearance to Land margin decreases for ROT constrained pairs).

REC-37-W3-SAF-R4.3: The objectives studied looked at safety up to the level of potential for loss of separation, limited by the nature of real time simulations. In order to assess the risk of a mid-air collision and the risk of wake turbulence related accidents, as is required in SESAR safety reference material (SRM), in a follow on project it is recommended to use Dynamic Risk Modelling to assess the safety benefits of the combination of tools more accurately.

Table 14: Results for OBJ-37-W3-DEMOP-SAF1-0004: There shall not be a negative impact on the number of losses of separation (wake turbulence separation, minimum radar separation infringements and tactical conflicts)

OBJ-37-W3-DEMOP-SAF1-0005		
Objective	The perceived controllability of the operation by ATCO shall not degrade due to the use of the integrated tool.	
Success Criterion	CRT-37-W3-DEMOP-SAF1-0005	The tool gives the ATCO the means to intervene. The use of the tool does not lead to a perceived loss of controllability of the operation by the ATCO in relation to the conventional operation. This is assessed through a qualitative analysis.
Results	At the beginning of RTS1, the controllers did feel less in control during the solution runs, compared to the reference runs. However, this seemed to be mainly due to the use of a single tool rather than to the combination of tools. Moreover, post-experiment they indicated to have grown more positive regarding the solution runs. The execution of RTS2 helped the controllers to become more familiar with and obtain more experience with the integrated tool, resulting in increased trust. However, some simulation issues arose during the runs, leading to concerns about the perceived controllability in real-world operations. In real operational context, controllers must handle various disturbances such as rain clouds, go-arounds, unexpected aircraft behaviour, and aircraft flying too fast or too slow.	

Some of such types of situations were also encountered during some of the RTS2 runs (grossly unexpected aircraft/pilot behaviour, difference between actual and planned arrival sequence), leading to a rapid loss of control and the need to halt the simulation. The main issue is the integration between AMAN and FIM; the concerns warrant further attention in future testing and simulations.

Therefore, at this moment we cannot conclude that objective OBJ-37-W3-DEMOP-SAF1-0005 is fully met.

Recommendations

REC-37-W3-SAF-R5.1: Assess the similarity of simulation issues encountered during RTS2 to real-world operational scenarios. In future testing and simulations, include these types of events in scenarios to gauge the operational efficiency and durability of the tools used.

REC-37-W3-SAF-R5.2: Evaluate the ability of controllers to handle non-typical operational disruptions that occur frequently in real-world practice. Incorporate these events into scenarios for future testing and simulations to assess the efficiency and stability of the tools and overall operation during such situations.

Table 15: Results for OBJ-37-W3-DEMOP-SAF1-0005: The perceived controllability of the operation by ATCO shall not degrade due to the use of the integrated tool

4.3.2 Data collection and Assessment

The analysis results in the previous subsection have been driven by the following activities:

1. Workshop with solution members to identify, in more detail, the VLD-like objectives/High-level requirements from a safety point of view;
2. Preparation and production of safety observation questionnaires to produce the required data and evidence;
3. Provision of a safety briefing to participants and solution members;
4. Observations during the RTSs to provide the required data and evidence;
5. Development and running a specific scenario to run in one of the RTSs to produce the required data and evidence;
6. Collection and analysis of data of the RTSs of the VLD-like to produce the required evidence;
7. Conduction of post VLD-like Safety workshop activities with operational experts (ATCO, pilots, safety experts) to assess and analyse any safety issues, derive mitigations and assess (if possible) if the safety objectives of this VLD-like are satisfied.
8. Use of operational expert judgement.

The data referred to in activities 2 and 6 included:

- Data from the questionnaires, i.e.

- the scoring the air traffic controllers gave to the questions (from strongly disagree to strongly agree);
- the explanations they gave to clarify or justify the answers.
- Data produced by the simulations, including
 - the 4D path flown by all aircraft, which allowed to generate their pairwise vertical and horizontal separations as a function of time, as well as go arounds;
 - recordings of all RTS runs, both visually (i.e. the controller radar display), and aurally (the R/T between pseudo-pilots and controllers), which allowed to zoom in on situations of potential safety concern;
 - observations and notes developed by all observing and supporting participants.

For more information please refer to Appendix A of the Demonstration Report Part II Safety Report.

4.3.3 Extrapolation to ECAC wide

These Demonstration exercises were conducted in a simulation environment in the airspace of Amsterdam Schiphol Airport, which is representative of a Very Large/Large airport in terms of layout, configuration and traffic mix. These results could be extrapolated to similar aerodromes in ECAC, however, currently there is not enough quantitative evidence available to support this statement for extrapolation to other aerodromes in these categories.

Furthermore, the limited results which were collated regarding potential traffic levels and congestion in the TMA could be extrapolated in ECAC, however, consideration should be made with regards to the airways structure.

This section analyses the Safety KPIs and PIs from the SESAR Safety Reference Material. Since the PJ37-W3-ITARO combined solutions were focused in the TMA, KPIs related to en-route, the runway and the taxiway are out of scope. Since the solutions are ATM tools, CFIT accidents are also out of scope. This means that remaining are:

- SAF2.X: Mid-air collision – TMA
- SAF6.X: Wake related accident - Final APP

Mandatory PI	Performance Benefits Expectations at Network Level (ECAC Wide or Local depending on the KPI) ¹⁰	Confidence in Results ¹¹
SAF1.X: Mid-air collision - En-Route	NA	NA, en-route outside of scope

¹⁰ Negative impacts are indicated in red.

¹¹ High – the results might change by +/-10%
Medium – the results might change by +/-25%

Mandatory PI	Performance Benefits Expectations at Network Level (ECAC Wide or Local depending on the KPI) ¹⁰	Confidence in Results ¹¹
SAF2.X: Mid-air collision – TMA SAF2.1 Mid-Air Collisions SAF2.2 Imminent Collisions SAF2.3 Imminent Infringements SAF2.4 Crew/Aircraft Induced conflicts SAF2.5 Planned conflicts SAF2.6 ATC Induced Tactical conflicts SAF2.7 Pre-Tactical conflicts	0% The data of RTS1 showed that the solution runs did not seem to have more cases of loss of separation than the reference runs, and even showed much fewer. During RTS2, the number of losses of separation during solution runs was similar to the number of losses in reference runs under comparable circumstances. The controllers did have a few concerns regarding losses, but these seemed to be mainly due to the high traffic density, the perceived controllability and the use of IM, rather than due to the combination of tools. Therefore, the results of RTS2 appeared to confirm the RTS1 conclusion. Concluding, we cannot argue that there is an increase in the number of losses of separation in the TMA. In a follow on project it is recommended to use Dynamic Risk Modelling to assess this benefit more accurately.	Low, since Dynamic Risk Modelling out of scope of RTS
SAF3.X: RWY-collision accident	NA	NA, ground ops outside of scope
SAF4.X: TWY-collision accident	NA	NA, ground ops outside of scope
SAF5.X: CFIT accident	NA	NA, not ATM related hence out of scope
SAF6.X: Wake related accident SAF6.1 Wake induced accidents SAF6.2 Wake encounter (moderate, severe, extreme) SAF6.3 Imminent wake encounter under fault-free conditions SAF6.4 Unmanaged under-separation SAF6.5 Unmanaged under-separation induced by ATC through inadequate selection and management of separation mode	0% According to the data, there were no wake turbulence separation losses in either RTS1 or RTS2. Nevertheless, in the questionnaires and the debriefing the controllers did have a few concerns with wake turbulence separation losses. Upon further analysis, these concerns seemed to be mainly due to the high traffic density, the perceived controllability and the use of IM, rather than due to the combination of tools. Concluding, we cannot argue that there is an increase in the number of wake separation losses in the TMA. In a follow on project it is recommended to use Dynamic Risk	Low, since Dynamic Risk Modelling out of scope of RTS

Low – the results might change by +/-50% or greater

N/A – not applicable, i.e., the KPI cannot be influenced by the Solution

Mandatory PI	Performance Benefits Expectations at Network Level (ECAC Wide or Local depending on the KPI) ¹⁰	Confidence in Results ¹¹
SAF6.6 Imminent Infringement (during interception, on final approach) SAF6.7 Crew/Aircraft induced spacing conflict during the interception SAF6.8 Crew/Aircraft induced spacing conflict on the final approach path	Modelling to assess this benefit more accurately.	
SAF7.X: RWY-excursion accident	NA	NA, ground ops outside of scope
SAF8.X ...: Other SAF Risks	NA	NA

4.3.4 Discussion of Assessment Result

The safety assessment in the project PJ37-W3-ITARO was built on the use of real time simulations. More advanced methods such as Dynamic Risk Modelling were not in the scope of the project resources. Therefore, the risks cannot be assessed up to the level of accidents and serious incidents, without resorting to using major assumptions and providing quantitative values with significant uncertainty levels. In a follow on project it is recommended to use Dynamic Risk Modelling to assess this benefit more accurately.

4.3.5 Additional Comments and Notes

For more information please refer to the Demonstration Report Part II Safety Report [16].

4.4 Environment: Fuel Efficiency / CO₂ emissions

Fuel efficiency and CO₂ emissions are impacted by the solution. For more information please refer to Section 4.3 of the Demonstration Report Part IV Environmental Assessment Report [13].

4.4.1 Performance Mechanism

For more information please refer to Section 4.3.1 of the Demonstration Report Part IV Environmental Assessment Report [13].

4.4.2 Assessment Data (Exercises and Expectations)

For more information please refer to Section 4.3.2 of the Demonstration Report Part IV Environmental Assessment Report [13].

Exercise ID or Expert judgement	Benefits contribution to FEEF1	Benefits contribution to ENV1
EXE.PJ.37-W3-001	9.9%	9.9%
EXE.PJ.37-W3-002	6.7%	6.7%

Table 16: Local fuel burn and CO₂ emissions saving per Exercise (solution scenario compared to reference scenario)

4.4.3 Extrapolation to ECAC wide

On ECAC/Network level, to translate the 6.7% reduction in fuel and CO₂, use is made of the S2020 Common Assumptions [6]. Average fuel burn per flight is 5280 kg (F-0001), of which 5% (F-0006) is the TMA arrival fuel consumption contribution or 264 kg. 6.7% of 264 is 17.7 kg. However, the integrated solution works for peak arrivals at Very Large and Large airports (APT-PC-VL-2035, APT-PC-L-2035, from which only 50% is arriving traffic) or $((47.23\% + 14.99\%)/2 = 31.11\%)$. This results in $17.7 * 31.11\%$ is 5.5 kg reduction in fuel usage. Out of the total fuel burn per flight, 5.5 kg equals to $(5.5/5280*100=0.1\%)$. The CO₂ emissions results from multiplying the fuel burn by 3.15, or 17.3 kg.

For more information please refer to Section 4.3.3 of the Demonstration Report Part IV Environmental Assessment Report [13]. The confidence in the results is high as the data is based on the BADA aircraft performance models. The confidence in the generalised finding of the impact of the solution is low level due to the limited number of (RTS) evaluations. As only a limited number of simulations have been performed in a RTS, extrapolating the results to ECAC wide network level requires further investigation using FTS.

KPIs / Pls	Unit	Calculation	Mandatory	Absolute expected performance benefit in SESAR2020	% expected performance benefit in SESAR2020
FEEF1 Actual fuel burn per flight	Kg fuel per movement	Total amount of actual fuel burn divided by the number of movements	YES	5.5 kg	0.1%

KPIs / PIs	Unit	Calculation	Mandatory	Absolute performance SESAR2020	expected benefit in SESAR2020	% performance SESAR2020	expected benefit in SESAR2020
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	17.3 kg		0.1%	

Table 17: Fuel burn and CO2 emissions saving for Mandatory KPIs/PIs

4.4.4 Discussion of Assessment Result

For more information please refer to Section 4.3.4 of the Demonstration Report Part IV Environmental Assessment Report [13].

4.4.5 Additional Comments and Notes

For more information please refer to Section 4.3.5 of the Demonstration Report Part IV Environmental Assessment Report [13].

4.5 Environment: Noise, Local Air Quality, and non-CO2 Emissions

Aircraft noise is impacted by the solution. Extrapolation at the ECAC level is not provided as it is not possible for noise and local air quality, and not required for non-CO2 emissions. For more information please refer to Section 4.4 of the Demonstration Report Part IV Environmental Assessment Report [13].

4.5.1 Performance Mechanism

Is there a Benefit Mechanism available? Yes

For more information please refer to Section 4.4.1 of the Demonstration Report Part IV Environmental Assessment Report [13].

4.5.2 Assessment Data (Exercises and Expectations)

The confidence in the results is high as the data is based on the BADA aircraft performance models and the Doc29 guidance standard of computing noise contours around airports has been used. The confidence in the generalised finding of the impact of the solution is low level due to the limited number of (RTS) evaluations. To increase the confidence of the generalised finding (and to also transfer this to ECAC wide level) FTS have to be performed.

For more information please refer to Section 4.4.2 of the Demonstration Report Part IV Environmental Assessment Report [13].

PIs	Unit	Calculation	Mandatory	Absolute expected performance benefit in SESAR2020	% expected performance benefit in SESAR2020
NOI1 Relative noise scale	-2 to +2	It is a qualitative scale based on expert judgment. -2 very negative effect or benefit, 0 neutral and +2 very positive effects or benefit. The objective of this metric is to provide a global assessment of the noise impact. This metric is built upon the other quantitative noise PIs (NOI2, NOI3, NOI4, NOI5)	YES for Airport OE Solutions	NA, single NOI PI evaluated	NA, single NOI PI evaluated
NOI2 Size and location of noise contours	Contours of noise level thresholds (e.g. LDEN 55 see ERM document for the list of recommended PIs). Surface of these contours(Km ²)	Noise contours to be calculated according to the ECAC Doc.29 methodology. Surface of the noise contours calculated using a GIS tool or modules. Suggest the use of IMPACT tool.	YES for Airport OE Solutions	NA	1% or lower decrease of 55dB contour area
(NOI4) Number of people exposed to noise levels exceeding a given threshold	Number of people inside noise contours.	Population count inside the contours calculated above. Need the availability of population census data. Calculated using a GIS tool or modules. IMPACT tool includes this functionality, using the EEA population database.	YES for Airport OE Solutions	NA, simulation generalised i.o. dependent on geography	NA, simulation generalised i.o. dependent on geography

PIs	Unit	Calculation	Mandatory	Absolute expected performance benefit in SESAR2020	% expected performance benefit in SESAR2020
LAQ1 Geographic distribution of pollutant concentrations	Airport Local Air Quality (ALAQs) Studies inventory method generally uses mg/m ³ for each pollutant	Measurement to be performed within LTO cycle. • NOx: Nitrogen oxides, including nitrogen dioxide (NO₂) and nitrogen oxide (NO); • VOC: Volatile organic compounds (including non-methane hydrocarbons (NMHC)); • CO: Carbon monoxide; • PM: Particulate matter (fraction size PM_{2.5} and PM₁₀); • SOx: Sulphur oxides. • Recommended tools: Open-ALAQs	YES for Airport OE Solutions relative to LTO (=>below 3000ft)	NA, no analysis performed on pollutant	NA, no analysis performed on pollutant

Table 18: Noise and Local Air Quality benefit for Mandatory PIs

Were there any benefits obtained in SESAR2020 Wave1 for this Demo? No. Individual solutions had benefits, however the combined integrated concept has not been tested before.

4.5.3 Extrapolation to ECAC wide

There is no ECAC wide extrapolation required for NOI1, NOI2, NOI4 and LAQ1 in the Performance Assessment Report.

4.5.4 Discussion of Assessment Result

For more information please refer to Section 4.4.4 of the Demonstration Report Part IV Environmental Assessment Report [13].

4.5.5 Additional Comments and Notes

For more information please refer to Section 4.4.5 of the Demonstration Report Part IV Environmental Assessment Report [13].

4.6 Airspace Capacity (Throughput / Airspace Volume & Time)

Does the Demo impact this KPA? Yes, as the integrated solution could enable an increased runway throughput and thus increased level of traffic through a fixed part of the airspace. However, the aim of the simulation was not to identify the maximum traffic load.

The KPI is evaluated by Objective OBJ-37-W3-DEMOP-CAP1-0002, as described in Appendix A.3.2 and B.3.2 of the DEMOR part I [14].

4.6.1 Performance Mechanism

Is there a Benefit Mechanism available? Yes, arrivals follow a transition from TMA entry point towards the runway. These transitions are fixed routes. When traffic load is increased, the traffic on the transition will also increase. And thus the airspace throughput per a fixed time interval will as well.

4.6.2 Assessment Data (Exercises and Expectations)

The Objective is evaluated in detail in Appendix A.3.2 paragraph 15 for EXE-PJ.37-W3-001 and B.3.2 paragraph 15 for EXE-PJ.37-W3-002.

Exercise ID or Expert judgement	Benefits contribution to CAP1	Benefits contribution to CAP2
EXE-PJ.37-W3-001	NA	NA
EXE-PJ.37-W3-002	6-12% more aircraft under control per hour depending on controller position when increasing traffic load from 40 to 43 (+8%)	NA

Table 19: Airspace Capacity benefits per Exercise

KPIs / Pls	Unit	Calculation	Mandatory	Absolute expected performance benefit in SESAR2020 (local)	% expected performance benefit in SESAR2020 (local)
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	Airspace capacity increased to accommodate increase of traffic load up to 3 aircraft per hour (+8%), which has been controlled in nominal situations. Integrated solution not tested to maximum capacity.	NA
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	YES	NA, TMA only	NA, TMA only

KPIs / Pls	Unit	Calculation	Mandatory	Absolute expected performance benefit in SESAR2020 (local)	% expected performance benefit in SESAR2020 (local)
		TMA's airspace at peak demand hours.			

Table 20: Airspace benefits for Mandatory KPIs /Pls

Were there any benefits obtained in SESAR2020 Wave1 for this Demo? No. Individual solutions had benefits, however the combined integrated concept has not been tested before.

4.6.3 Extrapolation to ECAC wide

There is no ECAC wide extrapolation required for this KPI in the Performance Assessment Report.

4.6.4 Discussion of Assessment Result

The confidence in the generalised finding of the impact of the solution is low level due to the limited number of (RTS) evaluations. To increase the confidence of the generalised finding (and to also transfer this to ECAC wide level) FTS have to be performed.

Further details are described in Appendix A.3.2 paragraph 15 and B.3.2 paragraph 15 of the DEMOR [14].

4.6.5 Additional Comments and Notes

All additional comments are mentioned in Appendix A.3.2 and B.3.2 of the DEMOR [12].

4.7 Airport Capacity (Runway Throughput Flights/Hour)

Does the Demo impact this KPA? Yes, as the integrated solution could enable an increased runway throughput. As in the simulations the runway was used for arrivals only, KPI “CAP3.2 Peak Arrival throughput per hour (Segregated mode)” is evaluated. However, the aim of the simulation was not to identify the maximum traffic load.

The KPI is evaluated by Objective OBJ-37-W3-DEMOP-CAP1-0001, as described in Appendix A.3.2 and B.3.2 of the DEMOR part I [14].

4.7.1 Performance Mechanism

Is there a Benefit Mechanism available? Yes, as the integrated solution could enable an increased runway throughput by handling more traffic per runway. However, the aim of the simulation was not to identify the maximum traffic load.

4.7.2 Assessment Data (Exercises and Expectations)

The Objective is evaluated in detail in Appendix A.3.2 paragraph 14 for EXE-PJ.37-W3-001 and B.3.2 paragraph 14 for EXE-PJ.37-W3-002.

Exercise ID or Expert judgement	Benefits contribution to CAP3	Benefits contribution to CAP3.1	Benefits contribution to CAP3.2 (local)	Benefits contribution to CAP4
EXE-PJ.37-W3-001	N/A	N/A	Traffic load simulated from 35 to 40 aircraft per hour per runway (+14%).	N/A
EXE-PJ.37-W3-002	N/A	N/A	Traffic load simulated from 40 to 43 aircraft per hour per runway (+8%).	N/A

Table 21: Airport Capacity benefits per Exercise

KPIs / Pls	Unit	Calculation	Mandatory	Absolute expected performance benefit in SESAR2020	% expected performance benefit in SESAR2020
CAP3 Peak Runway Throughput (Mixed mode)	% and Flight per hour	% and also total number of movements per one runway per one hour for specific traffic mix and density (in mixed mode RWY operations). The percentage change is measured against the maximum observed throughput during peak demand hours in the mixed-mode RWY operations airports group.	YES	NA, no mixed mode	NA, no mixed mode
CAP3.1 Peak Departure	% and Flight per hour	% and also total number of departures per one runway per one hour for specific traffic mix and density (in segregated mode of operations). The percentage change is	YES	NA, departures out of scope	NA, departures out of scope

KPIs / Pls	Unit	Calculation	Mandatory	Absolute expected performance benefit in SESAR2020	% expected performance benefit in SESAR2020
throughput per hour (Segregated mode)		measured against the maximum observed throughput during peak demand hours in the segregated-mode RWY operations airports group.			
CAP3.2 Peak Arrival throughput per hour (Segregated mode)	% and Flight per hour	% and also total number of arrivals per one runway per one hour for specific traffic mix and density (in segregated mode of operations). The percentage change is measured against the maximum observed throughput during peak demand hours in the segregated-mode RWY operations airports group.	YES	Arrival runway throughput increased to 43 aircraft per hour, which has been controlled in nominal situations. Integrated solution not tested to maximum capacity.	NA
CAP4 Un-accommodated traffic reduction	Flights/year	Reduction in the number of un-accommodated flights i.e. a flight that would have been scheduled if there were available slots at the origin/destination airports. NB: Supports CBA Inputs. NB: Relates to Airport Capacity because this is STATFOR computation. CBA calculate this based on the assessment of the runway throughput we provide with and without the solutions and STATFOR data.	YES For CBA.	NA, all traffic accommodated	NA, all traffic accommodated

Table 22: Airport Capacity for Mandatory KPIs /Pls

Were there any benefits obtained in SESAR2020 Wave1 for this Demo? No. Individual solutions had benefits, however the combined integrated concept has not been tested before.

4.7.3 Extrapolation to ECAC wide

There is no ECAC wide extrapolation required for this KPI in the Performance Assessment Report.

4.7.4 Discussion of Assessment Result

The confidence in the generalised finding of the impact of the solution is low level due to the limited number of (RTS) evaluations. To increase the confidence of the generalised finding (and to also transfer this to ECAC wide level) FTS have to be performed.

Further details are described in Appendix A.3.2 paragraph 14 and B.3.2 paragraph 14 of the DEMOR [14].

4.7.5 Additional Comments and Notes

All additional comments are mentioned in Appendix A.3.2 and B.3.2 of the DEMOR [12].

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

Does the Demo impact this KPA? No

4.9 Flight Times

Does the Demo impact this KPA? No

4.10 Predictability

Does the Demo impact this KPA? Yes as to operate at very high runway throughput using the integrated solution, the arrival planning has to be followed accurately. To do so, the traffic has to operate as predicted.

The KPI is evaluated by Objective OBJ-37-W3-DEMOP-PRD1-0001, as described in Appendix A.3.2 and B.3.2 of the DEMOR part I [14].

4.10.1 Performance Mechanism

Is there a Benefit Mechanism available? Yes, as using the integrated tool would enable operations closer to their separation minima. By doing so, the runway throughput can be increased. The arrival planning ensures that the arrival times of the different flights are such that it can be managed by the controllers and no runway infringements occur. To ensure aircraft arrive as planned, the planned arrival times and the actual arrival times should match as much as possible.

4.10.2 Assessment Data (Exercises and Expectations)

The objective is evaluated in detail in the DEMOR Part I, Appendix A.3.2 paragraph 16 for EXE-PJ.37-W3-001 and B.3.2 paragraph 16 for EXE-PJ.37-W3-002.

Exercise ID or Expert judgement	Benefits contribution to PRD1 (local)	Benefits contribution to PRD2 (local)
EXE-PJ.37-W3-001	On average, -18s to 50s difference between the AMAN planned time and actual flight time per flight between the reference and solution run	Median for the solution runs are smaller than for the reference run, thus the difference between the actual and planned time in the TMA are more similar.
EXE-PJ.37-W3-002	On average, -18s to -2s difference between the AMAN planned time and actual flight time per flight between the reference and solution run	Order of 0.5 mins for 50% of the traffic Spread between the 95% of the data in the reference run is the largest. In the solution run the spread is the smallest. Increasing IM equipage rate, spread seems to decrease. When traffic load is increased, in general, smallest spread observed.

Table 23: Predictability benefits per Exercise

4.10.3 Extrapolation to ECAC wide

On network level, improved TMA arrival predictability would result in a reduction in deviations from CDOs and fixed arrival routes, resulting in environmental benefits next to runway throughput capacity. Due to the limited number of runs, no meaningful qualitative extrapolation to ECAC/Network level can be made.

Table 24 is showing the impact on flight phases (provided when it is possible).

	Taxi out	TMA departure	En-route	TMA arrival	Taxi in
PRD1	NA	NA	NA	In the order of seconds	NA

	Taxi out	TMA departure	En-route	TMA arrival	Taxi in
Average of Difference in actual & Flight Plan or RBT durations					
PRD2 Variance of Difference in actual & Flight Plan or RBT durations	NA	NA	NA	Reduces with increasing IM equipage rate, reduces with increasing traffic load	NA

Table 24: Predictability benefit per flight phase

Were there any benefits obtained in SESAR2020 Wave1 for this Demo? No. Individual solutions had benefits, however the combined integrated concept has not been tested before.

4.10.4 Discussion of Assessment Result

The Objective is evaluated in detail in the DEMOR Part I, Appendix A.3.2 paragraph 16 for EXE-PJ.37-W3-001 and B.3.2 paragraph 16 for EXE-PJ.37-W3-002.

The confidence in the results is high as the AMAN used in the simulation is a research tool that is based on an operational AMAN system with adjustments made to accommodate operation with the integrated tool. In addition, this AMAN has been used in many European and local projects in which the developments required for this project have been implemented. The simulation data is based on the BADA aircraft performance models and thus are realistic. However the confidence in the generalised finding of the impact of the solution is low level due to the limited number of (RTS) evaluations. To increase the confidence of the generalised finding and to also transfer this to ECAC wide level, FTS have to be performed. Thus no extrapolation is performed.

4.10.5 Additional Comments and Notes

All additional comments are mentioned in Appendix A.3.2 and B.3.2 of the DEMOR [12].

4.11 Punctuality

Does the Demo impact this KPA? No

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

Does the Demo impact this KPA? No

4.13 Flexibility

Does the Demo impact this KPA? No

4.14 Cost Efficiency

Does the Demo impact this KPA? No

4.15 Airspace User Cost Efficiency

Does the Demo impact this KPA? No

4.16 Security

Does the Demo impact this KPA? No

4.17 Human Performance

4.17.1 HP arguments, activities and metrics

A Scoping & Change Assessment workshop was held to systematically identify and capture the nature of the change that may result due to the introduction of the concept under investigation. Following this workshop, a further review by the HP Lead of the relevant SESAR documentation was conducted.

In summary, two high level HP Arguments are impacted in some way by the integrated arrival concept being developed by PJ.37-W3 Solution Track 1A. These are:

Arg 1: The role of the human is consistent with human capabilities and limitations.

Arg 2: Technical systems support the human actors in performing their tasks.

No changes are foreseen related to arguments 3 and 4 given the applicable maturity level.

For a detailed description of the Human Performance results of the demonstration, refer to DEMOR Part III [15].

PIs	Activities & Metrics	Second level indicators	Covered
HP1 Consistency of human role with respect to human capabilities and limitations	RTS 1 and 2, questionnaire and debriefing	HP1.1 Clarity and completeness of role and responsibilities of human actors	NA
		HP1.2 Adequacy of operating methods (procedures) in supporting human performance	Closed
		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	RTS 1 and 2, debriefing, questionnaires, observations, simulator data	HP2.1 Adequacy of allocation of tasks between the human and the machine (i.e. level of automation).	NA
		HP2.2 Adequacy of technical systems in supporting Human Performance with respect to timeliness of system responses and accuracy of information provided	NA
		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	NA	HP3.1 Adequacy of team composition in terms of identified roles	NA
		HP3.2 Adequacy of task allocation among human actors	NA
		HP3.3	NA

PIs	Activities & Metrics	Second level indicators	Covered
		Adequacy of team communication with regard to information type, technical enablers and impact on situation awareness/workload	
HP4 Feasibility with regard to HP-related transition factors	NA	HP4.1 User acceptability of the proposed Demo	NA
		HP4.2 Feasibility in relation to changes in competence requirements	NA
		HP4.3 Feasibility in relation to changes in staffing levels, shift organization and workforce relocation.	NA
		HP4.4 Feasibility in relation to changes in recruitment and selection requirements .	NA
		HP4.5 Feasibility in terms of changes in training needs with regard to its contents, duration and modality.	NA

Table 25: HP arguments, activities and metrics

4.17.2 Extrapolation to ECAC wide

There is no ECAC wide extrapolation required for this KPI.

4.17.3 Open HP issues/ recommendations and requirements

All identified HP issues and benefits have been addressed during the RTS1 and RTS2. An indication for each recommendation is provided whether it has been validated in RTS2. For Human Performance, the following recommendations have been formulated.

REC-37-W3-HUP-R4.1: Design arrival routes such that turns are 135 degree or larger and that routes to parallel runways are not exactly mirrored (avoid head-on base legs). **Validated in RTS2.**

REC-37-W3-HUP-R4.2: Standardise the altitude at IAF or start the RNP approach at the merge point. **Standardised altitude was validated in RTS2.**

REC-37-W3-HUP-R4.3: The concept should ensure a minimum separation at the merge point. As a solution the IM achieve-by point can be placed at the merge point. **This was validated in RTS 2.**

REC-37-W3-HUP-R4.4: The integrated concept ideally ensures a gradual reduction of speeds. This requires sufficient testing of the integrated tools and investigate at what point to (automatically) terminate IM earlier.

REC-37-W3-HUP-R6.1: In case of changes in the inbound sequence it is recommended to update the inbound planning (AMAN/Supervisor) or cancel the IM for one (or several) flights, instead of changing IM targets.

REC-37-W3-HUP-R6.2: It is recommended to take a closer look at responsibilities such as monitoring the traffic at final, with high volumes of traffic. Can this reasonably be expected from the ATCO?

REC-37-W3-HUP-R7.1: Design the HMI, such that:

- It is clear which flights are IM capable and which are not; **Validated in RTS2**
- It is clear which flights are applying IM (**validated in RTS2**), and whether it is applied correctly (to the flight preceding on the route);
- It is clear which flights are established on RNP; **Validated in RTS2**
- That ATCO can change the sequence with a minimal number of actions

REC-37-W3-HUP-R7.2: When the actual sequence is different from the planned sequence, the planning is preferably updated (automatically ensuring the right IM target for each flight). If a mix up of IM targets is a possible occurrence, the controller could be made aware of such mix-ups.

REC-37-W3-HUP-R8.1: Consider automated adherence monitoring of the NTZ.

REC-37-W3-HUP-R8.2: The concept should ensure the gradual reduction of speeds of arriving traffic.

REC-37-W3-HUP-R9.1: Divide the work of the FDR between two ATCOs (TWEC/TOC). **Validated in RTS 2.**

REC-37-W3-HUP-R9.2: Expand Non Transition Zone (automated monitoring) for traffic established on RNP (18/18). **Validated in RTS 2**

REC-37-W3-HUP-R10.1: Trust should develop with more experience. Test the concept with, for example:

- Go-arounds: **Validated in RTS2**
- Provide a gap for runway inspection
- Change sequence (e.g. emergency). **Validated in RTS2**
- Runway closure
- Runway change

REC-37-W3-HUP-R11.1: Improve IM alert: **Validated in RTS2**

REC-37-W3-HUP-R11.2: Improve HMI to provide an indication when a flight is established on RNP: **Validated in RTS2**

REC-37-W3-HUP-R11.3: Alternatively, a turn in the designed route may serve as a checkpoint whether a flight is established: **Validated in RTS2**

REC-37-W3-HUP-R14.1: Provide ghost indicator only for flights almost in TMA. **Validated in RTS 2**

PIs	Number of open issues/ benefits	Nr. of recommendations	Number of requirements
HP1 Consistency of human role with respect to human capabilities and limitations	4 (Objectives are POK)	16 (8 closed)	0
HP2 Suitability of technical system in supporting the tasks of human actors	1 (Objective is POK)	4 (3 closed)	0
HP3 Adequacy of team structure and team communication in supporting the human actors	NA	NA	NA
HP4 Feasibility with regard to HP-related transition factors	NA	NA	NA

Table 26: Open HP issues/ recommendations and requirements

4.17.4 Concept interaction

The aim of this solution track PJ.37-W3-01A was to identify possible interactions between the SESAR solutions.

4.17.5 Most important HP issues

Please list here any important issues that might have a major impact on the performance of the Demo.

In case issues that impact other solutions are envisaged please list them here to facilitate the aggregation of data into deployment scenarios

PIs	Most important issue of the Demo	Most important issues due to solution interdependencies
HP1 Consistency of human role with respect to human capabilities and limitations	Overall, working procedures seem not fully acceptable and complete. Certain aspects require further attention, e.g. how to deal with (inevitable) unexpected traffic behaviour, but still fall under normal operations. Working procedures clarity and consistency were neutrally rated in RTS 2. It seems that this requires further attention.	NA as the aim of this solution track PJ.37-W3-01A was to identify possible interactions between the SESAR solutions.
	The ability of the controller to follow the working procedures: Overall, high amounts of traffic and high speeds make it difficult to monitor the traffic at all route segments in the same way it is done in current operations. Also,	NA as the aim of this solution track PJ.37-W3-01A was to identify possible interactions between the SESAR solutions.

PIs	Most important issue of the Demo	Most important issues due to solution interdependencies
	the task of changing IM targets should be avoided.	
	The ATCOs' confidence in the concept was rated positively, with the remark that in the simulation the pilots were very collaborative and timely following up instructions, which is not the case in current day operations.	NA as the aim of this solution track PJ.37-W3-01A was to identify possible interactions between the SESAR solutions.
HP2 Suitability of technical system in supporting the tasks of human actors	Overall, working procedures seem not fully acceptable and complete. Certain aspects require further attention, e.g. how to deal with (inevitable) unexpected traffic behaviour, but still fall under normal operations	NA as the aim of this solution track PJ.37-W3-01A was to identify possible interactions between the SESAR solutions.
HP3 Adequacy of team structure and team communication in supporting the human actors	NA	NA
HP4 Feasibility with regard to HP-related transition factors	NA	NA

Table 27: Most important HP issues

4.17.6 Additional Comments and Notes

None.

4.18 Other PIs

Further PIs from the Performance Framework update have not been assessed.

4.19 Gap Analysis

The objective of the gap analysis is a comparison between the validation targets and the performance assessment. No Validation Targets have been allocated to this solution track by PJ.19 and, therefore, the most relevant KPIs for the solution track have been identified and reported against. The table below summarizes the comparison done in sections 4.3.4, 4.4.4, 4.6.4, 4.7.4 and 4.10.4.

KPI	Validation Targets – Network Level (ECAC Wide)	Performance Benefits at Network Level (ECAC Wide or Local depending on the KPI) ¹²	Rationale ¹³
SAF1: Safety - Total number of estimated accidents with ATM Contribution per year	NA	NA	NA, accident assessment requires Dynamic Risk Modelling
FEFF1: Fuel Efficiency - Actual average fuel burn per flight	NA	ECAC/Network wide: 5.5 kg saving per flight. 6.7% on local level for peak arrivals in the TMA for large and very large airports.	As expected
CAP1: TMA Airspace Capacity - TMA throughput, in challenging airspace, per unit time.	NA	Traffic load in simulation was increased by 7.5%, however solution was not stressed to maximum traffic load (local).	As expected
CAP2: En-Route Airspace Capacity - En-route throughput, in challenging airspace, per unit time	NA	NA	NA, en-route outside of scope
CAP3: Airport Capacity – Peak Runway Throughput (Mixed mode).	NA	NA	NA, no mixed mode operation in simulation. PI CAP3.2 is evaluated.

¹² Negative impacts are indicated in red.

¹³ Discuss the outcome if the gap indicates a different understanding of the contribution of the Solution (for example, the Solution is enabling other Solutions and therefore is not contributing a direct benefit). **Please contact your PJ19.04 Solution Champion to clarify when the Gap Rationale is needed.**

KPI	Validation Targets – Network Level (ECAC Wide)	Performance Benefits at Network Level (ECAC Wide or Local depending on the KPI) ¹²	Rationale ¹³
TEFF1: Gate-to-gate flight time	NA	NA	NA, ground ops outside of scope
PRD1: Predictability – Average of Difference in actual & Flight Plan or RBT durations	NA	In the order of seconds (local)	Results show very accurate resemblance to planning
PUN1: Punctuality – Average departure delay per flight	NA	NA	NA, focus on arrivals
CEF2: ATCO Productivity – Flights per ATCO - Hour on duty	NA	NA	NA, ATCO productivity not quantified
CEF3: Technology Cost – Cost per flight	NA	NA	NA, not evaluated

Table 28: Gap analysis Summary

5 References

- [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)¹⁴
- [3] SESAR Performance Framework (2019), Edition 01.00.01, Dec 2019
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- [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
- [6] SESAR, S2020 Common Assumptions (2019), PJ.19.CI, Deliverable D4.0.30, Sep 2019.

Content Integration

- [7] SESAR ATM Lexicon

Performance Management

- [8] PJ19.04 D4.1 Validation Targets - Wave 2 (2020)¹⁵
- [9] SESAR Solution PJ.01-05 SPR/INTEROP-OSED for V2 - Part V - Performance Assessment Report (PAR) (2019), Edition 00.02.00, Oct 2019
- [10] SESAR Solution PJ.01-05 SPR/INTEROP-OSED for V2 - Part IV – Human Performance Assessment Report, Edition 00.02.00, Oct 2019
- [11] SESAR Solution 02-01 SPR/INTEROP-OSED for V3 - Part V - Performance Assessment Report (2020), Edition 01.00.00, Jan 2020
- [12] SESAR Solution 02-08 SPR/INTEROP-OSED for V3 - Part V - Performance Assessment Report (PAR) (2020), Edition 00.04.00, Jan 2020
- [13] SESAR 2020 Project PJ37-W3-ITARO, D1.5 – PJ.37-W3-DEMOR – Part IV ENVAR, Track PJ.37-W3-01A, Edition 00.02.00, May 2023

¹⁴ At the time of the creation of the PAR template, the Methodology (PJ19.04 Internal Document) is foreseen to be update in 2020.

¹⁵ At the time of the creation of the PAR template the Validation Target is foreseen to be delivered in June 2020

[14]SESAR 2020 Project PJ37-W3-ITARO, D1.5 – PJ.37-W3-DEMOR – Part I, Edition 00.02.00, May 2023

[15]SESAR 2020 Project PJ37-W3-ITARO, D1.5 – PJ.37-W3-DEMOR – Part III HPAR, Edition 00.02.00, May 2023

[16]SESAR 2020 Project PJ37-W3-ITARO, D1.5 – PJ.37-W3-DEMOR – Part II SAR, Edition 00.02.00, May 2023

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

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

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

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[21]Accident Incident Models – AIM, release 2017

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Security

[26]16.06.02 D103 SESAR Security Ref Material Level

[27]16.06.02 D137 Minimum Set of Security Controls (MSSCs).

[28]16.06.02 D131 Security Database Application (CTRL_S)