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PJ37-W3-ITARO

INTEGRATED TMA, AIRPORT AND RUNWAY OPERATIONS

This Performance Assessment Report is part of project PJ.37-W3-ITARO 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

This document provides the Performance Assessment Report (PAR) for departure demonstration exercise PJ.37-W3-01B - Departure Operations, which consists of the extrapolation to ECAC-wide level of the performance assessment results conducted from EXE-PJ37-W3-004 and the process applied to obtain the results.

EXE-PJ37-W3-004 was a Real Time Simulation (RTS) conducted at Heathrow Airport Tower simulators and built upon the validation activities conducted in SESAR Wave 1 PJ.02-01-02 to assess the Optimised Separation Delivery (OSD) tool for departures (AO-0329), which was validated to V3 maturity. The PJ.37-W3-01B solution track extends the functionality of the Wave 1 OSD tool to support the Tower Runway Controller to apply refined, more granular route spacings. The simulation also builds on validation activities conducted in SESAR Wave 2 PJ.01-W2-08B, by including an emulated Terminal Manoeuvring Area (TMA) data-feed from the Systemised Airspace Management (SYSMAN) tool into the extended OSD tool in order to dynamically adjust the departure flow rate along individual Standard Instrument Departure (SID) routes if the workload in the TMA is predicted to become too high.

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1 Executive Summary

This document provides the Performance Assessment Report (PAR) for departure demonstration exercise PJ.37-W3-01B.

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

Description:

The PJ.37-W3-01B ITARO Departure solution track builds on previous work conducted in SESAR2020 Wave 1 and Wave 2 and can be split into two parts: (1) Optimised Separation Delivery (OSD) tool support and (2) integration of TMA information into the extended OSD tool through a Tower Platform RTS.

The PJ.37-W3-01B ITARO Departures solution track incorporates a TMA data-feed to ensure that the optimised route spacings do not put an excessive demand onto TMA sectors.

The aim is to extend the OSD tool developed in SESAR PJ.02-01-02 (AO-0329) by including tool support for applying optimised route spacings on departure. In addition, the PJ.37-W3-01B ITARO Departures solution track has been developed to align with work being carried out in SESAR Wave 2 Project PJ.01: Enhanced Arrivals and Departures, Solution PJ.01-W2-08B (Dynamic TMA/E-TMA for Advanced Optimised Descent Operations). The operational feasibility of this SYSMAN approach is investigated in the PJ.37-W3-01B ITARO Departures Solution track.

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.

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 for each KPI from PJ19 [11]. The impact of a Demo on the performances are described in the Benefit Impact Mechanism¹. All the KPIs and mandatory PIs from the Benefit Mechanism which the Demo potentially impact have to be assessed via validation results, expert judgment, etc.

There are three cases of assessment results:

¹ There are no BIMs available for PJ.37-W3-01B; however BIMs were produced for Wave 1, which can be referred to in the SESAR Solution PJ02-01 SPR-INTEROP/OSD for V3 - Part I [8]

1. An assessment result of 0 with a 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) ²	Confidence in Results ³
SAF1: Safety - Total number of estimated accidents with ATM Contribution per year	N/A	N/A	N/A
FEFF1: Fuel Efficiency - Actual average fuel burn per flight	N/A	extended OSD without a TMA data-feed (SOL1): - 1.6 kg per flight (-0.03%) extended OSD with a TMA data-feed (SOL2): - 3.7 kg per flight (-0.07%) Departure (50%) flights into very large (30%) and large (8%) airports = 19% of all ECAC flights impacted	Medium – the results might change by +/- 25%
CAP1: TMA Airspace Capacity - TMA throughput, in challenging airspace, per unit time.	N/A	N/A	N/A

² Negative impacts are indicated in red.

³ 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

CAP2: En-Route Airspace Capacity - En- route throughput, in challenging airspace, per unit time	N/A	N/A	N/A
CAP3: Airport Capacity – Peak Runway Throughput (Mixed mode).	N/A	N/A	N/A
TEFF1: Gate-to-gate flight time	N/A	extended OSD Tool without TMA Data Feed (SOL1): 0.07 minutes (0.07%) extended OSD Tool with TMA Data Feed (SOL2): 0.18 minutes (0.18%) Departure (50%) flights out of very large (30%) and large (8%) airports = 19% of all ECAC flights impacted	Medium – the results might change by +/- 25%
PRD1: Predictability – Average of Difference in actual & Flight Plan or RBT durations	N/A	extended OSD Tool without TMA Data Feed (SOL1): 0.07 minutes (0.07%) extended OSD Tool with TMA Data Feed (SOL2): 0.18 minutes (0.18%) Departure (50%) flights out of very large (30%) and large (8%) airports = 19% of all ECAC flights impacted	Medium – the results might change by +/- 25%
PUN1: Punctuality – Average departure delay per flight	N/A	Unable to be assessed quantitatively	N/A
CEF2: ATCO Productivity – Flights per ATCO -Hour on duty	N/A	extended OSD Tool without TMA Data Feed (SOL1): 0.12 (0.21%) increase aircraft handled per hour	Medium – the results might change by +/- 25%

		extended OSD Tool with TMA Data Feed (SOL2): 0.31 (0.56%) increase in aircraft handled per hour Departure (50%) flights out of very large (30%) and large (8%) airports = 19% of all ECAC flights impacted	
CEF3: Technology Cost – Cost per flight	N/A	N/A	N/A

Table 1: KPI Assessment Results Summary

Mandatory PI	Performance Expectations at Network Level (ECAC Wide or Local depending on the KPI) ⁴	Benefits at Network	Confidence Results ⁵	in
SAF1.X: Mid-air collision - En-Route	N/A		N/A	
SAF2.X: Mid-air collision - TMA	N/A		N/A	
SAF3.X: RWY-collision accident	N/A		N/A	
SAF4.X: TWY-collision accident	N/A		N/A	
SAF5.X: CFIT accident	N/A		N/A	
SAF6.X: Wake related accident	N/A		N/A	
SAF7.X: RWY-excursion accident	N/A		N/A	
SAF8.X ...: Other SAF Risks	N/A		N/A	

⁴ Negative impacts are indicated in red.

⁵ 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

SEC1: A security risk assessment has been carried out	N/A	N/A
SEC2: Risk Treatment has been carried out	N/A	N/A
SEC3: Residual risk after treatment meets security objective.	N/A	N/A
ENV1: Actual Average CO2 Emission per flight	extended OSD without a TMA data-feed (SOL1): -5.0 kg per flight (-0.03%) extended OSD with a TMA data-feed (SOL2): -11.7 kg per flight (-0.07%) Departure (50%) flights out of very large (30%) and large (8%) airports = 19% of all ECAC flights impacted	Medium – the results might change by +/-25%
NOI1: Relative noise scale	N/A	N/A
NOI2: Size and location of noise contours	N/A	N/A
NOI4: Number of people exposed to noise levels exceeding a given threshold	N/A	N/A
LAQ1: Geographic distribution of pollutant concentrations	N/A	N/A
CAP3.1: Peak Departure throughput per hour (Segregated mode)	extended OSD without TMA Data Feed: +1.3 (2.4%) extended OSD with TMA Data Feed: +1.7 movements (3.2%). Departure (50%) flights out of very large (30%) and large (8%) airports = 19% of all ECAC flights impacted	Medium – the results might change by +/-25%
CAP3.2: Peak Arrival throughput per hour (segregated mode)	N/A	N/A
CAP4: Un-accommodated traffic reduction	N/A	N/A
RES1: Loss of Airport Capacity Avoided	N/A	N/A

RES1.1: Airport time to recover from non-nominal to nominal condition	N/A	N/A
RES2: Loss of Airspace Capacity Avoided.	N/A	N/A
RES2.1: Airspace time to recover from non-nominal to nominal condition.	N/A	N/A
RES4: Minutes of delays.	N/A	N/A
RES5: Number of cancellations.	N/A	N/A
TEFF2: Taxi in time	N/A	N/A
TEFF3: Taxi out time	extended OSD Tool without TMA Data Feed (SOL1): 0.07 minutes (0.07%) extended OSD Tool with TMA Data Feed (SOL2): 0.18 minutes (0.18%) Departure (50%) flights out of very large (30%) and large (8%) airports = 19% of all ECAC flights impacted	Medium – the results might change by +/-25%
TEFF4: TMA arrival time	N/A	N/A
TEFF5: TMA departure time	N/A	N/A
TEFF6: En-Route time	N/A	N/A
PRD2: Variance of Difference in actual & Flight Plan or RBT durations	extended OSD Tool without TMA Data Feed (SOL1): - 0.17 (-0.35%) extended OSD Tool with TMA Data Feed (SOL2): - 0.65 (-1.34%) Departure (50%) flights out of very large (30%) and large (8%) airports = 19% of all ECAC flights impacted	Medium – the results might change by +/-25%
PUN2: % Flights departing within +/- 3 minutes of scheduled departure time due to ATM and weather related delay causes	N/A	N/A
CEF1: Direct ANS Gate-to-gate cost per flight	N/A	N/A

AUC3: Direct operating costs for an airspace user	N/A	N/A
AUC4: Indirect operating costs for an airspace user	N/A	N/A
AUC5: Overhead costs for an airspace user	N/A	N/A
CMC1.1: Allocated vs. Requested ARES duration	N/A	N/A
CMC1.2: Allocated vs. Requested ARES dimension	N/A	N/A
CMC1.3: Deviation of Transit Time to/from airbase to ARES	N/A	N/A
CMC 1.3.1: Allocated ARES duration vs. total mission duration	N/A	N/A
CMC 1.3.2: Deviation of total mission duration by iOAT FPL validation	N/A	N/A
CMC 1.4.1: Rate of iOAT FPLs acceptance by NM systems	N/A	N/A
CMC 1.4.2: Rate of iOAT FPLs acceptance by ATC systems	N/A	N/A
CMC2.1: Fuel and Distance saved by GAT	N/A	N/A
HP1: Consistency of human role with respect to human capabilities and limitations	N/A	N/A
HP2: Suitability of technical system in supporting the tasks of human actors	N/A	N/A
HP3: Adequacy of team structure and team communication in supporting the human actors	N/A	N/A
HP4: Feasibility with regard to HP-related transition factors	N/A	N/A
FLX1: Average delay for scheduled civil/military flights with change request and non-scheduled or late flight plan request	N/A	N/A

Table 2 Mandatory PIs Assessment Summary

2 Introduction

2.1 Purpose of the document

The Performance Assessment covers the Key Performance Areas (KPAs) defined in the SESAR2020 Performance Framework [3]. Assessed are at least the Key Performance Indicators (KPIs) and the mandatory Performance Indicators (PIs), but also additional PIs as needed to capture the performance impacts of the 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 validation 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 validation exercises results have been consolidated) used to achieve this performance assessment result.

2.2 Intended readership

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

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

2.3 Inputs from other projects

The document includes information from the following SESAR 2020 Wave 1 projects:

- PAGAR 2019 [4]: Performance Assessment and Gap Analysis Report (2019), where are collected the final benefits from SESAR 2020 Wave 1.

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.

- ## 2.4 Glossary of terms

2.5 Acronyms and Terminology

Term	Definition
ADIS	Airport Display Information System
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
DB	Deployment Baseline
DOD	Detailed Operational Description
E-ATMS	European Air Traffic Management System
ECAC	European Civil Aviation Conference
extended OSD	Extended Optimised Separation Delivery
HMI	Human-Machine Interface

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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
QoS	Quality of Service
RBT	Reference Business / Mission Trajectory
RTS	Real Time Simulation
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.
SYSMAN	Systemised Airspace Management

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

Term	Definition	Source
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
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

Term	Definition	Source
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
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

Term	Definition	Source
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
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

Term	Definition	Source
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
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

Term	Definition	Source
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
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

Term	Definition	Source
Systemised Airspace Management (SYSMAN)	Based on the iACM (Indra Airspace Capacity Manager), the product that aims to help ANSPs to adapt demand and capacity strategically, enabling ANSPs to optimize operational and environmental performances, the SYSMAN “Systemised Airspace Manager” prototype is an extension with new functionality aiming at the balancing of demand among routes on a Systemised airspace.	
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 purpose of solution-track PJ.37-W3-01B - Departure Operations was to investigate the application of reduced, more granular route spacings on departure with an extended OSD tool. The RTS considered segregated runway operations in the Heathrow environment. The concept also assessed the integration of a TMA data-feed into the extended OSD tool, which dynamically adjusted the departure flow rate into the TMA dependent on the predicted TMA workload.

The RTS was built on the validation activities conducted in SESAR Wave 1 PJ.02-01-02 to assess the Optimised Separation Delivery (OSD) tool for departures (AO-0329), which was validated to V3 maturity. The PJ.37-W3-01B solution track extends the functionality of the Wave 1 OSD tool to support the Tower Runway Controller to apply refined, more granular route spacings. The simulation also builds on validation activities conducted in SESAR Wave 2 PJ.01-W2-08B, by including an emulated TMA data-feed from the SYSMAN tool into the extended OSD tool in order to dynamically adjust the departure flow rate along individual SIDs if the workload in the TMA is predicted to become too high.

The RTS was configured for London Heathrow, which is classified as a Very Large Airport according to the Airports' classification scheme in SESAR 2020 [6]. The RTS involved Tower controllers and a TMA expert observer from NATS. The simulation was led by NATS and supported by INDRA, who provided expert advice on the TMA data-feed requirements.

The exercise addressed the following key demonstration objectives to support route spacing reduction and refinement on departure, which could be dynamically adjusted based information from an emulated TMA data-feed: OPF Operational Feasibility, HUP Human Performance, CAP Capacity, OPE Operational Efficiency, ENV Environment, CEF Cost Efficiency and SAF Safety.

To assess the operational feasibility of the ITARO Departures Solution with and without the TMA data feed (Solution Scenarios) a comparative assessment was conducted against two Reference Scenarios:

1. RECAT-EU 6-CAT wake time separations with OSD tool organisation (no route spacing tool support).
2. PWS-D solution organisation based on 103x103 PWS and 20-CAT PWS wake time separations with OSD tool support (no route spacing tool support).

Four Solution Scenarios were tested:

1. Time-Based RECAT-EU with extended OSD tool support with an emulated TMA data-feed.
2. Time-Based PWS-D with extended OSD tool support with an emulated TMA data-feed.
3. Time-Based RECAT-EU with extended OSD tool support without a TMA data-feed.
4. Time-Based PWS-D with extended OSD tool support without a TMA data-feed

For a detailed description of the Demonstration Exercise, including objective, success criteria, and experimental design refer to the Demonstration Plan (DEMOP) [7].

3.2 Detailed Description of relationship with other Solution

Solution Number	Solution Title	Relationship	Rational for the relationship
PJ.02-W2-14.8	Enhanced separation delivery for departures (extended OSD)	Is preferable to	The extended OSD tool validated in PJ.37 replaces and improves upon previous iterations of the tool assessed under previous SESAR solutions
PJ.02-01-02	Optimised spacing delivery for departure	Is preferable to	The extended OSD tool validated in PJ.37 replaces and improves upon previous iterations of the tool assessed under previous SESAR solutions
PJ.02-01-06	Wake Separations (for Departures) based on Static Aircraft Characteristics	Is pre-requisite to	A separation delivery tool is required to operate pairwise wake separations on departure.

Table 5: Relationships with other Solutions

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.

Organisation	Document Title	Publishing Date
EUROCONTROL and NATS	SESAR SOLUTION 02-01-02 VALR for V3	31 st January 2020

Table 6: Pre-SESAR2020 Exercises

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

Exercise ID	Exercise Title	Release	Maturity	Status
EXE-PJ.37-W3-004	ITARO for departures in segregated runway operations	R12	TRL7-ongoing	Completed

Table 7: SESAR2020 Validation Exercises

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

Exercise	OI Step	Exercise scenario & scope	Performance Results
EXE-PJ.37-W3-004	AO-0329 ⁷	Real Time Simulation demonstration of reduced and refined non-wake SID separations on departure and their integration with an extended departure Optimised Separation Delivery (extended OSD) tool with a TMA data feed on a single runway in segregated mode (London Heathrow).	CAP3.1: SOL1 (extended OSD without TMA Data Feed) achieved a higher throughput than the REF in 9 out of 11 matches and an average increase of 1.3 movements an hour (2.4%). SOL2 (extended OSD with TMA Data Feed) achieved a higher throughput than the REF in 7 out of 10 matches and an average increase of 1.7 movements (3.2%). PRD1:

⁷ PJ.37-W3-01B is not developing or explicitly validating this OI any further than the already validated V3 maturity status. Instead, elements within this OI are being used and the scope is being broadened in order to obtain maximum performance benefits in this VLD-like activity

			Taxi-out Variability: When comparing REF to SOL1 (extended OSD without TMA Data Feed), the average taxi time was higher in REF than for SOL1 in 8 out of 11 matches. When comparing REF to SOL2 (extended OSD with TMA Data Feed), the average taxi time was higher in REF than for SOL2 in 7 out of 9 matches. For the majority of matches, the REF average taxi times were higher than for either SOL1 or SOL2. The results show a reduction in Standard Deviation for SOL1 runs compared to the matched Reference Scenario runs of - 0.10 minutes. A similar result is found for SOL2 compared with the matched Reference Scenario runs with a reduction of standard deviation by -0.40 minutes. RHA Delay: The data analysis shows that there was a reduction in mean RHA delay of 0.3 minutes when comparing REF with SOL1 (extended OSD without TMA Data Feed) and REF with SOL2 (extended OSD with TMA Data Feed). The standard deviation in RHA delay in the SOL1 and SOL2 Scenario runs was reduced compared to the matched reference scenario runs. <u>ENV1:</u> extended OSD without a TMA data-feed (SOL1): -18 kg fuel burn per flight (- 0.03%) extended OSD with a TMA data-feed (SOL2): -7 kg fuel burn per flight (-0.07%) extended OSD Tool with a TMA data feed (SOL2): reduction in CO2 emissions of 57 kg per flight compared to the Reference Scenario. extended OSD Tool without TMA Data Feed (SOL1): reduction in Co2 emissions of 23 kg per flight compared to the Reference Scenario.
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			ATCO Productivity: extended OSD Tool without TMA Data Feed (SOL1): 0.6 (1.1%) increase aircraft handled per hour. extended OSD Tool with TMA Data Feed (SOL2): 1.6 (2.9%) increase in aircraft handled per hour.
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Table 8: Summary of Validation Results.

4.2 Conditions / Assumptions for Applicability

The following Table 9 summarises the applicable operating environments.

OE	Applicable sub-OE	Special characteristics
Airport	Airport very large	Runway capacity-constrained airports during peak periods
	Airport large	Segregated mode-only

Table 9: Applicable Operating Environments.

The runway configurations and modes of operations employed at Very Large and Large Airports include:

- Independent parallel runways operating in segregated mode operations.
- Dependent parallel runways operating in segregated mode operations with the option of some arrival aircraft landing on the designated departure runway.
- Closely spaced parallel runways operating in segregated mode operations.
- Single runway operating in mixed mode operations.
- Closely spaced parallel runways operating in mixed mode / partially segregated operations.

However, the scope of the PJ.37-W3-01B validation activity has been limited to runways operating in segregated mode operations.

Note: For the purposes of representative extrapolation of KPI benefits, the standard classification list of Very Large and Large Airports has been further refined to only consider those that are expected to be capacity-constrained in the expected deployment timeframe (9 Very Large and 10 Large). Based on this, the proportion of flights impacted at ECAC level has been re-calculated.

4.3 Safety

4.3.1 Safety Design drivers and Performance Mechanism

The SESAR solution that has been demonstrated in PJ.37-W3-01B (Departures operations) and the respective operational improvement step can be summarised below:

SESAR Solution ID and Title	SESAR Solution Description	OI Steps ref. (coming from EATMA)	Enablers ref. (coming from EATMA)
PJ.02-01-02 Optimised spacing delivery for departure	OSD is the ATC support to enable safe, consistent and efficient delivery of the required separation or spacing between departure pairs from the follower aircraft becoming airborne.	AO-0329 Optimised Separation Delivery for Departure	AERODROME-ATC-69 (Develop) ATC system to support optimised departure separation

Table 10:SESAR Solution ID, Description with relevant OI steps and Enablers.

The SAC setting is driven by the analysis of the impact of the change on the relevant AIM models (identified in DEMOR Part II Appendix **Error! Reference source not found.**).

The following section defines the SAC applicable to the operational scenario for the whole of the PJ.37-W3-01B ITARO solution (described in the DEMOP Part I Section 4.3.2). Two sets of safety criteria are formulated:

- A first one aimed at ensuring an appropriate separation design, i.e., definition of SID separation minima which, if correctly applied in operation, guarantee safe operations on runway departure, on the initial common departure path and SID, respectively.
- A second one aimed at ensuring correct Spacing delivery, i.e., that the defined SID spacing minima are correctly applied for spacing delivery by ATC.

In support of the above, the following SACs have been defined for the whole solution:

	Wording	Rationale
SAC#D1a	There shall be no increase in imminent wake separation infringements which are induced by ATC to the 1 st aircraft whilst on departure (2 nd aircraft not yet airborne) in operations based on the extended OSD tool compared to operations with the Reference Scenario OSD tool (AO-0329).	On possibility of imminent wake separation infringement on departure induced by ATC and the second aircraft is not yet airborne (see WE7F.1.a in AIM Wake Induced Risk on Initial Departure).
SAC#D2a	There shall be no increase in imminent wake separation infringements which are induced by ATC to the 1 st or 2 nd aircraft whilst on departure in operations based	On possibility of imminent wake separation infringement on departure induced by ATC and the second aircraft is airborne (see

	on the extended OSD tool compared to operations with the Reference Scenario OSD tool (AO-0329).	WE7F.2 in AIM Wake Induced Risk on Initial Departure).
SAC#D3:	There shall be no increase in imminent minimum radar separation infringements (non-wake) on the initial departure induced by ATC for the 1 st or 2 nd aircraft whilst on departure in operations based on the extended OSD tool compared to operations with the Reference Scenario OSD tool (AO-0329).	On possibility of an imminent radar separation infringement on the initial departure path induced by ATC for either 1 st or 2 nd aircraft. (see ME7F.1 and ME7F.2 AIM MAC Risk on initial Departure).
SAC#D5a	There shall be no increase in tactical conflicts (non-wake) in the TMA departing sectors induced by ATC for the 1 st or 2 nd aircraft whilst on departure in operations based on the extended OSD tool compared to operations with the Reference Scenario OSD tool (AO-0329).	On possibility of tactical conflicts whilst in the TMA induced by ATC for either 1 st or 2 nd aircraft. (see MF7.1.1.2 and MF7.1.1.2.1 leading to MF7.1 in AIM MAC Risk in TMA).
SAC#D5b	There shall be no increase in imminent minimum radar separation (non-wake) in the TMA departing sectors induced by ATC for the 1 st or 2 nd aircraft whilst on departure in operations based on the extended OSD tool compared to operations with the Reference Scenario OSD tool (AO-0329).	On possibility of an imminent minimum radar separation infringement whilst in the TMA induced by ATC for either 1 st or 2 nd aircraft. (see MF7 in output of MB14.2 in AIM MAC Risk in TMA).
SAC#D6	The probability per departure of severe and or extreme wake turbulence events shall be no greater in operations using the extended OSD tool compared to operations with the reference scenario OSD tool.	On possibility of severe and or extreme wake turbulence events on departure induced by ATC for either 1 st or 2 nd aircraft. (see WE3 and WE2 in AIM WAKE ID).

Table 11: Summary of Safety Criteria for PJ.37-W3-01B.

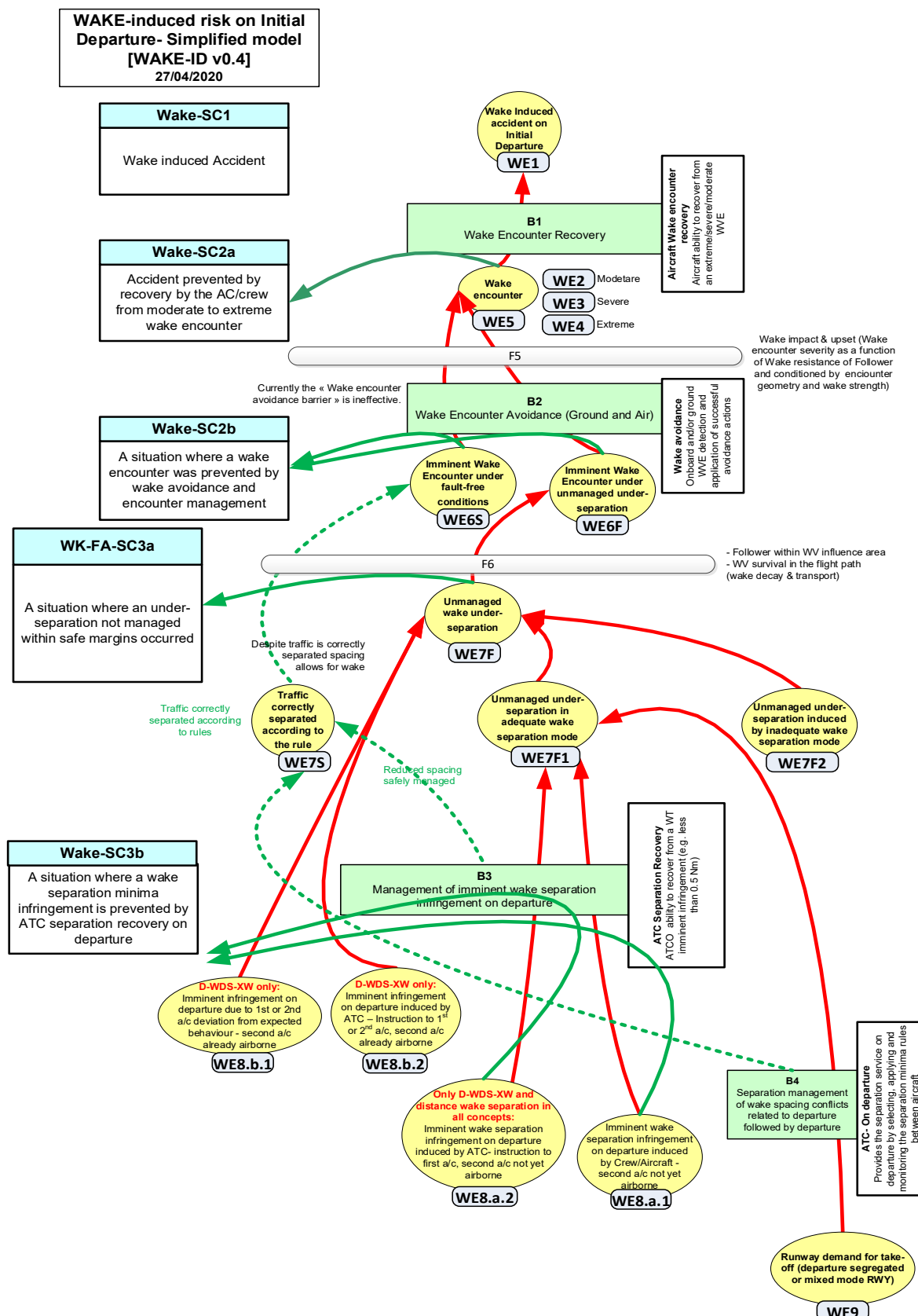


Figure 1: Simplified Aim Diagram for Wake Induced Risk on Initial Departure.

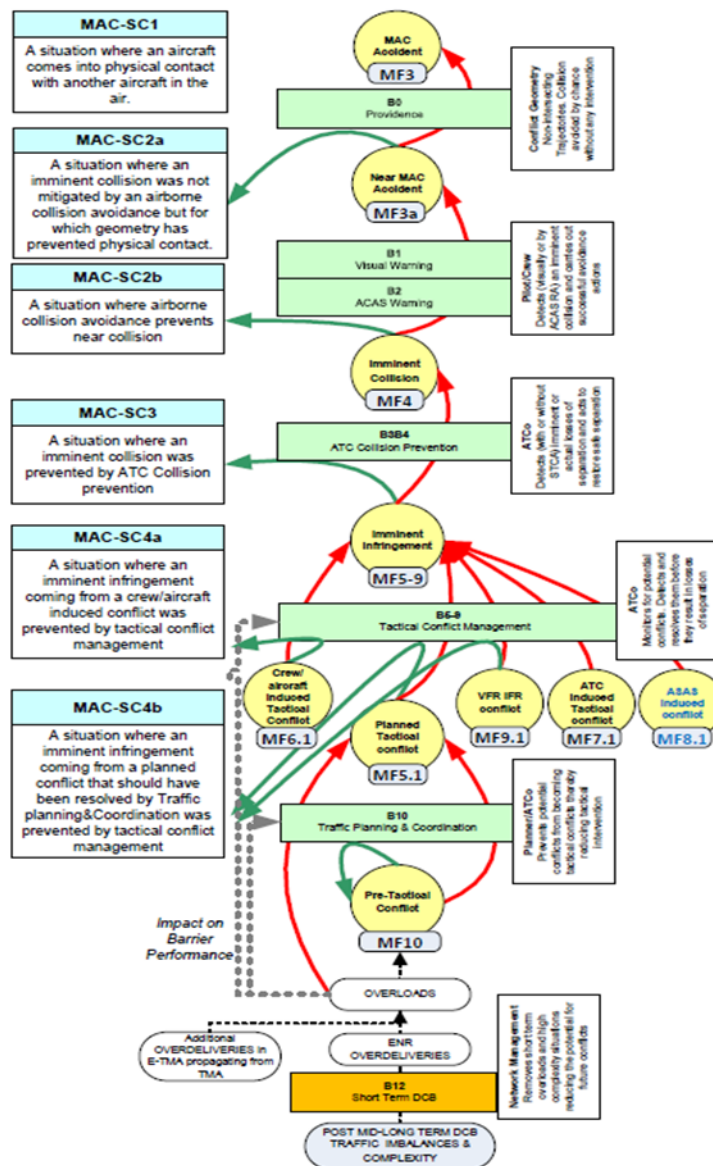


Figure 2: Simplified AIM Diagram for Mid-Air Collision Risk.

4.3.2 Data collection and Assessment

From the Safety Criteria listed in the previous section and by following the SRM process, Safety Objectives (SO) have been developed within the success approach (ensuring that the design enables safe operations in absence of failure within the solution scope) and the failure approach (via identification of operational hazards). Therefore, the Safety Criteria are implicitly achieved by the design through the demonstration that the design meets the aforementioned SOs. The safety demonstration, documented in the SAR is based on a combination of evidence gathered from the validation simulations, post simulation workshop, controller questionnaires and data analysis from ATCOs, PJ.37-W3-01B team members and analytical experts at NATS.

Table 12 summarises the safety objectives for the demonstration of the success criterion and the related evidence strands:

ID	Demonstration Exercise Safety Objectives	Success Criterion	Evidence Strands
OBJ-37-W3-DEMOP-SAF1-0008	To assess the impact of the ITARO Departures Solution on operational safety in the Tower compared to the Reference Scenario.	CRT-37-W3-DEMOP-004-SAF-001 - There is evidence that the level of safety for the Tower controllers' operations is maintained and not negatively impacted with the ITARO Departures Solution compared to the Reference Scenario. CRT-37-W3-DEMOP-004-SAF-002 - There is evidence that the ITARO Departures Solution does not increase the number of minor under-separations and decreases the number of large under-separations (i.e. those with potential for severe wake encounters and / or loss of separation) compared to the Reference Scenario.	Observations during the validation simulations to identify safety issues. Safety questionnaires for ATCOs to complete at the end of the day asking for their opinions on operational safety Post validation simulation workshop to discuss feedback & recommendations. Collect and analyse data from the validation simulations relating to achieved separations standards. (Wake / Under separations). An internal analytical study on catch-up in the TMA. End of day validation simulation discussions with ATCOs to identify safety issues.
OBJ-37-W3-DEMOP-SAF1-0009	To assess the impact on safety by the associated procedures	CRT-37-W3-DEMOP-004-SAF-003 - Evidence is gathered regarding the impact on safety and associated procedures that the ITARO Departure Solution has.	Safety questionnaires for ATCOs to complete at the end of the day asking for their opinions and any relevant impact on procedures Post validation simulation workshop to discuss feedback & recommendations. End of day discussion with ATCOs post exercise to identify safety issues.
OBJ-37-W3-DEMOP-	Understand the equipment requirements, e.g. corrupt data, hardware failure	CRT-37-W3-DEMOP-004-SAF-004 - Evidence is gathered regarding equipment	Safety questionnaires for ATCOs to complete at the end of the day asking for their

SAF1-0010		requirements and the ITARO Departure Solution.	opinions on failures & corrupt data. End of day discussion with ATCOs post exercise to identify safety issues. Post validation simulation workshop to discuss feedback & recommendations.
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Table 12: Summary of Safety Objectives, success criterion and relevant Evidence Strands.

The evidence strands have been collated, analysed and a full detailed discussion included in the PJ.37-W3-ITARO (01B) DEMOR Part II. Table 13, Table 14 and Table 15 summarise the salient points of each safety objective and related success criterion and feature suggested recommendations for future projects.

Identifier	OBJ-37-W3-DEMOP-SAF1-0008	KPA Category	Safety
Title	Safety 0008		
Objective	To assess the impact of the ITARO Departures Solution on operational safety in the Tower compared to the Reference Scenario		
Success Criterion	CRT-37-W3-DEMOP-004-SAF-001	There is evidence that the level of safety for the Tower controllers' operations is maintained and not negatively impacted with the ITARO Departures Solution compared to the Reference Scenario.	
	CRT-37-W3-DEMOP-004-SAF-002a	There is evidence that the ITARO Departures Solution does not increase the number of minor wake under-separations and decreases the number of large wake under-separations (i.e. those with potential for severe wake encounters and / or loss of separation) compared to the Reference Scenario.	
	CRT-37-W3-DEMOP-004-SAF-002b	There is evidence that the ITARO Departures Solution does not increase the number of route under-spacing events relative to the target distance spacing and compared to the Reference Scenario.	

Results	The overall feedback from ATCOs was that safety was not compromised as a result of the concept and discussions with ATCOs revealed they were confident with the output of the tool with regards to wake separations and route spacings. To provide evidence for the success criterion, data created in the validation simulations was collated and specific analysis was undertaken for wake-separations, route under-separations, route under-spacings and potential catch-ups in the TMA. This has provided evidence to support the success criterion; however, the analysis did highlight a number of issues and areas where improvements could be incorporated to progress the concept for future iterations. The following summarises the issues and recommendations:	OK														
<table><tr><th>Safety Issue</th><th>Recommendation</th></tr><tr><td>To ensure Reduced Separation is recorded correctly and accurately.</td><td>REC-37-W3-SAF-R1.1: During future testing of this solution in future projects, more robust procedures should be created to ensure all forms of Reduced Separation that ATCOs apply are recorded accurately and correctly in the simulation environment.</td></tr><tr><td>To ensure accuracy amongst all SID profile combinations.</td><td>REC-37-W3-SAF-R1.2: For future iterations of the extended OSD algorithm, refinements are required to ensure accuracy of the input values to the extended OSD tool describing the SID profiles flown by aircraft.</td></tr><tr><td>Effects of simulated weather conditions on the algorithm</td><td>REC-37-W3-SAF-R1.3: Further investigation should be undertaken regarding the MET conditions used in simulations and its interaction with the algorithm in order to refine the calculation of the route time spacing required.</td></tr><tr><td>To ensure realistic departure speed profiles are inputted in the simulation environment.</td><td>REC-37-W3-SAF-R1.4: Further investigation should be undertaken in future projects to ensure realistic departure speed profiles are used as an input in the simulation environment (Note this aligns with Operational Feasibility Recommendation R1 in the PJ.37-W2-01B Demo Report Part 1 [10]).</td></tr><tr><td>Reduce the probability of under-separations on certain route pairings.</td><td>REC-37-W3-SAF-R1.5: Further investigations should be undertaken in future projects to examine the use of 'safety buffers' on certain route pairings.</td></tr><tr><td>To understand differing aircraft speed data and performance.</td><td>REC-37-W3-SAF-R1.6: A larger sample size of differing aircraft types should be utilised in future projects to deduce whether improved departure speed</td></tr></table>			Safety Issue	Recommendation	To ensure Reduced Separation is recorded correctly and accurately.	REC-37-W3-SAF-R1.1: During future testing of this solution in future projects, more robust procedures should be created to ensure all forms of Reduced Separation that ATCOs apply are recorded accurately and correctly in the simulation environment.	To ensure accuracy amongst all SID profile combinations.	REC-37-W3-SAF-R1.2: For future iterations of the extended OSD algorithm, refinements are required to ensure accuracy of the input values to the extended OSD tool describing the SID profiles flown by aircraft.	Effects of simulated weather conditions on the algorithm	REC-37-W3-SAF-R1.3: Further investigation should be undertaken regarding the MET conditions used in simulations and its interaction with the algorithm in order to refine the calculation of the route time spacing required.	To ensure realistic departure speed profiles are inputted in the simulation environment.	REC-37-W3-SAF-R1.4: Further investigation should be undertaken in future projects to ensure realistic departure speed profiles are used as an input in the simulation environment (Note this aligns with Operational Feasibility Recommendation R1 in the PJ.37-W2-01B Demo Report Part 1 [10]).	Reduce the probability of under-separations on certain route pairings.	REC-37-W3-SAF-R1.5: Further investigations should be undertaken in future projects to examine the use of 'safety buffers' on certain route pairings.	To understand differing aircraft speed data and performance.	REC-37-W3-SAF-R1.6: A larger sample size of differing aircraft types should be utilised in future projects to deduce whether improved departure speed
Safety Issue	Recommendation															
To ensure Reduced Separation is recorded correctly and accurately.	REC-37-W3-SAF-R1.1: During future testing of this solution in future projects, more robust procedures should be created to ensure all forms of Reduced Separation that ATCOs apply are recorded accurately and correctly in the simulation environment.															
To ensure accuracy amongst all SID profile combinations.	REC-37-W3-SAF-R1.2: For future iterations of the extended OSD algorithm, refinements are required to ensure accuracy of the input values to the extended OSD tool describing the SID profiles flown by aircraft.															
Effects of simulated weather conditions on the algorithm	REC-37-W3-SAF-R1.3: Further investigation should be undertaken regarding the MET conditions used in simulations and its interaction with the algorithm in order to refine the calculation of the route time spacing required.															
To ensure realistic departure speed profiles are inputted in the simulation environment.	REC-37-W3-SAF-R1.4: Further investigation should be undertaken in future projects to ensure realistic departure speed profiles are used as an input in the simulation environment (Note this aligns with Operational Feasibility Recommendation R1 in the PJ.37-W2-01B Demo Report Part 1 [10]).															
Reduce the probability of under-separations on certain route pairings.	REC-37-W3-SAF-R1.5: Further investigations should be undertaken in future projects to examine the use of 'safety buffers' on certain route pairings.															
To understand differing aircraft speed data and performance.	REC-37-W3-SAF-R1.6: A larger sample size of differing aircraft types should be utilised in future projects to deduce whether improved departure speed															

	profiles are required and if there are any issues with specific aircraft speed data.
To ensure that the target distance separations used in the extended OSD tool are sufficiently accommodating of all traffic operating in the wider TMA environment.	REC-37-W3-SAF-R1.7: Additional simulations should be undertaken to explore the interactions of Heathrow departures with all traffic movements both through the TMA and into and out of the major airports in the London TMA, with a consideration to include unfavourable wind profiles at all levels.
To understand whether other parameters need to be included in the solution to increase accuracy.	REC-37-W3-SAF-R1.8: Further investigation should be undertaken in future projects to ascertain whether other significant parameters need to be included in the Solution (e.g., Airline, destination, and air pressure.)
To understand of what impact the Solution has on traffic above the Controlled Traffic Region.	REC-37-W3-SAF-R1.9: Further investigations should be undertaken in future projects regarding same SID pair departures, catch-ups and potential wake encounters above the Controlled Traffic Region.
To ensure wake separations are clearly displayed to the ATCO	REC-37-W3-SAF-R1.10: The HMI needs to clearly display when there is wake separation.
To understand the impact of the extended OSD tool on catch-ups in the TMA.	REC-37-W3-SAF-R1.11: Further investigations should be undertaken to assess the impact of the extended OSD tool on catch-up occurring in the TMA and if the defined spacing delivery points for the leader and follower aircraft are appropriate on a SID pair basis.
To assess the target distance spacings for SID pair combinations.	REC-37-W3-SAF-R1.12: Further investigations should be undertaken to assess whether the target distance spacings assigned to SID pair combinations are sufficient.
To assess the differences in aircraft performance, particularly the planned distances to be flown and associated differing Take-Off Weights for different aircraft.	REC-37-W3-SAF-R1.13: An investigation into whether a destination reference table should be an input to the extended OSD tool should be carried out.

Table 13: Summary of Results for OBJ-37-W3-DEMOP-SAF1-0008.

Identifier	OBJ-37-W3-DEMOP-SAF1-0009	KPA Category	Safety
Objective	To assess the impact on safety by the associated procedures		
Success Criterion	CRT-37-W3-DEMOP-004-SAF-003	Evidence is gathered regarding the impact on safety and associated procedures that the ITARO Departure Solution has.	

Results

OK

Overall, once the ATCOs became familiar with the extended OSD tool during the validation simulations, there was little impact on safety and associated procedures. After collating information from the questionnaires and discussing the pertinent points in the post-sim workshop, the main issues which were raised surround the placement and design of the countdown timers, MDI and TMA data information (HMI design) and the potential failure of the tool and the subsequent procedures associated with these issues. The following summarises the issues and recommendations:

Safety Issue	Recommendation
Timer display.	REC-37-W3-SAF-R2.1: A toggle switch should be provided to enable ATCO personalisation of the timer (see also REQ-37-W3-HP-6).
Placement of wake and SID countdown timer.	REC-37-W3-SAF-R2.2: A HMI workshop should be held to discuss suitable placement of the extended OSD tool output. (See also REQ-37-W3-HP-7).
Placement of MDI and TMA data feed information.	REC-37-W3-SAF-R2.3: A HMI workshop should be held to discuss the suitable placement of the MDI and TMA data feed information.
Ability for ATCO to undertake other safety critical tasks.	REC-37-W3-SAF-R2.4: During the next wave of this solution, more scenarios and tasks that ATCOs experience daily should be incorporated into the simulated exercises.
Procedures when extended OSD tool fails.	REC-37-W3-SAF-R2.5: A simple to follow separations matrix and immediate action procedures should be produced to enable safe operations to continue.
Procedures to deal with skill fade.	REC-37-W3-SAF-R2.6: HF, Safety and ATCOs should fully investigate the required procedures, tasks and possible ATCO training requirements in the event of tool failure.
Future deployment and effect on current procedures.	REC-37-W3-SAF-R2.7: All ATC procedures which will be affected by the deployment of the tool should be highlighted early in future projects to assess for any major safety issues.
Refresher training to enable ATCOs to manually calculate separations if extended OSD tool fails.	REC-37-W3-SAF-R2.8: Further investigations are required to fully understand the content and duration and frequency of training required for ATCOs to sufficiently maintain currency and skills to manually apply accurate and efficient separations.

Table 14: Summary of Results for OBJ-37-W3-DEMOP-SAF1-0009.

Identifier	OBJ-37-W3-DEMOP-SAF1-0010	KPA Category	Safety
Objective	Understand the equipment requirements, e.g. corrupt data, hardware failure		
Success Criterion	CRT-37-W3-DEMOP-004-SAF-004	Evidence is gathered regarding equipment requirements and the ITARO Departure Solution	

Results

Following ATCOs comments raised in the questionnaires and subsequently discussed in detail in the workshop, the main area of concern was the failure of the extended OSD tool and associated hardware in addition to the delivery of corrupt but believable data to the controller which would be difficult for the ATCO to notice. The conversations allowed a greater understanding of the safety implications of tool failure / corrupt data. The following have been recommended.

OK

Safety Issue	Recommendation
Tool error / failure messages.	REC-37-W3-SAF-R3.1: A visual-only alert (not audible) of the status of the equipment is required to allow maximum time for controllers to identify the failure and then to quickly revert to the alternate procedures.
Interaction between existing ATC equipment (including back-up servers).	REC-37-W3-SAF-R3.2: Further investigations are undertaken regarding possible interaction between other ATC systems and the extended OSD tool system and the utilisation of any back up servers already in use in the Air Traffic Control tower.
Tool Failure – Corrupt but believable data.	REC-37-W3-SAF-R3.3: A function should be introduced to allow the Supervisor only to switch off the system (either in certain elements or the whole extended OSD tool) in situations where there was any doubt about the integrity of the information being presented to the controller. (See REQ-37-W3-HP-3) REC-37-W3-SAF-R3.4: Further investigation into the issue of corrupt but believable data and its impact to the system should be undertaken in future projects. REC-37-W3-SAF-R3.5: Further examination should be made into the assigning of the correct software assurance level to the system in association with compliance of ED153.

Table 15: Summary of Results for OBJ-37-W3-DEMOP-SAF1-0010.

4.3.3 Extrapolation to ECAC wide

This Validation exercise was conducted at Heathrow 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, location of nearby airports with interacting departure and arrival routes and whether Free Route Airspace (FRA) is being employed.

4.3.4 Discussion of Assessment Result

Consensus amongst the controlling cadre who participated in the demonstration simulation felt that from their own experience and knowledge, the solution had no negative impact on Operational Safety (50% stated it was the same as current operations and 50% felt it had a positive impact). Although this result gives confidence that the solution appears safe at this stage, it should be noted that both the sample of ATCOs and the size of the RTS is small and does not account for live operations and its associated parameters (MET conditions, airline SOPs, pilot behaviours etc).

Table 13, Table 14 and Table 15 detail the individual assessment of each safety objective. When these results are collectively considered, it indicates that in its present maturity, the solution is OK with respect to safety. Suggested recommendations have been highlighted and detailed to mitigate the safety issues which were identified in the detailed analysis of the demonstration simulation data and subsequent discussions with ATCOs and the PJ.37-W3-ITARO (01B) team. Due to these recommendations being against future iterations of this solution, this reinforces the overall result of OK for this solution.

Considering the current stage of maturity of this solution and if the suggested recommendations listed in Table 12, 13 and 14 were applied, the following table summarises the status of the associated SACs.

	Wording	Rationale	Satisfied	Evidence
SAC#D 1a	There shall be no increase in imminent wake separation infringements which are induced by ATC to the 1 st aircraft whilst on departure (2 nd aircraft not yet airborne) in operations based on the extended OSD tool compared to operations with the Reference Scenario OSD tool (AO-0329).	On possibility of imminent wake separation infringement on departure induced by ATC and the second aircraft is not yet airborne (see WE7F.1.a in AIM Wake Induced Risk on Initial Departure).	Yes	Please see PJ.37-W3-ITARO (01B) DEMO Report Part II: Appendix A.1.1.1 – Analysis of Wake Encounter Risk. Appendix A.1.1.2 – Analysis of total number of Wake Under

				Separations (Solution vs Reference Runs) Appendix A.1.1.2 – Controller Delivery performance using the Wake Countdown timer.
SAC#D 2a	There shall be no increase in imminent wake separation infringements which are induced by ATC to the 1st or 2nd aircraft whilst on departure in operations based on the extended OSD tool compared to operations with the Reference Scenario OSD tool (AO-0329).	On possibility of imminent wake separation infringement on departure induced by ATC and the second aircraft is airborne (see WE7F.2 in AIM Wake Induced Risk on Initial Departure).	Yes	Please see PJ.37-W3-ITARO (01B) DEMO Report Part II: Appendix A1.1.1– Analysis of Wake Encounter Risk. Appendix A.1.1.2 – Analysis of total number of Wake Under Separations (Solution vs Reference Runs) Appendix A.1.1.2 – Controller Delivery performance using the Wake Countdown timer.
SAC#D 3:	There shall be no increase in imminent minimum radar separation infringements (non-wake) on the initial departure induced by ATC for the 1st or 2nd aircraft whilst on departure in operations based on the extended OSD tool compared to operations with the Reference Scenario OSD tool (AO-0329).	On possibility of an imminent radar separation infringement on the initial departure path induced by ATC for either 1st or 2nd aircraft. (see ME7F.1 and ME7F.2 AIM MAC Risk on initial Departure).	Yes	Please see PJ.37-W3-ITARO (01B) DEMO Report Part II: Appendix A.1.2.1 – Analysis of Total Number of Route Under-Separations / Under-Spacings (Solution vs. Reference Runs). Appendix A.1.2.1 - Analysis of Rate of Route Under-Separations / Under-Spacings per 100

				000 Departures (Solution vs. Reference Runs). Appendix A.1.2.1 - Analysis of Under Separations / Under-Spacings per SID Pair (Solution vs Reference Runs). Appendix A.1.2.1 - Analysis of Under Separation / Under-Spacings per MET Condition (Solution vs Reference Runs).
SAC#D 5a	There shall be no increase in tactical conflicts (non-wake) in the TMA departing sectors induced by ATC for the 1 st or 2 nd aircraft whilst on departure in operations based on the extended OSD tool compared to operations with the Reference Scenario OSD tool (AO-0329).	On possibility of tactical conflicts whilst in the TMA induced by ATC for either 1 st or 2 nd aircraft. (see MF7.1.1.2 and MF7.1.1.2.1 leading to MF7.1 in AIM MAC Risk in TMA).	No	Due to the constraints of the project, a specific simulation to understand the impact of the solution on the TMA was not able to be undertaken. However, two internal pieces of analysis were undertaken; one focused on catch-ups in the TMA pre-COVID Operations, the second compared the actual time spacings achieved in the first report and compared them to what the extended OSD tool would have advised. This resulted in REC-37-W3-SAF-R1.11 and REC-37-W3-SAF-R1.12 which could provide evidence in future iterations to satisfy this SAC.

SAC#D 5b	There shall be no increase in imminent minimum radar separation (non-wake) in the TMA departing sectors induced by ATC for the 1 st or 2 nd aircraft whilst on departure in operations based on the extended OSD tool compared to operations with the Reference Scenario OSD tool (AO-0329).	On possibility of an imminent minimum radar separation infringement whilst in the TMA induced by ATC for either 1 st or 2 nd aircraft. (see MF7 in output of MB14.2 in AIM MAC Risk in TMA).	No	Due to the constraints of the project, a specific simulation to understand the impact of the solution on the TMA was not able to be undertaken. However, two internal pieces of analysis were undertaken; one focused on catch-ups in the TMA pre-COVID Operations, the second compared the actual time spacings achieved in the first report and compared them to what the extended OSD tool would have advised. This resulted in REC-37-W3-SAF-R1.11 and REC-37-W3-SAF-R1.12 which could provide evidence in future iterations to satisfy this SAC
SAC#D 6	The probability per departure of severe and or extreme wake turbulence events shall be no greater in operations using the extended OSD tool compared to operations with the reference scenario OSD tool.	On possibility of severe and or extreme wake turbulence events on departure induced by ATC for either 1 st or 2 nd aircraft. (see WE3 and WE2 in AIM WAKE ID).	Yes	Please see PJ.37-W3-ITARO (01B) DEMO Report Part II: Appendix A1.1.1– Analysis of Wake Encounter Risk.

Table 16: Status of SACs

4.3.5 Additional Comments and Notes

N/A

4.4 Environment: Fuel Efficiency / CO₂ emissions

Does the Demo impact this KPA? Yes

To reduce the CO₂ emissions from flights, it is necessary to reduce their fuel consumption as every tonne of fuel burned generates 3.15 tonnes of CO₂ emissions.

The ITARO Departures Solution track PJ.37-W3-01B enables reduced and more granular SID spacing times so departure pairs will be spaced closer together for some SID pairs. This allows the average ground holding duration per flight to be reduced during peak periods. Reducing ground holding therefore decreases the amount of fuel burnt and CO₂ emitted whilst the engines of aircraft are idle and pilots waiting to be issued with take-off clearance.

4.4.1 Performance Mechanism

Is there a Benefit Mechanism available? No

There are no BIMs available for PJ.37-W3-01B, however BIMs were produced for Wave 1, which can be referred to in the SESAR Solution PJ02-01 SPR-INTEROP/OSED for V3 - Part I [8].

The lower the average ground holding duration per flight, the less fuel is burnt on the ground (e.g., in case of taxi time holding), leading to a positive impact on Fuel Efficiency in terms of the airline's fuel costs.

4.4.2 Assessment Data (Exercises and Expectations)

The environmental assessment is based on the data from RTS⁸ conducted on segregated runway operations in the Heathrow environment, which is classified as a Very Large Airport according to the Airports' classification scheme in SESAR 2020 **Error! Reference source not found.** The RTS exercises were based on Heathrow runway operations between the peak periods of 09:00 to 10:00 and 11:00 to 12:00.

The RTS investigated the application of reduced, more granular non-wake SID separations on departure with an extended OSD tool. The RTS also assessed the integration of a TMA data-feed into the extended OSD tool to dynamically adjust the departure flow rate into the TMA to ensure that the optimised SID separations do not put excessive demand onto TMA sectors.

To assess the environmental benefits of the ITARO Departures Solution track PJ.37-W3-01B with and without the TMA data feed (Solution Scenarios), a comparative assessment is conducted against a Reference Scenario:

1. RECAT-EU 6-CAT or PWS-D wake time separations with OSD tool.

There are two Solution Scenarios:

1. Time-Based RECAT-EU or PWS-D with extended OSD tool support without a TMA data-feed.

⁸ Details are contained in the DEMOP-Part I [7].

2. Time-Based PWS-D or PWS-D with extended OSD tool support with an emulated TMA data-feed.

Only flights that were airborne in one of the Solution Scenarios and the corresponding Reference Scenario were included in the environmental analysis. As a result, the total sample size was reduced by 60% from 2,694 flights down to 1,071 flights for comparison.

Table 17 **Error! Reference source not found.** shows that the generally the extended OSD tool with or without the TMA data-feed would decrease the average departure separation times compared to the Reference OSD tool⁹, therefore reducing ground holding (i.e., taxi time) durations and potentially decrease the amount of fuel burnt and CO₂ emitted. Scenario 1 presented the most efficient departure separation times resulting in lower average taxi time durations compared to Scenario 2 however, there is a risk of overloading the TMA sectors by not using a TMA data-feed.

⁹ Not all aircraft were airborne in the RTS; those that were airborne are classified as flights in this report.

Scenario	Average Departure Separation Time	Average Taxi Time Duration
Reference Scenario: OSD	1m 7s	11m 18s ¹⁰
Scenario 1: extended OSD without TMA data-feed	1m 4s	10m 29s
Scenario 2: extended OSD with emulated TMA data-feed	1m 5s	10m 42s

Table 17: Average departure separation time and taxi time durations per airborne flight in the Scenarios

To perform the fuel burn analysis the taxi time durations¹¹ were calculated in each scenario. For each aircraft type, the BADA 4.2 taxi fuel burn rate was applied to the taxi time durations. The resulting taxi time fuel burns were then compared against its ground holding fuel burn in the corresponding Reference Scenario to calculate the fuel burn and CO₂ emissions differences¹² for each flight. The average fuel burn and CO₂ emissions differences per flight from the Reference Scenarios are shown in Table 18. **Error! Reference source not found..**

Scenario	Average Difference Per Flight from Reference Scenario	
Solution Scenario	Fuel Burn Difference	CO ₂ Emissions Difference
Scenario 1: extended OSD without TMA data-feed	-7 kg	-23 kg
Scenario 2: extended OSD with emulated TMA data-feed	-18 kg	-57 kg

Table 18: Average fuel burn and CO₂ emissions difference per flight compared to the Reference Scenario

Scenario 2 resulted in the lowest average environmental savings of 18 kg fuel burn reduction and 57 kg reduced CO₂ emissions per flight compared to the Reference Scenario. Although Scenario 1 had more efficient departures and lower taxi time durations, it had smaller average environmental savings with reduced fuel burn of 7 kg and CO₂ emissions of 23 kg per flight compared to the Reference Scenario. This was due to more aircraft types with high taxi fuel burn rates holding for longer durations

¹⁰ Average across all airborne flights in the Reference Scenario for info. This value is different when only flights airborne in both the Reference and the corresponding Solution Scenario are compared – see detailed results contained in Appendix A.

¹¹ The ground holding duration is calculated as the time from the aircraft starting up its engine (which is consistent across all scenarios) to its airborne time in each of the scenarios.

¹² Using the direct link between fuel burn and the amount of CO₂ produced (3.15 times the mass of fuel burnt).

in Scenario 1 compared to Scenario 2 and also the small sample sizes likely to have an effect on the results.

The analysis indicates that extended OSD with a TMA data-feed would be more beneficial in environmental savings than extended OSD without a TMA data-feed. Furthermore, using a TMA data-feed may prevent excessive demand on the TMA sectors by dynamically adjusting the departure flow rate into the TMA. The participating ATCOs in the RTS expected to see more benefits for the solution **with** the TMA data-feed as it helps them to apply flow restrictions more accurately as well as allowing more granular flow restrictions to be applied (e.g., 3m 30s instead of 4m).

Exercise ID or Expert judgement	Benefits contribution to FEFF1	Benefits contribution to ENV1
EXE-PJ.37-W3-004	Scenario 1 (extended OSD Tool without TMA Data Feed): reduction in fuel burn of 7 kg per flight compared to the Reference Scenario. Scenario 2 (extended OSD Tool with an emulated TMA data feed): reduction in fuel burn of 18 kg per flight compared to the Reference Scenario.	Scenario 1 (extended OSD Tool without TMA Data Feed): reduction in fuel burn of 23 kg per flight compared to the Reference Scenario. Scenario 2 (extended OSD Tool with a TMA data feed): reduction in CO₂ emissions of 57 kg per flight compared to the Reference Scenario.

Table 19: Fuel burn and CO₂ emissions saving per Exercise

OI step	Relative benefits contribution to FEFF1	Relative benefits contribution to ENV1
AO-0329	100%	100%
TOTAL	100%	100%

Table 20: Fuel burn and CO₂ emissions saving relative benefit per OI step

4.4.3 Extrapolation to ECAC wide

An average of 18kg of fuel could be saved per flight departing from Heathrow at peak times with extended OSD with a TMA data-feed (Scenario 2). As the common assumption **Error! Reference source not found.** for average fuel burn per flight is 5280kg, a saving of 18kg represents 0.34%¹³ of fuel consumption reduction per flight.

However, as only flights departing from Very Large airports and Large Airports at peak times will reap the benefits of this operational improvement, the benefit of the improvement at ECAC / Network level

¹³ Calculated by 18 kg / 5280kg = 0.34%.

will concern only 19.35%¹⁴ of the ECAC traffic in 2035. This results in 0.07%¹⁵ of fuel reduction or 3.7kg¹⁶ of fuel per ECAC flight on average. This equates to an average CO₂ reduction of 0.07% or 11.7kg¹⁷ of CO₂ per ECAC flight on average.

The same method of extrapolation to ECAC is applied to the average fuel burn and CO₂ emissions differences in Table 18 **Error! Reference source not found.** for Scenario 1 to obtain the expected performance benefits in Table 21.

KPIs / Pls	Unit	Calculation	Mandatory	Absolute expected performance benefit in SESAR2020	% expected performance benefit in SESAR2020
FEFF1 Actual Average fuel burn per flight	Kg fuel per movement	Total amount of actual fuel burn divided by the number of movements	YES	Sc1 Extended OSD without a TMA data-feed: -1.6 kg Sc2 Extended OSD with an emulated TMA data-feed: -3.7 kg	Sc1 Extended OSD without a TMA data-feed: -0.03 % Sc2 Extended OSD with a TMA data-feed: -0.07 %
ENV1 Actual Average CO ₂ Emission per flight	Kg CO ₂ per flight	Amount of fuel burnt x 3.15 (CO ₂ emission index) divided by the number of flights	YES	Sc1 Extended OSD without a TMA data-feed: -5.0 kg Sc2 Extended OSD with an emulated TMA data-feed: -11.7 kg	Sc1 Extended OSD without a TMA data-feed: -0.03 % Sc2 Extended OSD with a TMA data-feed: -0.07 %

Table 21: Fuel burn and CO₂ emissions saving for Mandatory KPIs /Pls

Table 22**Error! Reference source not found.** shows the average fuel burn and CO₂ emissions per phase of flight (where applicable).

Solution Scenario	Taxi out	TMA departure	En-route	TMA arrival	Taxi in
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¹⁴ Assumption of Peak Traffic at Very Large (30.37%) and Large (8.33%) airports [9], from which only 50% (departing traffic) is affected; (30.37% * 50%) + (8.33% * 50%) = 19.35%

¹⁵ Calculated by 0.34% * 19.35% = 0.07%.

¹⁶ Calculated by 0.07% * 5280 kg = 3.7 kg.

¹⁷ CO₂ is 3.15 times fuel burnt; 3.7 kg * 3.15 = 11.7 kg.

FEFF1 Actual Average fuel burn per flight	Sc1 Extended OSD without a TMA data-feed Sc2 Extended OSD with an emulated TMA data- feed	1.6kg per flight saving 3.7 kg per flight saving	N/A	N/A	N/A	N/A
ENV1 Actual Average CO ₂ Emission per flight (Kg)	Sc1 Extended OSD without a TMA data-feed Sc2 Extended OSD with an emulated TMA data-feed	5 kg per flight saving 11.7 kg per flight saving	NA	N/A	N/A	N/A

Table 22: Average fuel burn and CO₂ emissions per phase of flight.

Were there any benefits obtained in SESAR2020 Wave1 for this Solution? Yes.

The ITARO Departures Solution track PJ.37-W3-01B will extend the OSD tool developed in SESAR 2020 Wave 1 to provide support for reduced and more granular route spacings on departure. The solution also builds work conducted in SESAR Wave 2 PJ.01-W2-08B, by including an emulated TMA data-feed from the SYSMAN tool into the extended OSD tool in order to dynamically adjust the departure flow rate along individual SIDs if the workload in the TMA is predicted to become too high.

4.4.4 Discussion of Assessment Result

The ITARO Departures Solution track PJ.37-W3-01B aims at assessing the impact of reduced route spacings supported by the extended OSD tool with and without a TMA data-feed as a comparative assessment against the deployed route separations currently employed at Heathrow without extended OSD tool support.

Analysis on the RTS data has indicated that the extended OSD tool with a TMA data-feed would give fuel burn savings of 18 kg and CO₂ emission savings of 57 kg per flight on average compared to the OSD tool. These savings are due to more efficient departure separation times between aircraft, therefore reducing ground holding (i.e., taxi time) durations and the amount of fuel burnt and CO₂ emitted compared to OSD.

However, the extended OSD tool without a TMA data-feed presented the most efficient departure separation times and lowest ground holding durations but resulted in smaller average environmental savings of 7kg fuel burn and 23 kg CO₂ emissions per flight respectively compared to the OSD tool. This was due to more aircraft types with higher taxi fuel burn rates holding for longer durations and also likely the small sample sizes likely to have an effect on the results.

As expected, the participating ATCOs in the RTS expected to see more benefits for the solution with the TMA data-feed as it helps them to apply flow restrictions more accurately as well as allowing more granular flow restrictions to be applied (e.g., 3m 30s instead of 4m). However, as these results are based on a very small RTS sample, they are highly dependent on the traffic samples and the ATCOs involved in the RTS. Furthermore, the RTS are focused on the London Heathrow operation only and considerations should be made on departure sequencing behaviours that are not necessarily universal at other airports. Other limitations include the simplified RTS environment (such as no other airport traffic simulated) and aircraft fleet mix which was used to determine these environmental benefits.

The results should therefore be considered as indicative and further investigations could be carried out using more sophisticated methods such as Fast-Time Simulations with larger traffic samples.

4.4.5 Additional Comments and Notes

N/A.

4.5 Environment / Emissions, Noise and Local Air Quality

Does the Demo impact this KPA? No

While ITARO Departures Solution track PJ.37-W3-01B is aimed at improving departure spacing, the impact is expected to be primarily on ground holding delay incurred by aircraft during the taxi phase, particularly if it is assumed that airport operators will not utilise the more efficient departures to introduce additional runway movements.

Under this assumption, the impact on noise can be considered to be negligible, as the reduction in noise is then related to reduction of APU use and time of engine at taxi power, which is of second order compared to full thrust noise emissions prevalent during take-off.

Similarly, the impact on local air quality and non-CO₂ emissions through the reduction of aircraft ground delay can be considered negligible in comparison to other emission sources.

4.6 Airspace Capacity (Throughput / Airspace Volume & Time)

Does the Demo impact this KPA? No

The ITARO Departures Solution track PJ.37-W3-01B is focused on increasing capacity in terms of runway throughput.

4.7 Airport Capacity (Runway Throughput Flights/Hour)

Does the Demo impact this KPA? Yes.

4.7.1 Performance Mechanism

Is there a Benefit Mechanism available? No.

There are no BIMs available for PJ.37-W3-01B; however BIMs were produced for Wave 1, which can be referred to in the SESAR Solution PJ.02-01 SPR-INTEROP/OSD for V3 - Part I [8].

4.7.2 Assessment Data (Exercises and Expectations)

Departure throughput indicates the number of departures that get airborne in an hour. The departure throughput for each run was calculated by:

$$\text{Throughput} = \frac{\text{Number of Movements} - 1^{18}}{\text{Last Airborne Time} - \text{First Airborne Time}}$$

Figure 1 shows the departure throughput for each run within a matched set (either a triple or double match). In the graph the different categories are as follows:

REF Runs – The Reference Scenario of either PWS or RECAT-EU with the OSD Tool.

SOL1 Runs – Solution Scenario of either PWS or RECAT-EU with the extended OSD tool, with no TMA Data Feed support

SOL2 Runs – Solution Scenario of either PWS or RECAT-EU with the extended OSD tool and the support of an emulated TMA Data Feed.

¹⁸ The -1 in the equation is due to the first aircraft departing not being counted in the capacity figures as there is not leader to the departure.

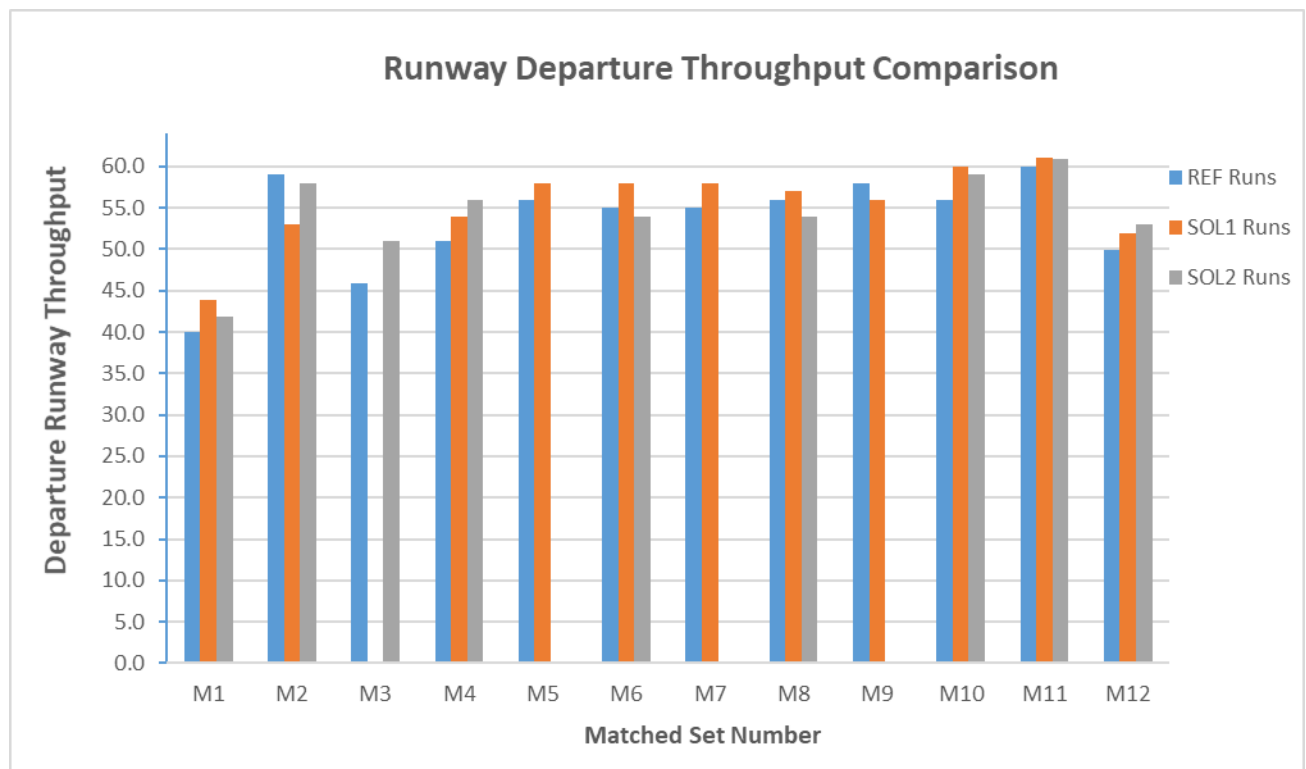


Figure 3: Runway Departure Throughput Comparison - All Matched Sets

From examining the Runway Throughput Comparison analysis in Figure 3, it shows that SOL1 achieved a higher throughput than the REF in 9 out of 11 matches. SOL2 achieved a higher throughput than the REF in 7 out of 10 matches. SOL2 achieved an equal or higher throughput in SOL1 in 4 out of 8 matches. There is no clear trend observed of an incremental increase in throughput from REF – SOL1 – SOL 2 across the triple matched pairs; however, there is an incremental increase in throughput for REF – SOL1 – SOL2 in 2 out of 9 matches (M5 and M12).

A lower throughput in M1 compared to the other matches was found. This can be attributed to the ATCO who was sat in the Air Departure seat requiring time to re-familiarise with the more complex and less often used Easterly operations at Heathrow.

For two matches (M2 and M9), the Reference Scenario achieved a higher throughput than the Solution Scenarios. The ATCOs reported that this was due to the impact of learning the traffic sample, as they were exposed to the same traffic sample across a number of consecutive runs during the same day in order to achieve the matched comparison experimental design. This learning effect helped the ATCO to be more efficient, as they knew what was coming up in the traffic sample and therefore could improve if possible on the order in which they departed the aircraft than in the previous run. This can be seen in M2 and M9 where the reference run was conducted after the solution runs. However, the experimental design was such that the order in which the reference and solution runs were conducted were mixed up in an attempt to mitigate against the learning effect. Another factor that must be considered when examining the capacity results are the improvements that are recommended to be made to the algorithm that calculates the required spacing between the leader and follower aircraft.

When the ATCOs were asked during the post simulation workshop if they were able to quantify the impact of the learning effect on the Capacity metric, they did not feel that this was possible with a high degree of accuracy. However, when asked for their feedback on whether the concept would bring

about an increase in capacity, taking into account improvements made to the algorithm, one ATCO commented that he thought the benefit would be in the region of one to two aircraft an hour, and the other ATCOs concurred.

When examining the average Runway Departure throughput, an increase can be seen between the Reference and Solution 1 and Reference and Solution 2, see Figure 4 **Error! Reference source not found..**

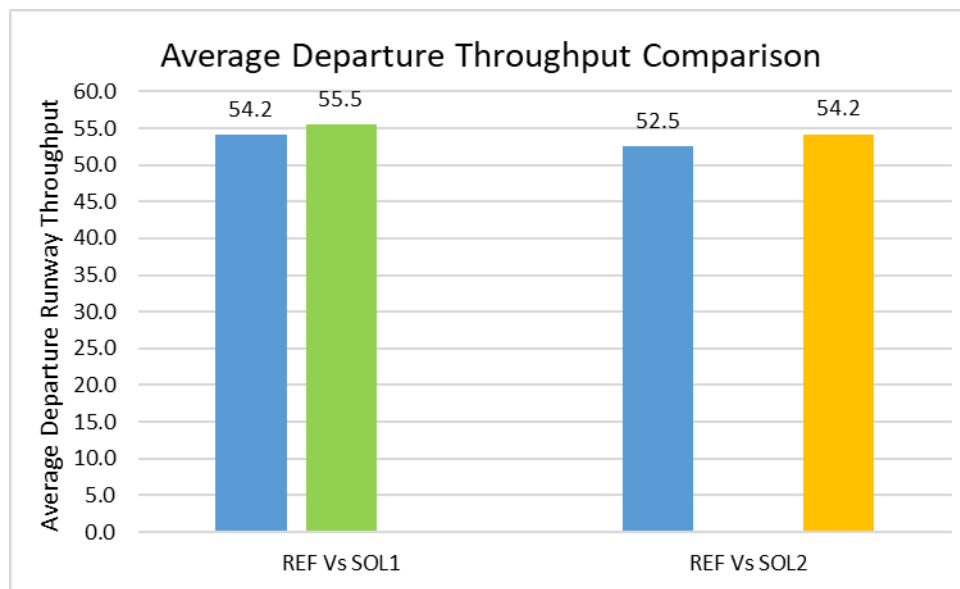


Figure 4: Average Departure Throughput Comparison REF V SOL1 and REF V SOL2

When comparing REF with SOL1 an increase of 1.3 movements an hour is seen (2.4%). When comparing REF with SOL2 an increase of 1.7 movements can be seen (3.2%). This is in agreement with the ATCOs estimate of an increase in movements of 1-2 per hour.

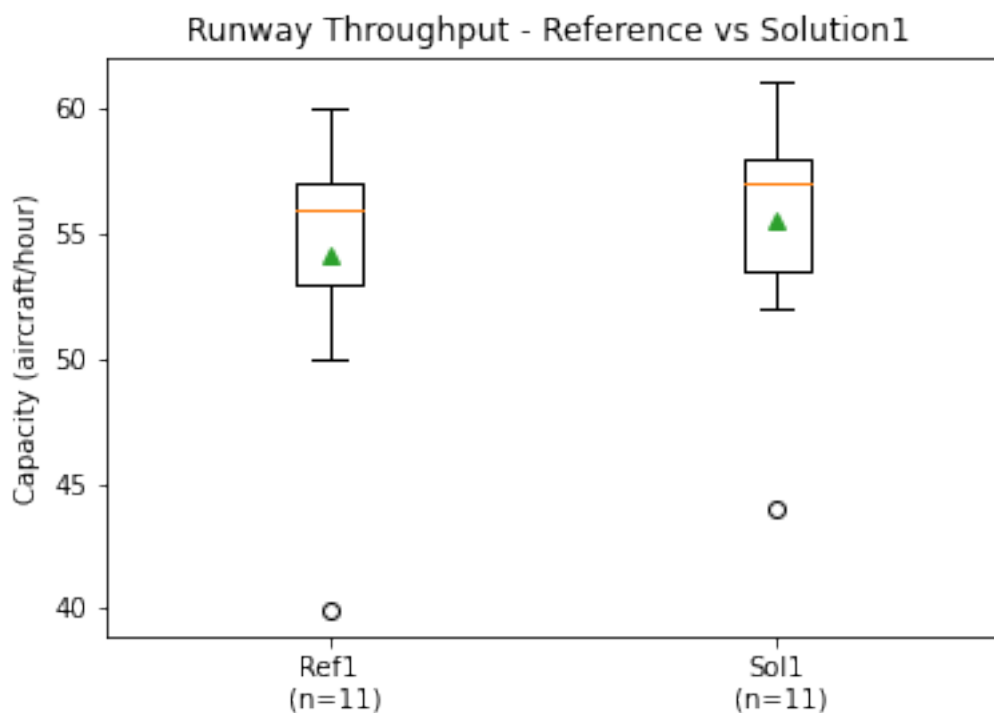


Figure 5: Departure Runway Throughput comparison REF Vs Solution 1

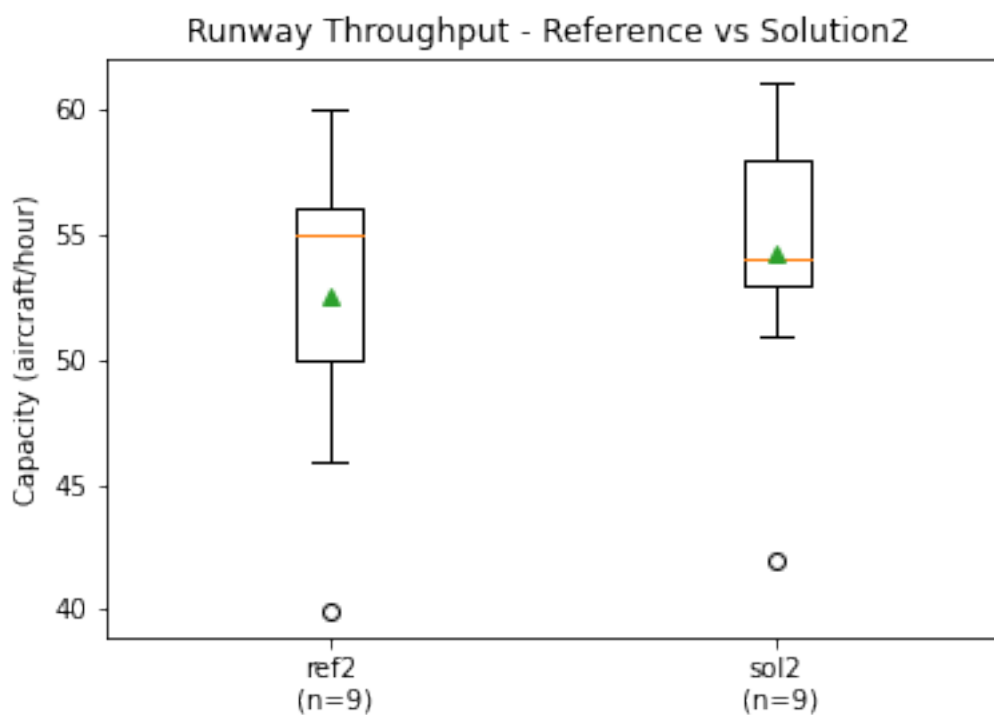


Figure 6: Departure Runway Throughput Comparison Reference Vs Solution 2

Figure 5 and Figure 6 show a more detailed picture of the departure runway throughputs. The orange lines in the boxes are the median values for the average throughput. The median value for Solution 1 is higher than the Reference (57 compared to 56). Although the median value is lower for Solution 2 than the Reference (54 compared to 55), the average value (as depicted by the green triangle) is higher for Solution 2 than the Reference.

The size of the boxes show the range of the throughput for each solution. Again, both figures show the range of throughput was higher than the Reference for both Solution 1 and Solution 2.

The circles denote outliers, and the outlier in the data was due to the lower throughput achieved in Match 1 as explained previously.

Exercise ID or Expert judgement	Benefits contribution to CAP3	Benefits contribution to CAP3.1	Benefits contribution to CAP3.2	Benefits contribution to CAP4
EXE-PJ.37-W3-004	N/A	extended OSD without TMA Data Feed(SOL1): +1.3 movements per hour (2.4%) extended OSD with emulated TMA Data Feed (SOL2): +1.7 movements per hour (3.2%).	N/A	N/A

Table 23: Airport Capacity benefits per Exercise

OI step	Relative benefits contribution to CAP3	Relative benefits contribution to CAP3.1	Relative benefits contribution to CAP3.2	Relative benefits contribution to CAP4
AO-0329	N/A	100%	N/A	N/A
TOTAL	N/A	100%	N/A	N/A

Table 24: Airport Capacity relative benefits per OI step

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	N/A	N/A

KPIs / Pls	Unit	Calculation	Mandatory	Absolute expected performance benefit in SESAR2020	% expected performance benefit in SESAR2020
CAP3.1 Peak Departure throughput per hour (Segregated mode)	% 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 measured against the maximum observed throughput during peak demand hours in the segregated-mode RWY operations airports group.	YES	Extended OSD without TMA Data Feed (SOL1): +1.3 movements per hour. Extended OSD with TMA Data Feed (SOL2): +1.7 movements per hour.	Extended OSD without TMA Data Feed (SOL1): 2.4% Extended OSD with emulated TMA Data Feed (SOL2): 3.2%.
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	N/A	N/A
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.	N/A	N/A

Table 25: Airport Capacity for Mandatory KPIs /Pls

Were there any benefits obtained in SESAR2020 Wave 1 for this Demo? Yes.

If yes, does the S2020 Wave 2 performance comes in addition to S2020 Wave 1 or replace it? It will replace it.

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 data analysis shows that there is an increase in capacity when comparing the Reference Scenario with Solution 1 and the Reference Scenario with Solution 2, which is corroborated with feedback from the ATCOs that they would expect to see an increase of around 1-2 aircraft per hour. The results of the

statistical test show that the difference between Solution 1 and Reference is not significant, whereas the difference between Solution 2 and Reference is significant.

During the simulation, the ATCOs reported a learning effect from being exposed to the same traffic sample numerous times which enabled them to be more efficient, therefore making it difficult to separate capacity gains from either the learning effect or the benefits of the tool. However, this was mitigated as much as possible by mixing up the order of the runs in which the reference, solution 1 and solution 2 runs were conducted. Feedback from the ATCOs indicated that even given the limitations of the simulation, they believed that the concept (with recommended algorithm improvements) would bring about an increase of capacity, therefore the results produced from this exercise can be interpreted with a medium level of confidence.

There is no target set for the CAP3.1 KPI by PJ.19, therefore these results cannot be compared.

4.7.5 Additional Comments and Notes

The PJ.37-W3-01B solution is applicable only to segregated-mode operations and benefits are only provided at runway capacity-constrained airports during peak periods. Therefore, Capacity findings are reported against CAP3.1 rather than CAP3 (mixed mode).

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? Yes.

The PJ.37-W3.01B concept aims to increase runway throughput. A higher departure throughput will lead to reduced runway delays and hence a reduction in the time an aircraft spends on the taxi-out and waiting to depart, and a reduction in the overall flight duration.

4.9.1 Performance Mechanism

Is there a Benefit Mechanism available? No.

There are no BIMs available for PJ.37-W3-01B; however BIMs were produced for Wave 1, which can be referred to in the SESAR Solution PJ.02-01 SPR-INTEROP/OSD for V3 - Part I [8]

4.9.2 Assessment Data (Exercises and Expectations)

The average taxi-out time was calculated for each scenario within a matched set as the difference between aircraft simulation start-up time and take-off roll time. As aircraft did not start-up at their gates, but at pre-determined points on the taxiways, taxi-times presented in this section are shorter than the taxi-time recorded in operational data. However, because these start-up locations were kept constant across scenarios, this comparison is considered acceptable. Figure 9 shows a comparison of the average taxi-out time in minutes per scenario between REF and SOL1 (extended OSD tool without TMA Data Feed), and Figure 10 shows a comparison between REF and SOL2 extended OSD tool with an emulated TMA Data Feed).

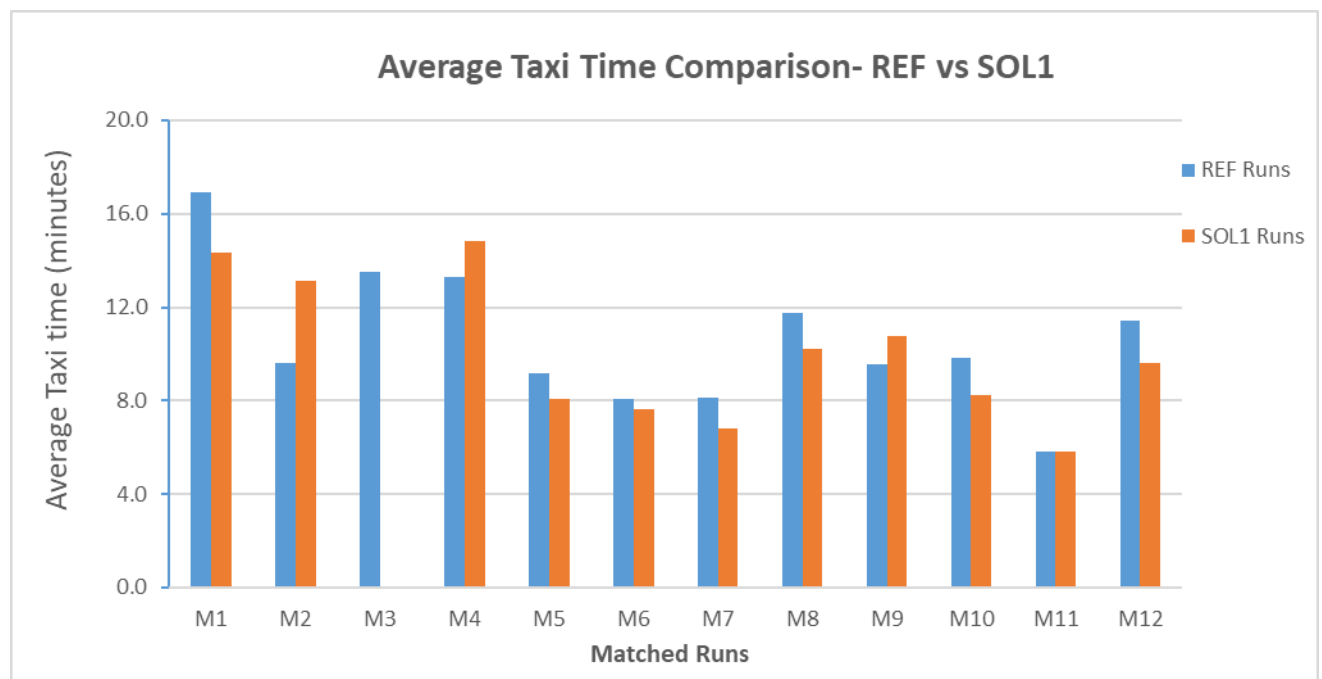


Figure 7: Average Taxi-out times in minutes per scenario per match – REF vs SOL1

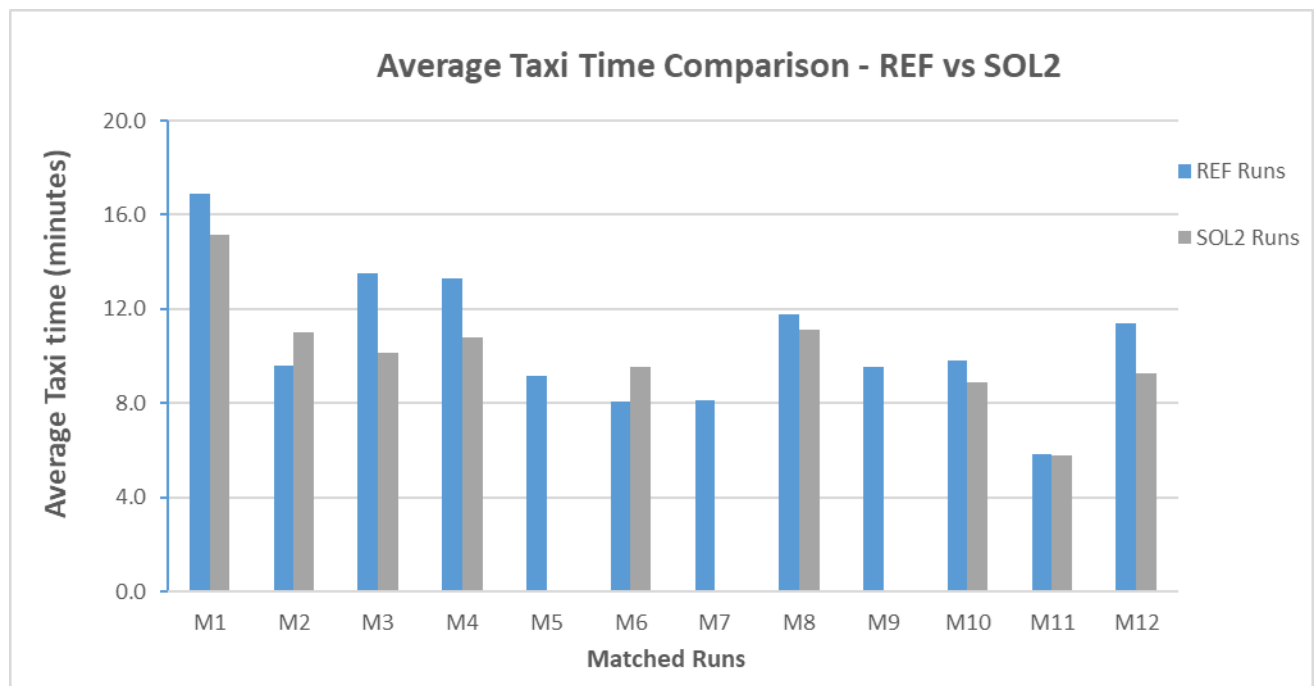


Figure 8: Average Taxi-out times in minutes per scenario per match – REF v's SOL2

When comparing REF to SOL1, the average taxi time was higher in REF than for SOL1 in 8 out of 11 matches. When comparing REF to SOL2, the average taxi time was higher in REF than for SOL2 in 7 out of 9 matches. For the majority of matches, the REF average taxi times were higher than for either SOL1 or SOL2.

The average taxi-out time for all aircraft across all matches and the delta between each solution and reference was calculated. See Table 26 below:

	SOL1 Comparison			SOL2 Comparison		
	REF	SOL1	Delta	REF	SOL2	Delta
Average taxi-out time across all matches (minutes)	10.3	9.9	0.4	11.1	10.2	0.9

Table 26: Average Taxi-out time across all matches (minutes)

As can be seen, the average taxi-out time for SOL1 compared to REF is reduced by 0.4 minutes. A reduction is also seen between SOL2 and REF of 0.9 minutes.

In order to report against TEFF1 (which is defined as Average of the distribution of actual gate-to-gate flight durations) as the only data available from the RTS is the taxi-out time from start-up time to the take-off roll, it is assumed that once the aircraft has departed, all other phases of flight are unaffected and therefore consistent between the solution and reference scenario.

As there were no flight plan durations available for comparison to actual flight durations, the mean actual flight duration was instead used. Although this means duration may not reflect what the planned duration might have been, it is still valuable to analyse the distribution around this time to establish a benefit in Flight times.

Exercise ID or Expert judgement	Benefits contribution to TEFF1	Benefits contribution to TEFF2	Benefits contribution to TEFF3	Benefits contribution to TEFF4	Benefits contribution to TEFF5	Benefits contribution to TEFF6
EXE-PJ.37-W3-004	The average taxi-out time across all matches for SOL1 compared to REF shows a reduction of 0.4 (3.9%) minutes. A reduction is also seen between SOL2 and REF of 0.9 (8.1%) minutes	N/A	The average taxi-out time across all matches for SOL1 compared to REF shows a reduction of 0.4 (3.9%) minutes. A reduction is also seen between SOL2 and REF of 0.9 (8.1%) minutes	N/A	N/A	N/A

Table 27: Flight Times benefits per Exercise

OI step	Relative benefits contribution to TEFF1	Relative benefits contribution to TEFF2	Relative benefits contribution to TEFF3	Relative benefits contribution to TEFF4	Relative benefits contribution to TEFF5	Relative benefits contribution to TEFF6
AO-0329	100%	N/A	100%	N/A	N/A	N/A
TOTAL	100%	N/A	100%	N/A	N/A	N/A

Table 28: Flight Times relative benefits per OI step

4.9.3 Extrapolation to ECAC wide

The following PJ.19 common assumptions have been used:

- Average ECAC flight time – 101.3 minutes.
- Departures traffic contribution – 50%.
- Airports peak traffic contribution:
 - Very large – 30.3653%.
 - Large – 8.3271%.
 - Medium – 0%.
 - Small – 0%.
 - Other – 0%.

Extrapolation logic:

1. Calculate the % of departures by the % of peak traffic contribution for Very Large and Large Airport: $50\% \times (30.3653\% + 8.3271\%)$ proportion of ECAC traffic that will benefit = 0.19%
2. To derive Absolute benefit per solution multiply proportion of ECAC traffic benefited by the reduction in average taxi-time achieved per solution:
 - a. SOL1 (extended OSD Tool without TMA Data Feed): $0.19\% \times 0.38 \text{ minutes} = 0.07 \text{ minutes}$
 - b. SOL2 (extended OSD Tool with an emulated TMA Data Feed): $0.19\% \times 0.95 \text{ minutes} = 0.18 \text{ minutes}$
3. To derive Relative benefit per solution, divide the Absolute benefit per solution from the average ECAC flight time (101.3 minutes) and multiply by 100 to get %:
 - c. SOL1 (extended OSD Tool without TMA Data Feed): $0.06 \text{ minutes} / 101.3 \text{ minutes} \times 100 = 0.07\%$
 - d. SOL2 (extended OSD Tool with an emulated TMA Data Feed): $0.14 \text{ minutes} / 101.3 \text{ minutes} \times 100 = 0.18\%$

KPIs / Pls	Unit	Calculation	Mandatory	Absolute expected performance benefit in SESAR2020	% expected performance benefit in SESAR2020
TEFF1 Gate-to gate flight time	Min/flight	Average of the distribution of actual gate-to-gate flight durations	YES	extended OSD Tool without TMA Data Feed (SOL1): 0.07 minutes extended OSD Tool with emulated TMA Data Feed (SOL2): 0.18 minutes	extended OSD Tool without TMA Data Feed (SOL1): 0.07% extended OSD Tool with emulated TMA Data Feed (SOL2): 0.18%
TEFF2 Taxi in time	Min/flight	Average of the distribution of actual taxi-in (including ground queuing during taxi-in) durations	When relevant	N/A	N/A
TEFF3 Taxi out time	Min/flight	Average of the distribution of actual taxi-out (including ground queuing during taxi-out) durations	When relevant	extended OSD Tool without TMA Data Feed (SOL1): 0.07 minutes extended OSD Tool with emulated TMA Data Feed (SOL2): 0.18 minutes	extended OSD Tool without TMA Data Feed (SOL1): 0.07% extended OSD Tool with emulated TMA Data Feed (SOL2): 0.18%
TEFF4 TMA arrival time	Min/flight	Average of the distribution of actual TMA arrival (including holdings) durations	When relevant	N/A	N/A

KPIs / Pls	Unit	Calculation	Mandatory	Absolute performance in SESAR2020	expected benefit in SESAR2020
TEFF5 TMA departure time	Min/flight	Average of the distribution of actual TMA departure durations	When relevant	N/A	N/A
TEFF6 En-Route time	Min/flight	Average of the distribution of actual en-route durations	When relevant	N/A	N/A

Table 29: Flight Times benefits for Mandatory KPIs /Pls

Table 30 is showing the impact on flight phases (provided when it is possible).

	Taxi out	TMA departure	En-route	TMA arrival	Taxi in
TEFF1 Gate-to gate flight time	extended OSD Tool without TMA Data Feed (SOL1): 0.07 minutes	N/A	N/A	N/A	N/A
	extended OSD Tool with emulated TMA Data Feed (SOL2): 0.18 minutes				
TEFF2 Taxi in time	N/A	N/A	N/A	N/A	N/A
TEFF3 Taxi out time	extended OSD Tool without TMA Data Feed (SOL1): 0.07 minutes	N/A	N/A	N/A	N/A
	extended OSD Tool with emulated TMA Data Feed (SOL2): 0.18 minutes				
TEFF4 TMA arrival time	N/A	N/A	N/A	N/A	N/A
TEFF5 TMA departure time	N/A	N/A	N/A	N/A	N/A
TEFF6 En-Route time	N/A	N/A	N/A	N/A	N/A

Table 30: Flight times benefit per flight phase.

Were there any benefits obtained in SESAR2020 Wave 1 for this Solution? Yes.

If yes, does the S2020 Wave 2 performance comes in addition to S2020 Wave 1 or replace it? It replaces it.

4.9.4 Discussion of Assessment Result

At an exercise level, the calculated benefits of average taxi-out time show a reduction of 0.4 (3.9%) minutes for solution 1 (extended OSD tool without TMA data feed) compared to the reference and a reduction of 0.9 (8.1%) minutes for solution 2 (extended OSD tool with an emulated TMA data feed) compared to the reference.

When the results are extrapolated to ECAC wide, the benefits calculated for solution 1 show a reduction in taxi-out time of 0.07 minutes compared to the reference and a reduction of 0.18 minutes for solution 2 compared to reference. The results for both TEFF1 and TEFF3 are the same, as for the TEFF1 calculation the taxi-out data has been used and then an assumption made that once the aircraft has departed, all other phases of flight are unaffected and therefore consistent between the solution and reference scenario.

The improvement in flight time correlates with the capacity results as described in Section 4.7, as if the solution brings about an increase in departure runway throughput, it can be expected that the aircraft spent less time between pushing back and beginning the take-off roll. As explained in the discussion of Capacity findings in section 4.7.4, although there were some limitations of the runway throughput results (i.e., learning effect of traffic sample and improvements required to the algorithm), the ATCOs opinion was that improvement in capacity and therefore a reduction in taxi-out time would be seen by the introduction of this concept.

In order to report against TEFF1 (which is defined as Average of the distribution of actual gate-to-gate flight durations) as the only data available from the RTS is the taxi-out time from start-up time to the take-off roll, it is assumed that once the aircraft has departed, all other phases of flight are unaffected and therefore consistent between the solution and reference scenario.

As there were no flight plan durations available for comparison to actual flight durations, the mean actual flight duration was instead used. Although this means duration may not reflect what the planned duration might have been, it is still valuable to analyse the distribution around this time to establish a benefit in Flight times

4.9.5 Additional Comments and Notes

N/A

4.10 Predictability

Does the Demo impact this KPA? Yes.

The PJ.37-W3.01B concept aims to increase runway throughput. A higher departure throughput will lead to reduced runway delays and hence more consistent and predictable taxi-out times.

4.10.1 Performance Mechanism

Is there a Benefit Mechanism available? No.

There are no BIMs available for PJ.37-W3-01B; however BIMs were produced for Wave 1, which can be referred to in the SESAR Solution PJ.02-01 SPR-INTEROP/OSD for V3 - Part I [8].

4.10.2 Assessment Data (Exercises and Expectations)

The average taxi-out time was calculated for each scenario within a matched set as the difference between aircraft simulation start-up time and take-off roll time. As aircraft did not start-up at their gates, but at pre-determined points on the taxiways, taxi-times presented in this section are shorter than the taxi-time recorded in operational data. However, because these start-up locations were kept constant across scenarios, this comparison is considered acceptable. Figure 9: Average Taxi-out times in minutes per scenario per match – REF vs SOL1

shows a comparison of the average taxi-out time in minutes per scenario between REF and SOL1 (extended OSD tool without TMA Data Feed), and Figure 10 shows a comparison between REF and SOL2 extended OSD tool with an emulated TMA Data Feed).

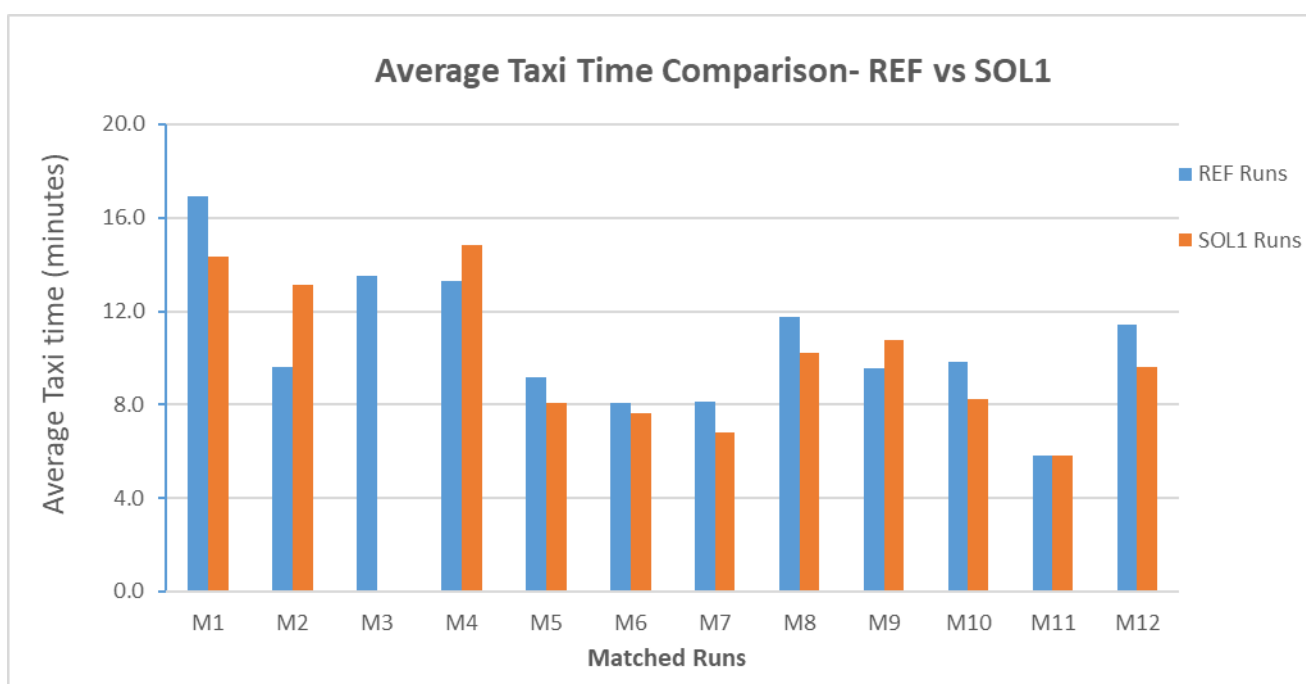


Figure 9: Average Taxi-out times in minutes per scenario per match – REF vs SOL1

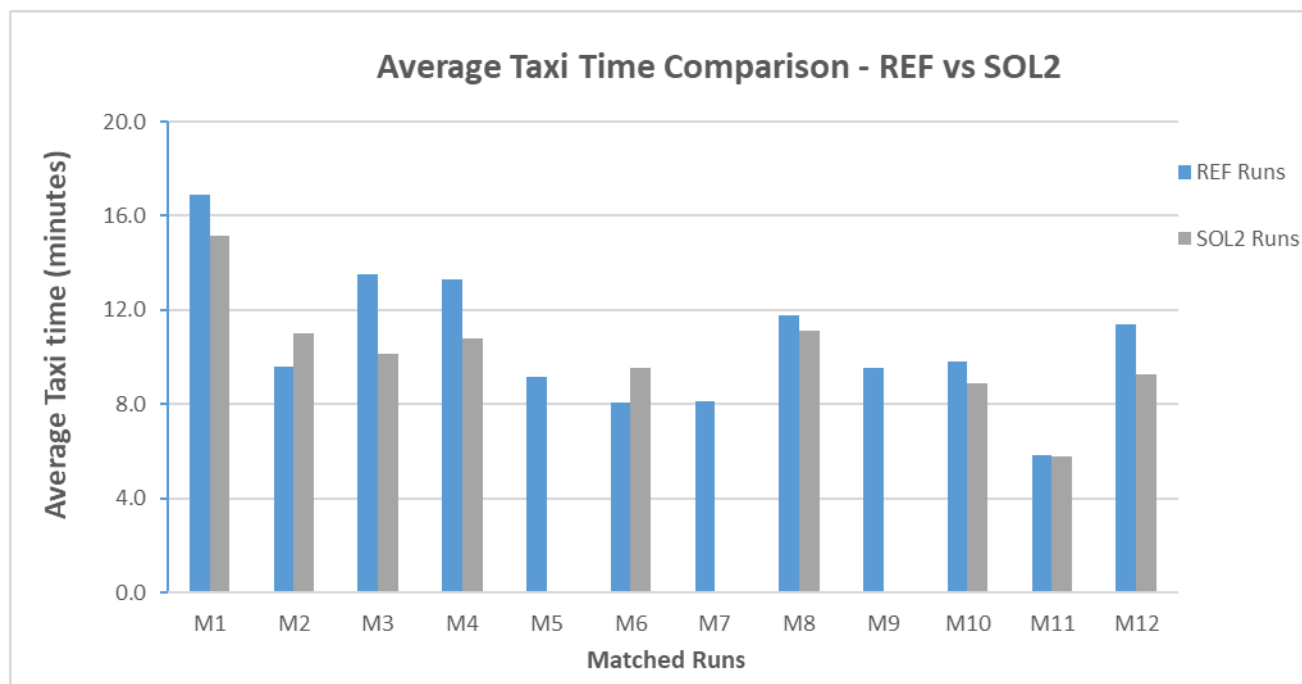


Figure 10: Average Taxi-out times in minutes per scenario per match – REF v's SOL2

When comparing REF to SOL1, the average taxi time was higher in REF than for SOL1 in 8 out of 11 matches. When comparing REF to SOL2, the average taxi time was higher in REF than for SOL2 in 7 out of 9 matches. For the majority of matches, the REF average taxi times were higher than for either SOL1 or SOL2.

The average taxi-out time for all aircraft across all matches and the delta between each solution and reference calculated. See Table 31 below:

	SOL1 Comparison			SOL2 Comparison		
	REF	SOL1	Delta	REF	SOL2	Delta
Average taxi-out time across all matches (minutes)	10.3	9.9	0.4	11.1	10.2	0.9

Table 31: Average Taxi-out time across all matches (minutes)

As can be seen, the average taxi-out time for SOL1 compared to REF is reduced by 0.4 minutes. A reduction is also seen between SOL2 and REF of 0.9 minutes.

As well as a reduction in the mean taxi-out time, Table 32 below compares the standard deviation in the mean taxi-out time for the Solution Scenario runs against the matched Reference Scenario runs. The standard deviation is a measure of variability and can be considered as an indicator of the predictability. A reduction in variability indicates more consistent taxi-out times and therefore

improved predictability. The results show a minor reduction in standard deviation in SOL1 runs compared to the matched Reference Scenario runs of -0.10 minutes. A similar result is found for SOL2 compared with the matched Reference Scenario runs with a reduction of standard deviation by -0.40 minutes.

	SOL1 Comparison			SOL2 Comparison		
	REF	SOL1	Delta	REF	SOL2	Delta
Standard Deviation in Taxi-Out Time (Minutes)	5.33	5.23	-0.10	5.33	4.93	-0.40

Table 32: Standard Deviation in Taxi-Out time Comparison between REF Vs SOL1 and REF Vs SOL2

This validation exercise assessed taxi-out delay (between the time at which the aircraft started up in the traffic sample and the time of the take-off roll), which is aligned with the PRD6 PI definition in the PJ19.04 Performance Framework [3]. This time includes the time spent at the Runway Holding Area (RHA), which was found to be the main factor in taxi-out variability.

In order to report against PRD1 (which is defined as Average of Difference in actual & Flight Plan or RBT durations) and PRD2 (which is defined as Variance of Difference in actual & Flight Plan or RBT durations), as the only data available from the RTS is the taxi-out time from start-up time to the take-off roll, it is assumed that once the aircraft has departed, all other phases of flight are unaffected and therefore consistent between the solution and reference scenario. As there were no flight plan durations available for comparison to actual flight durations, the mean actual flight duration was used instead. Although this means duration may not reflect what the planned duration might have been, it is still valuable to analyse the distribution around this time to establish a benefit in predictability.

Exercise ID or Expert judgement	Benefits contribution to PRD1	Benefits contribution to PRD2
EXE-PJ.37-W3-004	Average Taxi-out time: The average taxi-out time across all matches for SOL1 compared to REF shows a reduction of 0.4 (3.9%) minutes. A reduction is also seen between SOL2 and REF of 0.9 (8.1%) minutes.	Taxi-out Variability: The results show a reduction in Standard Deviation for SOL1 runs compared to the matched Reference Scenario runs of -0.10 minutes. A similar result is found for SOL2 compared with the matched Reference Scenario runs with a reduction of standard deviation by -0.40 minutes.

Table 33: Predictability benefits per Exercise

OI step	Relative benefits contribution to PRD1	Relative benefits contribution to PRD2
AO-0329	100%	100%
TOTAL	100%	100%

Table 34: Predictability relative benefits per OI step

4.10.3 Extrapolation to ECAC wide

The following PJ.19 common assumptions have been used:

- Average ECAC flight time – 101.3 minutes.
- Departures traffic contribution – 50%.
- Airports peak traffic contribution:
 - Very large – 30.3653%.
 - Large – 8.3271%.
 - Medium – 0%.
 - Small – 0%.
 - Other – 0%.
- B2B Absolute Variance – 49 minutes
- Taxi-out Contribution to Variability – 0.4.

Extrapolation logic and steps:

PRD1: PRD1 extrapolation is as reported for TEFF1 in Section 4.9.3, as the same data has been used for both KPIs.

PRD2:

1. Calculate the current variance: Multiply B2B Absolute Variance by Taxi-out Contribution to Variability = 49 minutes x 0.4 = 19.6
2. Calculate the current variability: Current Variance by the Power of 0.5: $19.6^{1/2} = 4.43$.
3. To calculate improvement in absolute variance (local) minus the difference in Standard Deviation between solution and reference and the current variability, squared:
 - a. SOL1 (extended OSD Tool without TMA Data Feed): $(4.43 - 0.1)^2 = 18.72$
 - b. SOL2 (extended OSD Tool with an emulated TMA Data Feed): $(4.43 - 0.4)^2 = 16.22$
4. To calculate absolute difference in variance (local) minus current variance from absolute variance (local):
 - a. SOL1 (extended OSD Tool without TMA Data Feed): $18.72 - 19.6 = -0.88$
 - b. SOL2 (extended OSD Tool with an emulated TMA Data Feed): $16.22 - 19.6 = -3.38$
5. To calculate Absolute Predictability benefit at ECAC level, multiply proportion of impacted ECAC traffic by the absolute difference in variance:
 - a. SOL1 (extended OSD Tool without TMA Data Feed): $0.19 \times -0.88 = -0.17$
 - b. SOL2 (extended OSD Tool with an emulated TMA Data Feed): $0.19 \times -3.38 = -0.65$
6. To calculate the improvement of B2B Variability (relative benefit) divide the Absolute Predictability benefit at ECAC level by B2B Absolute Variance:
 - a. SOL1 (extended OSD Tool without TMA Data Feed): $49 / -0.17 = -0.35\%$
 - b. SOL2 (extended OSD Tool with an emulated TMA Data Feed): $49 / -0.65 = -1.34\%$

KPIs / Pls	Unit	Calculation	Mandatory	Absolute expected performance benefit in SESAR2020	% expected performance benefit in SESAR2020
PRD1 Average of Difference in actual & Flight Plan or RBT durations	Minutes	Average of the distribution of the differences between flown trajectories & Flight Plans or RBT durations	YES	extended OSD Tool without TMA Data Feed (SOL1): 0.07 minutes extended OSD Tool with emulated TMA Data Feed (SOL2): 0.18 minutes	extended OSD Tool without TMA Data Feed (SOL1): 0.07% extended OSD Tool with emulated TMA Data Feed (SOL2): 0.18%
PRD2 Variance ¹⁹ of Difference in actual & Flight Plan or RBT durations	Minutes ²	Variance of the distribution of the differences between flown trajectories & Flight Plans or RBT durations	YES	extended OSD Tool without TMA Data Feed (SOL1): -0.17 extended OSD Tool with emulated TMA Data Feed (SOL2): -0.65	extended OSD Tool without TMA Data Feed (SOL1): -0.35% extended OSD Tool with emulated TMA Data Feed (SOL2): -1.34%

Table 35: Predictability benefits for Mandatory KPIs /Pls

Table 36 is showing the impact on flight phases (provided when it is possible).

	Taxi out	TMA departure	En-route	TMA arrival	Taxi in
PRD1 Average of Difference in actual & Flight Plan or RBT durations	extended OSD Tool without TMA Data Feed (SOL1): 0.07 minutes extended OSD Tool with emulated TMA Data Feed (SOL2): 0.18 minutes	N/A	N/A	N/A	N/A
PRD2 Variance of Difference in actual & Flight Plan or RBT durations	extended OSD Tool without TMA Data Feed (SOL1): -0.17 extended OSD Tool with emulated TMA Data Feed (SOL2): -0.65	N/A	N/A	N/A	N/A

Table 36: Predictability benefit per flight phase

¹⁹ Standard Deviation is also accepted (in minutes).

Were there any benefits obtained in SESAR2020 Wave 1 for this Demo? Yes.

If yes, does the S2020 Wave 2 performance comes in addition to S2020 Wave 1 or replace it? It replaces it.

4.10.4 Discussion of Assessment Result

At a local exercise level, the findings from the average Taxi-out time and Taxi-out variability data analysis sees an improvement in both solution scenarios compared to the reference scenario. The average taxi-out time across all matches for SOL1 compared to REF shows a reduction of 0.4 minutes (3.9%). A reduction is also seen between SOL2 and REF of 0.9 minutes (8.1%). For taxi-out Variability, the results show a reduction in Standard Deviation for SOL1 runs compared to the matched Reference Scenario runs of -0.10 minutes. A similar result is found for SOL2 compared with the matched Reference Scenario runs with a reduction of standard deviation by -0.40 minutes. A larger improvement is seen in SOL2 than SOL1 which is in line with expectations that the ATCOs were able to use the countdown timer rather than mental arithmetic to apply a flow restriction, therefore helping them to be more efficient.

The results correlate with the Capacity findings for the matches where the departure runway throughput was higher in the solution scenarios. This is to be expected because if the departure throughput is higher, as a consequence, the less time the aircraft spends taxiing and waiting to depart, and a reduction in variance is seen. As explained in the discussion of Capacity findings in Section 4.7.4, although there were some limitations of the runway throughput results (i.e., learning effect of traffic sample and improvements required to the algorithm), the ATCOs opinion was that improvement in capacity and therefore an improvement in predictability would be seen by the introduction of this concept.

On extrapolation of the KPI results to ECAC wide, for PRD1, the results show an improvement of SOL1 over REF with a reduction of 0.07 minutes of the average of difference in actual and flight plan, and a reduction of 0.18 minutes for SOL2 over REF. For PRD2 the results show a reduction in variance of difference in actual and flight plan of -0.17 minutes for SOL1 compared to REF and a reduction of -0.65 with SOL2 compared to REF. As explained in the assumptions used in the extrapolation section, as the only data available from the RTS is the taxi-out time from start-up time to the take-off roll, it is assumed that once the aircraft has departed, all other phases of flight are unaffected and therefore consistent between the solution and reference scenario. In addition, as there were no flight plan durations available for comparison to actual flight durations, the mean actual flight duration was instead used. Although this means duration may not reflect what the planned duration might have been, it is still valuable to analyse the distribution around this time to establish a benefit in predictability.

4.11 Punctuality

Does the Demo impact this KPA? Yes

Although the PJ.37-W3-01B solution is expected to have a benefit in terms of Punctuality, punctuality as defined by SESAR is departure delay in minutes of flights departing within +/- 3 minutes of SOBT (Scheduled Off-blocks Time), which is measured by taking the difference between AOBT (Actual Off-blocks time) and the SOBT. The data from the RTS is not available to measure this objective, as the aircraft in the traffic samples generated at holding points from the runway, rather than at the stand. However, a qualitative argument can be made for an improvement in Punctuality which links to the PRD001 and CAP results. If the solution reduces the variability in the taxi-out time, time spent waiting to depart at the RHA, and increases the runway throughput, it can therefore be argued that the queue of aircraft waiting to depart is reduced and the GMC may be able to push aircraft back sooner. In addition, in periods of disruption (i.e., adverse weather) the increase in runway throughput allows the runway throughput to recover faster than before.

4.11.1 Performance Mechanism

Is there a Benefit Mechanism available? No.

There are no BIMs available for PJ.37-W3-01B; however BIMs were produced for Wave 1, which can be referred to in the SESAR Solution PJ.02-01 SPR-INTEROP/OSED for V3 - Part I [8].

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? Yes.

The Cost Efficiency performance metric is the direct gate-to-gate ANS cost per flight. It is being assessed by means of the following two KPIs:

- ATCO Productivity improvement (%) – En-Route or TWR/APP, assessing the reduction of workload per controlled flight hour.
- Technology Related Cost-Efficiency Improvement (%) – by assessing the contributions of the technology enablers to a change in asset costs and/or operating costs (maintenance, etc), including support costs improvements (support personnel productivity).

4.14.1 Performance Mechanism

Is there a Benefit Mechanism available? No.

There are no BIMs available for PJ.37-W3-01B; however BIMs were produced for Wave 1, which can be referred to in the SESAR Solution PJ.02-01 SPR-INTEROP/OSED for V3 - Part I [8].

4.14.2 Assessment Data (Exercises and Expectations)

To assess Aerodrome Cost Efficiency, the productivity of the ATCO was calculated by measuring the number of flights handled per hour in the solution scenarios compared to the reference scenarios. The same data that was used to calculate the metrics for the Capacity KPI was used, however with the addition of including any arrivals and crossing aircraft (which were excluded from the Capacity analysis).

Figure 11 below shows a comparison of the number of flights handled per run across all matched sets between reference and solution scenarios.

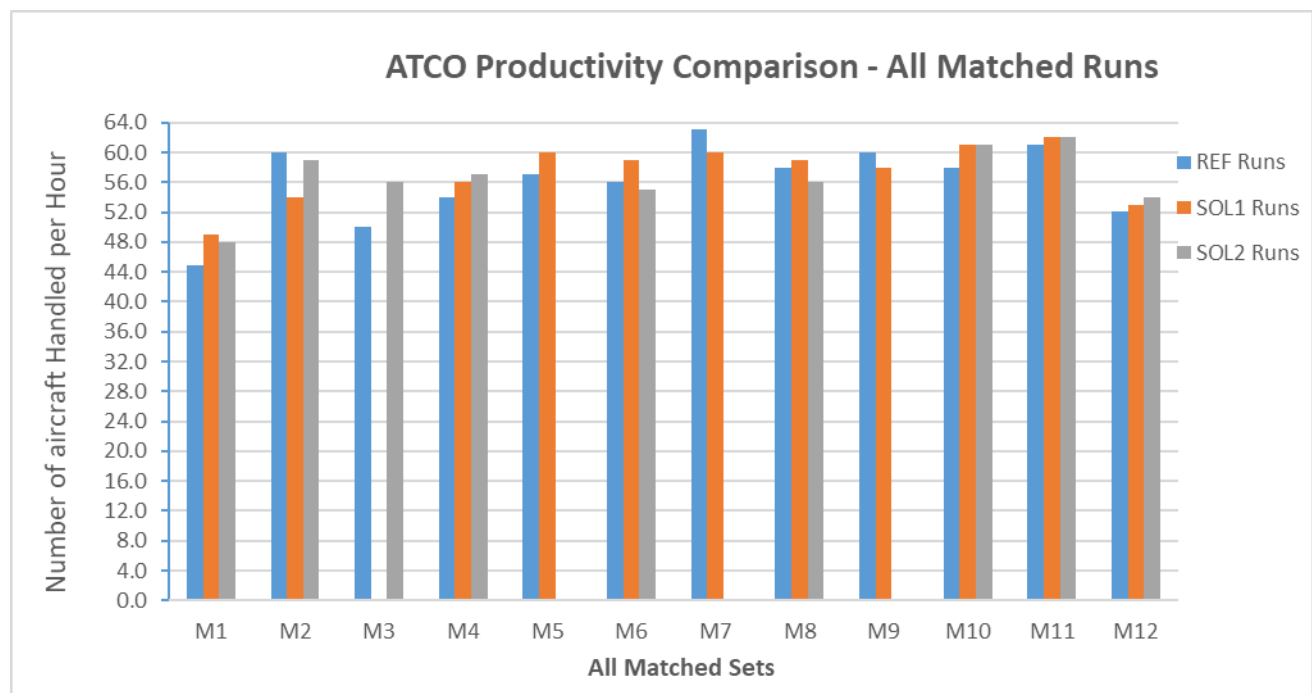


Figure 11: ATCO Productivity Comparison- Number of flights handled per hour across all matched runs

From examining the number of aircraft handled per hour (each exercise was run exactly for 1 hour, by 1 Departure Controller), it shows that SOL1 achieved a higher number of aircraft handled than the REF in 8 out of 11 matches. SOL2 achieved a higher number of aircraft handled than the REF in 6 out of 10 matches.

A lower ATCO productivity can be observed in M1 compared to the other matches was found. This can be attributed to the ATCO who was sat in the Air Departure seat requiring time to re-familiarise with the more complex and less often used Easterly operations at Heathrow.

In some of the matches the ATCO handled more flights in the REF scenario than either SOL1 or SOL2 or both. As explained in the Capacity results discussion, this could have been attributed to a learning effect of the traffic sample as they were exposed to the same traffic sample across a number of consecutive runs during the same day in order to achieve the matched comparison experimental design. However, the experimental design was such that the order in which the reference and solution runs were conducted were mixed up in an attempt to mitigate against the learning effect.

Figure 12 below shows the average number of aircraft handled per hour across all reference runs and all solution runs, and an increase can be seen for both solution scenarios, showing that on average the number of flights handled by the ATCO is increased **Error! Reference source not found..**

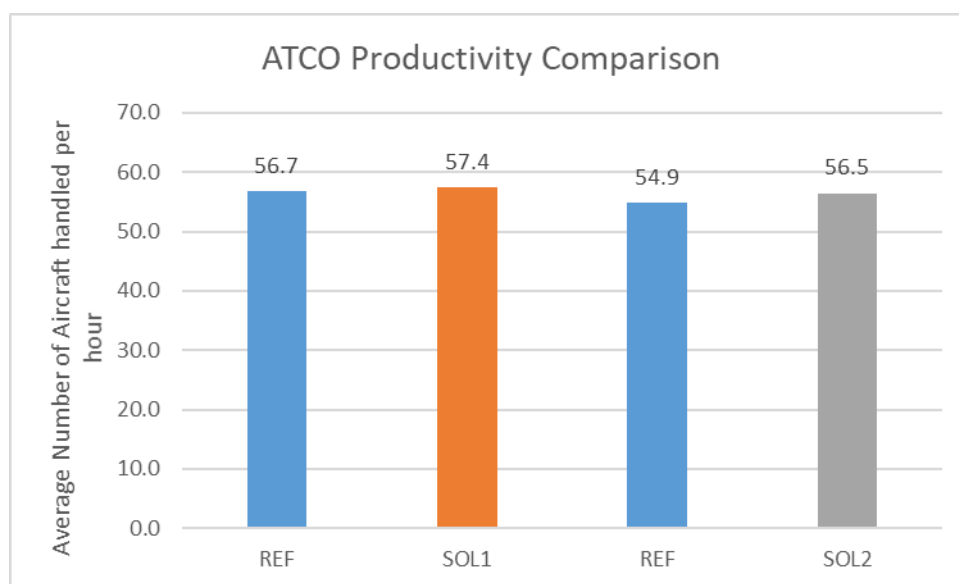


Figure 12: Average Number of Flights Handled per hour comparison REF V SOL1 and REF V SOL2

When comparing REF with SOL1 an increase in number of flights handled per hour of 0.6 movements is seen (1.1%). When comparing REF with SOL2 an increase of 1.6 movements can be seen (2.9%). This is in agreement with the ATCOs estimate of an increase in movements of 1-2 per hour when asked for their feedback in the post-sim expert workshop.

As discussed in the discussion of assessment results for the Capacity findings (Section 4.7.4), the ATCOs when questioned in the post-simulation workshop felt that the concept would bring about an increase in capacity which therefore will enable them to handle a greater number of aircraft per hour. In particular, the feedback from the ATCOs indicated that the concept would bring about an improvement in efficiency of ATCOS to become more consistent across the board, as currently there is a bell curve

of efficiency within the operation. The ATCOs all agreed that the concept would help to ‘flatten the curve’ and improve productivity.

Exercise ID or Expert judgement	Benefits contribution to CEF2	Benefits contribution to CEF3	Benefits contribution to CEF1
EXE-PJ.37-W3-004	extended OSD Tool without TMA Data Feed (SOL1): 0.6 (1.1%) increase aircraft handled per hour extended OSD Tool with TMA Data Feed (SOL2): 1.6 (2.9%) increase in aircraft handled per hour	N/A	N/A

Table 37: Cost Efficiency benefit per Exercise

OI step	Relative benefits contribution to CEF2	Relative benefits contribution to CEF3	Relative benefits contribution to CEF1
AO-0329	100%	N/A	N/A
TOTAL	100%	N/A	N/A

Table 38: Cost Efficiency relative benefit per OI step

4.14.3 Extrapolation to ECAC wide

The following PJ.19 common assumptions have been used:

- Departures traffic contribution – 50%.
- Airports peak traffic contribution:
 - Very large – 30.3653%.
 - Large – 8.3271%.

Extrapolation logic and steps:

1. Add Very Large and Large Airport peak traffic contribution together: 30.3653% + 8.3271% = 38.6924%
2. EXE Benefit SOL1 1.1% (0.6):
 - Relative productivity benefit at ECAC Level = 1.1% x 50% x 38.6924% = 0.21%
 - Absolute productivity benefit at ECAC Level = 0.6 x 50% x 38.6924% = 0.12
3. EXE Benefit SOL2 2.9% (1.6):
 - Relative productivity benefit at ECAC Level = 2.9% x 50% x 38.6924% = 0.56%
 - Absolute productivity benefit at ECAC Level = 1.6 x 50% x 38.6924% = 0.31

KPIs / Pls	Unit	Calculation	Mandatory	Absolute expected performance benefit in SESAR2020	% expected performance benefit in SESAR2020
CEF2²⁰ Flights per ATCO-Hour on duty	No	Count of Flights handled divided by the number of ATCO-Hours applied by ATCOs on duty.	YES	extended OSD Tool without TMA Data Feed (SOL1): 0.12 increase aircraft handled per hour extended OSD Tool with emulated TMA Data Feed (SOL2): 0.31 increase in aircraft handled per hour	extended OSD Tool without TMA Data Feed (SOL1): 0.21% increase aircraft handled per hour extended OSD Tool with emulated TMA Data Feed (SOL2): 0.56% increase in aircraft handled per hour
CEF3 Technology cost per flight	EUR / flight	G2G ANS cost changes related to technology and equipment.	YES	N/A	N/A
CEF1 Direct ANS Gate-to-gate cost per flight	EUR / flight	Derived by PJ19, taking into account results for the other two KPIs as contributing factors.	Yes but derived from the other two KPIs below	N/A	N/A

Table 39: Cost Efficiency benefit for Mandatory KPIs /Pls

Were there any benefits obtained in SESAR2020 Wave 1 for this Demo? Yes.

If yes, does the S2020 Wave 2 performance comes in addition to S2020 Wave 1 or replace it? It replaces it.

4.14.4 Discussion of Assessment Result

At a local exercise level, the findings from the number of aircraft handled per hour sees an improvement in both solution scenarios compared to the reference scenario, therefore improving ATCO productivity and in turn improving the Aerodrome cost efficiency.

When comparing REF with SOL1 an increase in number of flights handled per hour of 0.6 movements is seen (1.1%). When comparing REF with SOL2 an increase of 1.6 movements can be seen (2.9%). A larger improvement is seen in SOL2 than SOL1 which is in line with expectations that the ATCOs were able to use the countdown timer rather than mental arithmetic to increase the accuracy of delivery to a flow restriction, helping them to be more efficient, and that the TMA data feed enabled non-integer flow restrictions to be used. It is not possible to tell from the analysis conducted that this increase is completely down to the use of the TMA data feed, as there could be an element of random variation, however future projects will assess the benefits further.

This data analysis used the departure runway throughput data that was used for the Capacity analysis but with the addition of any arriving and crossing aircraft. As explained in the discussion of Capacity

²⁰ The benefits are determined by converting workload reduction to a productivity improvement, and then scale it to peak traffic in the applicable sub-OE category. It has to be peak traffic because there must be demand for the additional capacity (note that in this case the assumption is that the additional capacity is used for additional traffic).

findings in Section 4.7.4, although there were some limitations of the runway throughput results (i.e., learning effect of traffic sample and improvements required to the algorithm) the ATCOs opinion was that improvement in capacity and therefore an improvement in ATCO productivity would be seen by the introduction of this concept.

On extrapolation of the KPI results to ECAC wide, for CEF2, the results show an improvement of SOL1 over REF with an increase of 0.12 (0.21%) aircraft handled per hour, and an increase of 0.31 (0.56%) aircraft handled per hour for SOL2 over REF.

4.14.5 Additional Comments and Notes

N/A

4.15 Airspace User Cost Efficiency

Does the Demo impact this KPA? No. The Airspace User Cost Efficiency metrics capture monetised operational and non-operational airspace user benefits that are not already assessed through the other KPIs, meaning, benefits other than ANS cost improvements, fuel efficiency improvements, etc.

4.16 Security

The security requirements for PJ.37-W3-01B are based on requirements identified during SESAR Wave 1 PJ.02-01 and SESAR Wave 2 PJ.01-W2-08B, since both solutions form the starting point of PJ.37-W3-01B. The requirements have been reviewed and remain relevant.

The security topics covered are:

- Security Policy
- Organization of Information Security
- Human Resources Security
- Asset Management
- Access Control
- Physical and Environmental Security
- Operations Security
- Communications Security
- System Acquisition, Development and Maintenance
- Information Security Incident Management
- Information Security aspects of Business Continuity Management
- Compliance

4.17 Human Performance

4.17.1 HP arguments, activities and metrics

The main HP areas from the Human Performance Assessment Plan (HPAP) of interest were in accordance to the following HP Arguments:

- 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.
- Arg 3: Team structures and team communication support the human actors in performing their tasks.
- Arg 4: Human Performance related transition factors are considered.

Argument 3 (team structures and team communication support the human actors in performing their tasks) was considered in the initial phase of understanding the concept but the consensus of the project and ATC experts was that no changes were expected in this area

Evidence was gathered using both qualitative and quantitative methods. This included questionnaires at End of Runs (EOR) and End of Simulation (EOS). A post-validation expert workshop was also used to present the results and gather further feedback from the controllers.

For Workload (WL), the results showed acceptable WL levels with most of the participants indicating “negligible” workload as a result of the extended OSD tool. For Situation Awareness (SA), results also showed acceptable SA levels with most of the participants indicating “Very Good” SA. The feedback from the ATCOs also suggested that participants could follow the operating methods without significant WL increase or SA issues, as they did not consider that the risk is any greater with the extended OSD tool in the case of non-nominal scenarios.

However, ATCOs expressed a preference for additional support, e.g., a fallback matrix for degraded/failure modes. ATCO feedback suggests that the extended OSD tool can be highly beneficial, especially in a flow restriction and departure-heavy period, but system failure in such a situation could be problematic.

ATCOs felt like they could perform their tasks in a timely, efficient and accurate manner. They also agreed that the extended OSD tool supports them in creating an accurate mental model, which aids them in decision making and future state forecasting of separating aircraft. However, support from a type of Departure Manager (DMAN) would be useful: “having the knowledge about the departure sequence would be helpful and less distracting”. While several participants found the Human-Machine Interface (HMI) design reasonable and usable on Airport Display Information System (ADIS), some suggestions were put forth for the location of the timer.

For the next phase of the project, it is recommended that an HMI Development workshop is conducted to gather further feedback from the users.

Full details of the HP activities, results and conclusions can be found in the Human Performance Assessment Report (HPAR) (ref 19).

PIs	Activities & Metrics	Second level indicators	Covered
HP1 Consistency of human role with respect to human capabilities and limitations	Activity & Metric 1 – Risk and Benefit Analysis using AIM models.	HP1.1 Clarity and completeness of role and responsibilities of human actors	Open
	Activity & Metric 3 - Real Time Simulation using SHAPE questionnaires and qualitative group interview techniques.	HP1.2 Adequacy of operating methods (procedures) in supporting human performance	Open
		HP1.3 Capability of human actors to achieve their tasks in a timely manner, with limited error rate and acceptable workload level	Open
HP2 Suitability of technical system in supporting the tasks of human actors	Activity & Metric 1 – Risk and Benefit Analysis using AIM models.	HP2.1 Adequacy of allocation of tasks between the human and the machine (i.e. level of automation).	Open
	Activity & Metric 2 – Human-Machine Interface Design Workshop using CoRe design guides	HP2.2 Adequacy of technical systems in supporting Human Performance with respect to timeliness of system responses and accuracy of information provided	Open
	Activity & Metric 3 - Real Time Simulation using SHAPE questionnaires and qualitative group interview techniques.	HP2.3 Adequacy of the human machine interface in supporting the human in carrying out their tasks.	Open
HP3 Adequacy of team structure and team communication in	N/A	HP3.1 Adequacy of team composition in terms of identified roles	N/A

PIs	Activities & Metrics	Second level indicators	Covered
supporting the human actors		HP3.2 Adequacy of task allocation among human actors	N/A
		HP3.3 Adequacy of team communication with regard to information type, technical enablers and impact on situation awareness/workload	N/A
HP4 Feasibility with regard to HP-related transition factors	Activity & Metric 1 – Risk and Benefit Analysis using AIM models. Activity & Metric 3 - Real Time Simulation using SHAPE questionnaires and qualitative group interview techniques.	HP4.1 User acceptability of the proposed Demo	Closed
		HP4.2 Feasibility in relation to changes in competence requirements	Closed
		HP4.3 Feasibility in relation to changes in staffing levels, shift organization and workforce relocation.	N/A
		HP4.4 Feasibility in relation to changes in recruitment and selection requirements .	N/A
		HP4.5 Feasibility in terms of changes in training needs with regard to its contents, duration and modality.	N/A

Table 40: 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

PIs	Number of open issues/ benefits	Nr. of recommendations	Number of requirements
HP1 Consistency of human role with respect to human capabilities and limitations	6	7	2
HP2 Suitability of technical system in supporting the tasks of human actors	10	8	4
HP3 Adequacy of team structure and team communication in supporting the human actors	0	0	0
HP4 Feasibility with regard to HP-related transition factors	0	0	0

Table 41: Open HP issues/ recommendations and requirements

4.17.4 Concept interaction

No interactions with other SESAR 2020 Demos were identified.

4.17.5 Most important HP issues

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	The concept solution is designed to increase runway throughput. A credible hazard was identified that controllers may give premature take off clearances leading to an overload (i.e., controller reaches their limit of mental and physical capacity). This may increase the risk of further human errors/safety incidents occurring or impact service delivery goals.	None
	The concept solution provides additional information required by ATC roles and Flight Crew. Runway throughput will also be increased. More effort to build and maintain sufficient levels of SA will be needed (e.g., the visual scan of RWY controllers will take longer to complete). If there is insufficient time to complete the visual scan or build/update the mental picture human actors may not act when required, take the incorrect action or the correct action does not have the desired outcome.	
HP2 Suitability of technical system in supporting the tasks of human actors	If the system fails such that the automated task is either done incorrectly, inefficiently or not done at all then RWY controllers will have to resume the responsibility of calculating which separation standard and route spacing should be applied. If a RWY controller's workload is already near to or at their physical or cognitive capacity thresholds, then this may result in an overload and therefore increase the risk of a safety incident (e.g., the instruction "cleared to take off" is given too early to the follower aircraft).	None

PIs	Most important issue of the Demo	Most important issues due to solution interdependencies
HP3 Adequacy of team structure and team communication in supporting the human actors	None	None
HP4 Feasibility with regard to HP-related transition factors	None	None

Table 42: Most important HP issues

4.18 Gap Analysis

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

KPI	Validation Targets – Network Level (ECAC Wide)	Performance Benefits at Network Level (ECAC Wide or Local depending on the KPI) ²¹	Rationale
SAF1: Safety - Total number of estimated accidents with ATM Contribution per year	N/A	N/A	N/A
FEFF1: Fuel Efficiency - Actual average fuel burn per flight	N/A	extended OSD without a TMA data-feed (SOL1): -1.6 kg per flight (-0.03%) extended OSD with a TMA data-feed (SOL2): -3.7 kg per flight (-0.07%) Departure (50%) flights out of very large (30%) and large (8%) airports = 19% of all ECAC flights impacted	N/A
CAP1: TMA Airspace Capacity - TMA throughput, in challenging airspace, per unit time.	N/A	N/A	N/A
CAP2: En-Route Airspace Capacity - En-route throughput,	N/A	N/A	N/A

²¹ Negative impacts are indicated in red.

in challenging airspace, per unit time			
CAP3: Airport Capacity – Peak Runway Throughput (Mixed mode).	N/A	N/A	N/A
TEFF1: Gate-to-gate flight time	N/A	extended OSD Tool without TMA Data Feed (SOL1): 0.07 minutes (0.07%) extended OSD Tool with an emulated TMA Data Feed (SOL2): 0.18 minutes (0.18%) Departure (50%) flights out of very large (30%) and large (8%) airports = 19% of all ECAC flights impacted	N/A
PRD1: Predictability – Average of Difference in actual & Flight Plan or RBT durations	N/A	extended OSD Tool without TMA Data Feed (SOL1): 0.07 minutes (0.07%) extended OSD Tool with an emulated TMA Data Feed (SOL2): 0.18 minutes (0.18%) Departure (50%) flights out of very large (30%) and large (8%) airports = 19% of all ECAC flights impacted	N/A
PUN1: Punctuality – Average departure delay per flight	N/A	N/A	N/A

CEF2: ATCO Productivity – Flights per ATCO -Hour on duty	N/A	extended OSD Tool without TMA Data Feed (SOL1): 0.12 (0.21%) increase aircraft handled per hour extended OSD Tool with an emulated TMA Data Feed (SOL2): 0.31 (0.56%) increase in aircraft handled per hour Departure (50%) flights out of very large (30%) and large (8%) airports = 19% of all ECAC flights impacted	N/A
CEF3: Technology Cost – Cost per flight	N/A	N/A	N/A

Table 43: 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)²²
- [3] SESAR Performance Framework (2019), Edition 01.00.01, Dec 2019
<https://stellar.sesarju.eu/?link=true&domainName=saas&redirectUrl=%2Fjsp%2Fproject%2Fproject.jsp%3FobjId%3Dxrn%3Adatabase%3Aondb%2Frecord%2F16414675>
- [4] Performance Assessment and Gap Analysis Report (2019), Edition 00.01.02, Dec 2019
- [5] Methodology for the Performance Planning and Master Plan Maintenance, Edition 0.13, Dec 2017
- [6] SESAR2020 PJ.20 WP2.2 Airport OE (Edition February 2019) & TMA and En-Route OE (Edition April 2019)
- [7] SESAR Solution PJ.37 (ITARO), Demonstration Plan (DEMOP), Deliverable D1.4.03, Edition, 00.02.03, October 2022.
- [8] SESAR Solution PJ.02-01, SPR-INTEROP/OSED for V3 – Part I, Deliverable ID D1.1.021, Edition 00.01.00, November 2019.
- [9] SESAR Solution PJ.37 (ITARO), Demonstration Report (DEMOR) – Part I, Deliverable ID D1.5, Edition 00.02.00, May 2023.

Content Integration

- [10] SESAR ATM Lexicon

Performance Management

- [11] PJ19.04 D4.1 Validation Targets - Wave 2 (2020)²³

Validation

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

Safety

²² At the time of the creation of the PAR template, the Methodology (PJ19.04 Internal Document) is foreseen to be update in 2020.

²³ At the time of the creation of the PAR template the Validation Target is foreseen to be delivered in June 2020

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

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

[16]Accident Incident Models – AIM, release 2017

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Human Performance

[17]16.06.05 D 27 HP Reference Material D27

[18]16.04.02 D04 e-HP Repository - Release note

[19]D2.1 SESAR Solution PJ.37-W3-01B – DEMOR – Part III – Human Performance Assessment Report, Ed00.01.00 February 2023

Environment Assessment

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

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Security

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[23]16.06.02 D137 Minimum Set of Security Controls (MSSCs).

[24]16.06.02 D131 Security Database Application (CTRL_S)