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SESAR Solution PJ.05-W2-35 SPR/INTEROP-OSED Template for V3 - Part V - Performance Assessment Report (PAR) Template

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Authoring & Approval

Authors of the document

Beneficiary	Date
CRIDA/ENAIRE	18/10/2022
Hungarocontrol	11/11/2022
Deep Blue	15/11/2022
ENAV	20/10/2022
LFV	20/10/2022

Reviewers internal to the project

Beneficiary	Date
CRIDA/ENAIRE	30/11/2022
LFV-COOPANS	30/11/2022
DFS	30/11/2022
DLR	30/11/2022
INDRA	30/11/2022
HUNGAROCONTROL	30/11/2022
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DBL	30/11/2022
SAAB-NATMIG	30/11/2022

Reviewers external to the project

Beneficiary	Date

Approved for submission to the S3JU By - Representatives of all beneficiaries involved in the project

Beneficiary	Date
CRIDA/ENAIRE	30/11/2022
LFV-COOPANS	30/11/2022
DFS	30/11/2022
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PJ05-W2-DTT

DIGITAL TECHNOLOGIES FOR TOWER

This Performance Assessment Report (PAR) is part of a project that has received funding from the SESAR3 Joint Undertaking under grant agreement No 874470 under European Union's Horizon 2020 research and innovation programme.

Abstract

Remotely Provided Air Traffic Service for Multiple Aerodromes and development of the Remote Tower Centre are part of this development which started with Single Remote Towers.

This document is the "Performance Assessment Review" of PJ05-W2-35 – ''Multiple Remote Tower and Remote Tower Centre'' targeting at V3 maturity.

Five exercises in total, two of them split into several sub-exercises, were organised and performed at different locations based on different prototypes. The validations were conducted as both real-time simulation and as passive shadow mode trials. All the validations were performed in the Sub-OE defined as "Small Airports".

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1 Executive Summary

This document provides the Performance Assessment Report (PAR) for PJ05 Solution 35 “Multiple Remote Tower and Remote Tower Centre2.

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

Description:

The objective of Solution 35 is to increase ATCO productivity (i.e. reduce the number of ATCOs required) by a balance of workload between different MRTMs within a Remote Tower Centre. The balance is achieved through a flexible allocation of aerodromes to each MRTM. A flexible allocation of aerodromes in the MRTM implies that one aerodrome can take different positions within MRTMs (e.g. aerodrome A is at the left position of the MRTM (1) in the morning and after a transfer to another MRTM (2) is received back at the right position of the MRTM (1)).

The expectation is that this will increase the complexity, as it will be more difficult to maintain situational awareness for the ATCO on the controlled aerodromes, with this flexibility (this compared to a fixed presentation of 2 or 3 aerodromes).

Assessment Results Summary:

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

There are three cases:

1. An assessment result of 0 with confidence level other level High, Medium or Low indicates that the Solution is expected to impact in a marginal way the KPI or mandatory PI.

2. An assessment result (positive or negative) different than 0 with confidence level High, Medium or Low indicates that the Solution is expected to impact the KPI or mandatory PI.

3. An assessment result of N/A (Not Applicable) with confidence level N/A indicates that the Solution is not expected to impact at all the KPI or mandatory PI consistently with the Benefit Mechanism.

KPI	Validation Targets – Network Level (ECAC Wide)	Performance Benefits at Network Level (ECAC Wide or Local depending on the KPI)[1]	Confidence in Results[2]
SAF1: Safety - Total number of estimated accidents with ATM Contribution per year	***Level of Impact 1***	0	High
FEFF1: Fuel Efficiency - Actual average fuel burn per flight	N/A	N/A	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, 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	N/A	N/A
PRD1: Predictability – Average of Difference in actual & Flight Plan or RBT durations	N/A	N/A	N/A

[1] Negative impacts are indicated in red.

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

PUN1: Punctuality – Average departure delay per flight	N/A	N/A	N/A
CEF2: ATCO Productivity – Flights per ATCO -Hour on duty	***Level of Impact 2***	***1% - 2%***	***Low***
CEF3: Technology Cost – Cost per flight	N/A	N/A	N/A

Table 1: KPI Assessment Results Summary

Mandatory PI	**Performance Benefits Expectations at Network Level (ECAC Wide or Local depending on the KPI)[3]**	**Confidence in Results[4]**
SAF1.X: Mid-air collision - En-Route	N/A	N/A
SAF2.X: Mid-air collision - TMA	0	Medium
SAF3.X: RWY-collision accident	0	Medium
SAF4.X: TWY-collision accident	0	Medium
SAF5.X: CFIT accident	0	Medium
SAF6.X: Wake related accident	0	Medium
SAF7.X: RWY-excursion accident	0	Medium
SAF8.X ...: Other SAF Risks	0	Medium
SEC1: A security risk assessment has been carried out	Yes	Low
SEC2: Risk Treatment has been carried out	Yes	Low

[3] Negative impacts are indicated in red.

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

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SEC3: Residual risk after treatment meets security objective.	Yes	Low
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
PRD2: Variance of Difference in actual & Flight Plan or RBT durations	N/A	N/A
PUN2: % Flights departing within +/- 3 minutes of scheduled departure time due to ATM and weather related delay causes	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

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HP1: Consistency of human role with respect to human capabilities and limitations	Close	Medium
HP2: Suitability of technical system in supporting the tasks of human actors	Close	Medium
HP3: Adequacy of team structure and team communication in supporting the human actors	Close	Medium
HP4: Feasibility with regard to HP-related transition factors	Close	Medium

Table 2 Mandatory PIs Assessment Summary

Additional Comments and Notes:

N/A

2 Introduction

2.1 Purpose of the document

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

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

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

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

2.2 Intended readership

The intended audience for this document is primarily all the partners involved in SESAR 2020, PJ05 addressing Solution 35.

The intended readerships for this document are:

- **SESAR JOINT UNDERTAKING (SJU)** as SESAR 2020 Program coordinator
- **SESAR 2020 PJ.19** Content Integration that aims at assuring coherency, consistency, and comparability of the validation results throughout all SESAR Solutions.
- **SESAR 2020 PJ.20** European Master Planning of objectives - Coordination contact (s)
- **PJ05** Partners addressing PJ05-W2-35

External to the SESAR project, other stakeholders are to be found among:

- ANS providers
- ATM infrastructure and equipment suppliers
- Airspace users
- Airport owners/providers
- Affected NSA
- Affected PSOs

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SESAR 2020 Projects/Solutions:

- PJ.14 (EECNS) CNS

  (Solution PJ.14-W2-84 — New use and evolution of Cooperative and Non-Cooperative Surveillance)

SESAR 2020 Transversal Projects:

- PJ.19 W2 (CI) Content Integration PJ.20 W2 (AMPLE) Master Plan Maintenance

2.3 Inputs from other projects

The work done for single remote tower and contingency remote tower are the baseline for multiple remote tower concepts.

Validations in SESAR 1 were conducted within the frame of the three different Operational Improvements:

- SDM-0201 - Single Remote Tower for low density aerodromes
- SDM-0204 - Contingency solutions for aerodromes with one main RWY
- SDM-0205 - Multiple solution for two low density aerodromes simultaneously

All detailed information related to previous work done in SESAR 1, can be found in the data packs for the following solutions:

- Solution #71: “ATC and AFIS service in a single low density aerodrome from a remote CWP”
- Solution #52: ‘’Remote Tower Services for two low-density aerodromes’’
- Solution #12: “Single remote tower operations for medium traffic volumes”
- Solution #13: “Remotely provided air traffic service for contingency situations at aerodromes

Validations within SESAR 2020, wave 1 were performed at V2 and V3 maturity level for the following operational improvements:

- SDM-0207 – Multiple Remote Tower Module – V3 level
- SDM-0210 – Highly Flexible Allocation of Aerodromes to Remote Tower Modules – V2 level

All above mentioned solutions regarding Remote Tower concept developed and validated under SESAR programme projects (SESAR 1, SESAR 2020 wave1), have delivered results determining the solution PJ05-02-V3 as reference for Solution 35 regarding Multiple Remote Tower Modules.

2.4 Glossary of terms

Term	Definition	Source of the definition
ATS (Air Traffic Service)	A generic term meaning variously, Flight Information Service (FIS), Alerting Service (ALRS) and Air Traffic Control Service (ATC) (area control service, approach control service or aerodrome control service). In this document, when the term ATS is used, it is usually referring to TWR or AFIS.	ICAO, Annex 11
Aerodrome ATS	Aerodrome ATS means air traffic service for aerodrome traffic, in the form of 'aerodrome control service (ATC) or 'aerodrome flight information service' (AFIS).	EASA
Aerodrome Control Service (TWR)	The air traffic control (ATC) service provided by the Air Traffic Control Officer (ATCO) for aerodrome traffic. Air traffic control service is a service provided for the purpose of: • preventing collisions: • between aircraft, and • on the manoeuvring area between aircraft and obstructions; and expediting and maintaining an orderly flow of air traffic.	ICAO, Annex 11
APP (Approach control service)	**APP** (Approach control service) is the service for Arrival and Departing traffic (before and after they will be/have been under the TWR control. APP is provided by a single ATCO for one or more airports, either separate or in combination with TWR (TWR & APP from the Tower).	ICAO
APW	**APW** (Area Proximity Warning) warns the controller about unauthorised penetration of an airspace volume by generating, in a timely manner, an alert of a potential or actual infringement of the required spacing to that airspace volume.	SKYbrary
ATCO	**ATCO** (Air Traffic control Officer) is the person trained to maintain the safe, orderly, and expeditious flow of air traffic in the global air traffic control system.	NATCA
Conventional Tower	Conventional Tower means a facility located at an aerodrome from which aerodrome ATS is provided principally through direct out-of-the-window observation of the aerodrome and its vicinity.	EASA
Multiple mode of operation	Multiple mode of operation means the provision of ATS from one remote tower/remote tower module for two or more aerodromes at the same time (i.e. simultaneously).	EASA
Multiple Remote Tower Module (MRTM)	Multiple Remote Tower Module (MRTM) is a term used by project PJ.05 and in this document to specifically indicate a Remote Tower Module (RTM) which enables the possibility to provide ATS to two or more aerodromes at the same time (i.e. simultaneously).	PJ.05 definition

Out-of-the-window (OTW) view'	'Out-of-the-window (OTW) view means a view of the area of responsibility of the aerodrome ATS unit from a conventional tower, obtained via direct visual observation.	EASA
Remote Tower	Remote Tower means a geographically independent facility from which aerodrome ATS is provided principally through indirect observation of the aerodrome and its vicinity, by means of a visual surveillance system. (It is to be seen as a generic term, equivalent in level to a conventional tower).	EASA
Remote Tower Centre (RTC)	A Remote Tower Centre (RTC) means a facility housing one or more remote tower modules.	EASA
Remote Tower Module (RTM)	Remote Tower Module (RTM) means a combination of systems and constituents from where remote aerodrome ATS can be provided, including one or more ATCO/AFISO workstation(s) and the visual presentation. (It can be compared with the tower cabin of an aerodrome conventional tower.)	EASA
Remote Tower Centre Supervisor (RTC supervisor)	Remote Tower Centre Supervisor (RTC supervisor) The role of an RTC supervisor may be established in order to provide an efficient set up at all times and guarantee a flexible system by means of; maintaining overall supervision of all aerodromes within the RTC; managing the allocation of staff and Modules (MRTMs/RTMs); performing planning, administration, allocation of tasks and supervision of technical systems.	PJ.05 definition
Simultaneous movements	Simultaneous movements are all aircraft and vehicle movements under the control of the ATCO, or on the frequency at the same time.	PJ.05 definition
Single mode of operation	Single mode of operation means the provision of ATS from one remote tower/remote tower module for one aerodrome at a time.	EASA
Technical Enablers	Technical Enablers refer to additional features and functions within a single or a multiple module that enable the provision of ATS using the concept. These technical features will assist in the areas of visualisation and operational performance. Further information on the requirement status of the Technical Enablers is given within this document.	EASA
Visual Presentation	Visual Presentation means a view of the area(s) of responsibility of the aerodrome ATS unit, provided by a visual display.	EASA
Visual Surveillance System	Visual Surveillance System means of a number of integrated elements, normally consisting of optical sensor(s), data transmission links, data processing systems and situation displays providing an electronic visual presentation of traffic and any other information necessary to maintain situational awareness at an aerodrome and its vicinity. **Note:** EUROCAE ED-240/ED-240A is using the term 'remote tower optical system' for the same purpose.	ICAO, Doc 4444 EASA

Table 3: Glossary of terms

2.5 Acronyms and Terminology

Term	Definition
ANS	Air Navigation Service
ANSP	Air Navigation Service Provider
ATFM	Air Traffic Flow Management
ATM	Air Traffic Management
BAD	Benefits Assessment Date
BAER	Benefit Assessment Equipment Rate
CBA	Cost Benefit Analysis
DOD	Detailed Operational Description
E-ATMS	European Air Traffic Management System
ECAC	European Civil Aviation Conference
DB	Deployment Baseline
KPA	Key Performance Area
KPI	Key Performance Indicator
N/A	Not Applicable
OI	Operational Improvement
PAR	Performance Assessment Report
PI	Performance Indicator
PRU	Performance Review Unit
QoS	Quality of Service
RBT	Reference Business / Mission Trajectory
SESAR	Single European Sky ATM Research Programme
S3JU	SESAR3 Joint Undertaking (Agency of the European Commission)
SESAR2020 Programme	The programme which defines the Research and Development activities and Projects for the S3JU.

Table 4: Acronyms and terminology

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3 Solution Scope

3.1 Detailed Description of the Solution

The objective of Solution 35 is to increase ATCO productivity (i.e. reduce the number of ATCOs required) by a balance of workload between different MRTMs within a Remote Tower Centre. The balance is achieved through a flexible allocation of aerodromes to each MRTM. A flexible allocation of aerodromes in the MRTM implies that one aerodrome can take different positions within MRTMs (e.g. aerodrome A is at the left position of the MRTM (1) in the morning and after a transfer to another MRTM (2) is received back at the right position of the MRTM (1)). The expectation is that this will increase the complexity, as it will be more difficult to maintain situational awareness for the ATCO on the controlled aerodromes, with this flexibility (this compared to a fixed presentation of 2 or 3 aerodromes).

The task of flexible allocation of grouped aerodromes to dedicated MRTMs can be supported by a controller with a specific role (e.g. supervisor), who can be aided by a support tool that incorporates data like traffic volume/complexity, planned maintenance and other activities, weather conditions at the different airports, as well as ATCO endorsements and availability.

The validations were based on the assumption that an ATCO can hold endorsements for 4 aerodromes. These 4 aerodromes are grouped together and can be flexibly allocated to the MRTMs. Nevertheless, the concept could also be valid for a higher number of grouped aerodromes if the ATCO can hold endorsements for more aerodromes.

Solution 35 addresses any combination of small category aerodromes according to EATMA aerodrome classification:

- Small Airport Operating Environment: between 15,000 and 40,000 annual IFR movements
- Other Airport Operating Environment will be included within the RTC functionality

Solution 35 addresses any combination of small aerodrome category and needs to be validated for different kinds of environments that may be composed of:

- Different levels of airport complexity (RWYs, taxiways, etc.).
- Traffic volumes and their distribution over the controlled aerodromes.
- Various conditions at the different aerodromes (weather, daylight, geographical difference).
- Variable traffic mixes (VFR-IFR-mix, rotor-fixed wing, special).

Technical aspects, such as network quality of service, SWIM infrastructure and other resilience/redundancy related issues that are of key importance to the regulatory authorities are in place for the baseline Single Remote Tower.

Furthermore, the information needs for maintaining situational awareness including the local actual and forecasted weather (MET) and the local actual and forecasted status of the infrastructure (AIM) will need to be addressed from various operational perspectives.

3.2 Detailed Description of relationship with other Solutions

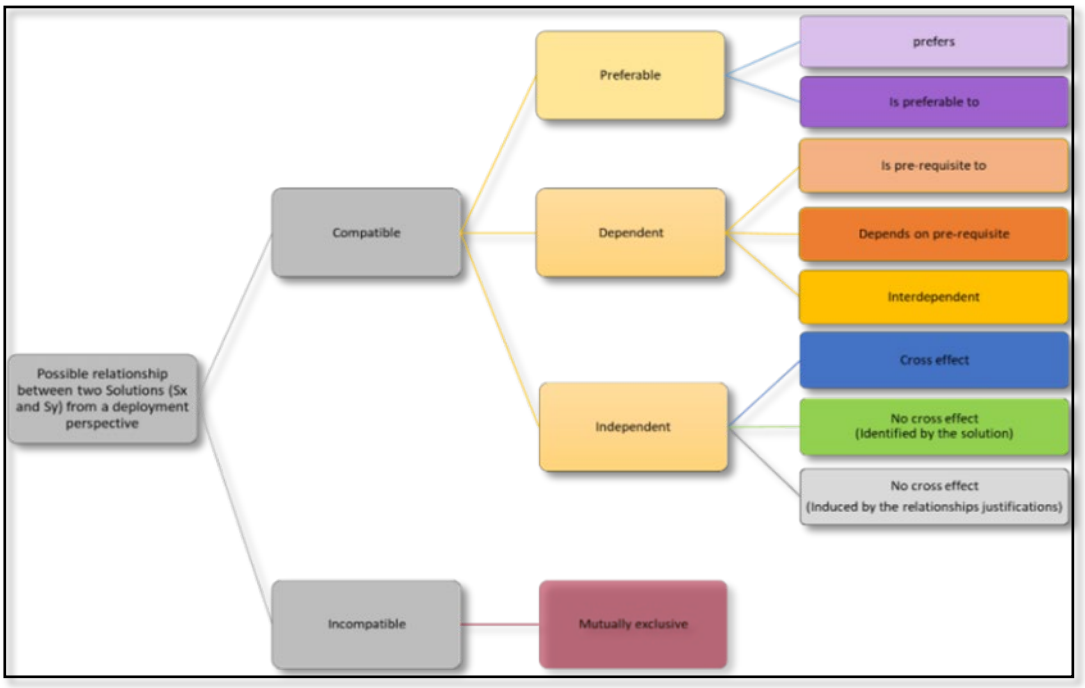

Figure 1: Possible relationship between Solutions from a deployment perspective

PJ05.35 W2 takes into account the work performed in SESAR 2020 W1 PJ5.02 [7] and PJ05.03 [4] (based on SESAR 1 in Project 06.09.03 [5]).

- W2.PJ5.35 represents the evolution of W1.PJ5.02 (used as reference for W2.PJ5.35) with the introduction of a flexible allocation of aerodromes between the available multi remote tower modules.

- W1.PJ5.03 completed the V2 level of maturity and W2.PJ5.35 is expected to complete the V3 level of maturity of W1.PJ5.03 investigated concept.

There is no relationship between the solution for the W2 solutions in airport operational environment and all relationships have been judged as “No cross effect” as it would increase cost for Remote Tower, which has as goal to reduce cost. Thus, these relationships are not mentioned except for the following, being part of the same project:

Solution Number	Solution Title	Relationship	Rational for the relationship
W2.PJ05.97.2	Improving controller productivity by ASR at the TWR CWP	Compatible/preferable /Prefers	W2.PJ5.35 prefers W2.PJ5.97.2 ASR solutions as the speech recognition module might support ATCOs responsible of the MRTMs

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W2.PJ05.97.1	HMI Interaction modes for Airport Tower	Incompatible	On one hand, HoloLens and remote tower cannot be used at the same time. On the other hand, virtual reality application with other means might be beneficial for RTC.

Table 5: Relationships with other Solutions

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4 Solution Performance Assessment

4.1 Assessment Sources and Summary of Validation Exercise Performance Results

No previous Validation Exercises (pre-SESAR2020 Wave 2, etc.) have been considered as relevant for the performance assessment of PJ.-W2-44 results.

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

Exercise ID	Exercise Title	Release	Maturity	Status
EXE-PJ05-W2-35-V3-2.1.1	The evaluation of a supervisor workplace in connection to a planning tool that allows and supports the flexible allocation of multiple RTM.	Q4 2021	V3	Completed
EXE-PJ05-W2-35-V3-2.1.2	The evaluation of a video tracking technology to enhance the Safety Nets and support the flexible allocation of multiple RTM.	Q4 2021	V3	Completed
EXE-PJ05-W2-35-V3-2.2 COOPANS	Remote Tower Centre with Flexible Allocation of Aerodromes between and within MRTMs.	Q2 2022	V3	Completed
EXE-PJ05-W2-35-V3-2.3.1	Real time Simulation with Avinor.	Q3 2021	V3	Completed
EXE-PJ05-W2-35-V3-2.3.2	Passive Shadow Mode with HungaroControl.	Q2 2022	V3	Completed
EXE-PJ05-W2-35-V3-2.3.3	Real time Simulation with HungaroControl.	Q4 2021	V3	Completed
EXE-05-W2-35-V3-2.4 ENAV	RTC with dynamic allocation of aerodromes to MRTMs	Q2 2022	V3	Completed
EXE-PJ05-W2-35-V3-2.5 DFS	Flexible Allocation of aerodromes to MRTMs in combination with automation tools (supported by basic ground surveillance)	Q3 2021	V3	Completed

Table 6: SESAR2020 Validation Exercises

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

Exercise	OI Step	Exercise scenario & scope	Performance Results	Notes
EXE-PJ05-W2-35-V3-2.1.1	SDM - 0210	The operational scope of this exercise includes the dynamic allocation with a maximum of 15 simulated small sized airports. The excessive focus is on the interaction of several multiple remote tower modules with the supervisor workplace. In relation to the supervisor workplace, the focus is on dynamic situations within such an environment. This includes that the supervisor interacts with each remote tower workplace.	Workload reduction that implies an increase in CEF2	-
EXE-PJ05-W2-35-V3-2.1.2	SDM - 0210	The focus area of the validation exercise is how the correlation and fusion of electro-optical and traditional surveillance detections and thereby possible safety net improvements can enhance the situational awareness. Passive Shadow Mode for a selected airport (Braunschweig Airport) with the aim to maximise the situational awareness with the additional surveillance information gained by correlation and fusion of traditional surveillance and electro-optical detections.	Workload reduction that implies an increase in CEF2	-
EXE-PJ05-W2-35-V3-2.2 COOPANS	SDM - 0210	The validation has been done as one part and the validation exercise has been performed as a Real Time Simulations. The operational scope of the Real Time Simulation in this validation exercise included provision of simultaneous ATS to three small operating environment aerodromes from MRTMs within the RTC by one ATCO. The aerodromes were flexibly allocated	Workload reduction that implies an increase in CEF2	-

Exercise	OI Step	Exercise scenario & scope	Performance Results	Notes
		between the MRTMs and within each MRTM.		
EXE-PJ05-W2-35-V3-2.3.1	SDM - 0210	The operational scope of this real-time simulation includes simultaneous ATS provided to four Norwegian other and small size aerodromes from two MRTMs by one ATCO per RTM and a Supervisor. The scope is fully in line with the context set out in the PJ05-35 Validation Plan (i.e. Solution PJ.05.35 will address the concept of 4 different aerodromes handled within an RTC, with up to 3 aerodromes per MRTM. Exercises addressing this aspect will use a minimum of 2 MRTMs to distribute 4 aerodromes to a limit of 3 in one MRTM).	Workload reduction that implies an increase in CEF2	-
EXE-PJ05-W2-35-V3-2.3.2	SDM - 0210	The operational scope of this passive shadow mode validation was to address the simultaneous ATS provision in small size Hungarian aerodromes from two MRTMs by one ATCO per RTM and a Supervisor. The aerodrome were the followings: • Nyíregyháza (AFIS, mostly VFRs) • Győr-Pér (AFIS, mostly VFRs) • Pápa (military aerodrome)	Workload reduction that implies an increase in CEF2	-
EXE-PJ05-W2-35-V3-2.3.3	SDM - 0210	The operational scope of this real-time simulation includes simultaneous ATS provided to four Norwegian other and small size aerodromes from two MRTMs by one ATCO per RTM and a Supervisor. The scope is fully in line with the context set out in the PJ05-35 Validation Plan (i.e. Solution PJ.05.35 will address the concept of 4 different aerodromes handled within an RTC, with up to	Workload reduction that implies an increase in CEF2	-

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Exercise	OI Step	Exercise scenario & scope	Performance Results	Notes
		3 aerodromes per MRTM. Exercises addressing this aspect will use a minimum of 2 MRTMs to distribute 4 aerodromes to a limit of 3 in one MRTM).		
EXE-05-W2-35-V3-2.4 ENAV	SDM - 0210	The validation exercise focuses on providing remotely Air Traffic Services from an RTC with the dynamic allocation of up to 3 small environment airports between two MRTMs and contribute to the OI Step SDM-0210 'Highly Flexible Allocation of Aerodromes to Remote Tower Modules'.	Workload reduction that implies an increase in CEF2	-
EXE-PJ05-W2-35-V3-2.5 DFS	SDM - 0210	The operational scope of this validation exercise includes simultaneous ATS provided to three small size aerodromes from a MRTM by one ATCO. All airports have a single runway and a simple layout of the manoeuvring area. The objective is to assess in a real-time simulation the ATCO's capability to provide ATS to three aerodromes simultaneously with a flexible allocation of aerodromes to different positions within the MRTM while the ATCO being supported by automation tools.	Workload reduction that implies an increase in CEF2	-

Table 7: Summary of Validation Results.

4.2 Conditions / Assumptions for Applicability

The following Table 8 summarises the applicable operating environments.

OE	Applicable sub-OE	Special characteristics
Airports	Small airports	Multiple small airports

Table 8: Applicable Operating Environments.

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The following table summarises the assumptions.

Assumptions Title and Description
PJ05.35 W2 Remotely Provided Air Traffic Service for Multiple Aerodromes as reference scenario
• Provision of remote ATS for a single aerodrome and for Multiple Aerodromes without flexible allocation is already available, i.e. ATCOs are used to providing ATS from a MRTM
Operating Methods / Traffic Characteristics
• The remote provision of ATS for multiple aerodromes is applicable to aerodromes with simultaneous traffic at the different airports
• Different airport layout usage configurations at the controlled airports (e.g. different runway configuration, different views on the runway) are possible
• The operational procedure/protocol for transfer of one airport between two ATCOs is developed
Weather Conditions
• Different visibility conditions might occur at the controlled airports (resulting in different operational procedures e.g. different CAT/VIS conditions, night and daytime)
• Different wind conditions might occur at the controlled airports
Remote Tower Modules within an RTC
• A unified Multiple Remote Tower Module (MRTM) solution will be developed and implemented (rather than different or even bespoke solutions) within an RTC.
• The minimum set of same systems are available at all controlled airports (i.e. air surveillance, electronic flight strips) and the HMIs of the systems of the controlled airports are harmonised
Allocation of airports to one MRTM can be:
• fixed to MRTM, i.e. no change, and is already available
• flexible to MRTM, i.e. changing at certain times (short term planning) or due to emergencies and is already available
• dynamic, i.e. changing depending on traffic demand (long term planning), which requires a supervisor role
Human actors are:
• ATCO: one single ATCO for one MRTM, i.e. no workshare between two MRTMs

• RTC Supervisor
Training/ Licensing:
• Controllers are familiar with the operating environment and tools
• ATCO can hold endorsements for up to 4(single) different airports harmonised in terms of systems and procedures

Table 9: Applicable assumption

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4.3 Safety

This safety assessment is conducted as per the SESAR Safety Reference Material (SRM) which itself is based on a twofold approach:

- ✓ a success approach which is concerned with the safety of the Solution operations in the absence of failure within the end-to-end Solution functional system, encompassing both Normal operation and Abnormal conditions,
- ✓ a conventional failure approach which is concerned with the safety of the Solution operations in the event of failures within the end-to-end Solution functional system.

These two approaches are applied to the derivation of safety properties at each of the successive lifecycle stages of the Solution development (Safety Requirements at service level and at design level).

4.3.1 Safety Design drivers and Performance Mechanism

The objective of solution 35 is to increase ATCO productivity (i.e. reduce the number of ATCOs required) through a better balance of workload between different MRTMs within a Remote Tower Centre. This will be achieved by a flexible allocation of grouped aerodromes to dedicated MRTMs, possibly supported by a Remote Tower Centre Supervisor role (RTC supervisor) and a Supervisor Planning Tool. An existing ATCO within the RTC can carry out this task, e.g. planning of the shift, need for added staff will be dependent on the size of the RTC.

The solution addressed in this Safety Assessment Report is:

- **Solution PJ05-W2-35: Multiple Remote Tower and Remote Tower Centre**

The OI step addressed in this Safety Assessment Report is:

- **SDM-0210: Highly Flexible Allocation of Aerodromes to Remote Tower Modules**

For PJ.05.35 Solution based on the analysis the following Safety Criteria were selected:

Safety Criteria related to Mid-Air Collision on Initial Departure

SAC#1 There shall be no increase of Imminent MRS infringement on initial departure in each area of responsibility for which ATS are remotely provided using Multiple Remote Tower

SAC#2 There shall be no increase of Imminent Collision in each area of responsibility for which ATS are remotely provided using Multiple Remote Tower

a. as a function of Ineffective ATC Collision prevention

Safety Criteria related to Mid-Air Collision on Final Approach

SAC#3 There shall be no increase of Imminent infringement on final approach in each area of responsibility for which ATS are remotely provided using Multiple Remote Tower

SAC#4 There shall be no increase of Imminent Collision in each area of responsibility for which ATS are remotely provided using Multiple Remote Tower

a. as a function of Ineffective ATC Collision prevention

Safety Criteria related to Mid-Air Collision in TMA *(approach operation is out of scope)*

SAC#5 There shall be no increase of Crew/Aircraft Induced conflict, Planning conflict and ATC Induced conflict in each area of responsibility for which ATS are remotely provided using Multiple Remote Tower

SAC#6 There shall be no increase of Imminent Infringement in each area of responsibility for which ATS are remotely provided using Multiple Remote Tower

a. as a function of Ineffective ATC induced conflict management

b. as a function of Ineffective Crew/AC induced conflict management

c. as a function of Ineffective plan induced conflict management

SAC#7 There shall be no increase of Imminent Collision in each area of responsibility for which ATS are remotely provided using Multiple Remote Tower

a. as a function of Ineffective ATC Collision prevention

Safety Criteria related to Controlled Flight into Terrain

SAC#8 There shall be no increase of Flight Towards Terrain commanded by ATC in each area of responsibility for which ATS are remotely provided using Multiple Remote Tower

SAC#9 There shall be no increase of Imminent Controlled Flight Into Terrain (CFIT) in each area of responsibility for which ATC are remotely provided using Multiple Remote Tower

a. as a function of Ineffective ATCO warning

Safety Criterion related to Wake Vortex Induced Accidents on Initial Departure

SAC#10 There shall be no increase of Wake Encounter on Initial Departure in each aerodrome for which ATS are remotely provided using Multiple Remote Tower

Safety Criterion related to Wake Vortex Induced Accidents on Final Approach

SAC#11 There shall be no increase of Wake Encounter on Final Approach in each aerodrome for which ATS are remotely provided using Multiple Remote Tower

Safety Criteria related to Taxiway Collision

SAC#12 There shall be no increase of Taxiway conflicts in each aerodrome for which ATS are remotely provided using Multiple Remote Tower

a. as a function of ineffective Tactical taxiway planning

SAC#13 There shall be no increase of Imminent Taxiway Infringement in each aerodrome for which ATC are remotely provided using Multiple Remote Tower

a. as a function of Inadequate taxiway conflict management

SAC#14 There shall be no increase of Imminent Taxiway Collision in each aerodrome for which ATC are remotely provided using Multiple Remote Tower

a. as a function of Ineffective ATC taxiway collision avoidance

SAC#15 There shall be no increase of pre-Tactical taxiway conflicts in each aerodrome for which ATC are remotely provided, using Multiple Remote Tower

Safety Criteria related to Runway Collision

SAC#16 There shall be no increase of Induced Incursion in each aerodrome for which ATC are remotely provided using Multiple Remote Tower

a. as a function of Inadequate Runway Incursion Monitoring

b. as a function of ineffective Runway Crossing Management

c. as a function of ineffective Line-up/Take-Off Management

d. as a function of ineffective Landing Management

SAC#17 There shall be no increase of Runway Conflict in each aerodrome for which ATC are remotely provided using Multiple Remote Tower

SAC#18 There shall be no increase of Imminent Runway Collision in each aerodrome for which ATC are remotely provided using Multiple Remote Tower

a. as a function of Inadequate ATC Runway Collision Avoidance

Safety Criteria related to "Landing accidents"

SAC#19 There shall be no increase of Runway Excursions in each aerodrome for which ATS are remotely provided using Multiple Remote Tower

a. as a function of ineffective ATCO weather conditions monitoring affecting arriving aircraft (leading to runway excursion)

b. as a function of ineffective check of the runway surface (with respect to snow, slush, RWY surface friction, FOD, …) (leading to runway excursion)

c. as a function of ineffective ATCO monitoring of AC trajectory on final approach (leading to runway excursion)

SAC#20 There shall be no increase of other Landing related Accidents in each aerodrome for which ATS are remotely provided, using Multiple Remote Tower

a. as a function of ineffective ATCO weather conditions monitoring affecting arriving aircraft (leading to landing accident)

b. as a function of ineffective check of the runway surface (with respect to snow, slush, RWY surface friction, FOD, …) (leading to loss of control on the runway)

c. as a function of ineffective ATCO monitoring of AC trajectory on final approach (leading to undershoot, AC landing in wrong/closed RWY, AC landing with undercarriage retracted)

d. as a function of ineffective monitoring of potential intrusions inside the landing-aid protection area (affecting landing AC) as a function of inefficient management of landing-aid light

4.3.2 Data collection and Assessment

From the Safety Criteria listed in the previous section and following the SRM process, Safety Requirements at Service level (SRS) and Operational Hazards have been developed and identified. The achievability of the Safety Criteria has been demonstrated through the satisfaction of the success criteria of the safety validation objectives defined in relation to the Solution planned validation exercises and other specific validation means (Safety and HP workshop).

The safety-related outcomes of the validation exercises (traced back to the safety validation objectives) bring an essential contribution to the demonstration of the Safety Criteria achievability by the Solution design. Decision for deriving (or not) additional Safety Requirements might be taken from these results. Indeed, an SRS functionality & performance addressing human factors or procedures might be covered by a validation exercise, but the validation outcome might be that it can be satisfied only partially or even not satisfied, in which case the design should ensure adequate risk mitigation.

The safety-relevant results of the validation exercises and of any other specific validation means (Safety and HP workshop) are summarized in SESAR 2020 Wave 2 SPR INTEROP OSED Part II - Safety Assessment Report - PJ05-W2-35, whilst indicating for each safety validation objective / success criteria the extent to which the relevant SRS have been covered.

Safety data collection and then safety assessment have been developed and built on safety workshops conducted with various operational and validation experts, e.g., ATCOs. The assessment based also on the results obtained from validation phase during Real Time Simulation (RTS) through questionnaires and debriefings conducted among the participants.

The Validation Report captured the Safety Validation Objectives, among others. These Safety Validation Objectives were covered by the Validation exercises and/or the HP and Safety workshop.

All nominal Safety Validation Objectives have been covered by either the Validation exercises or the Safety and HP workshop. Particularities on how to implement different aspects are to be developed in local implementation and therefore considered covered in V3.

The Safety Validation Objectives for abnormal conditions were validated in some cases during Validation Exercises. Discussions show that the Multiple Remote Tower setting would not impede ATCOs to deal with abnormal situations, although further assessment needs to be conducted locally for implementation, including the mitigations (additional ATCO, silent communication, etc.).

Some of the Safety Validation Objectives related to degraded modes of operations have been also covered during the validations, and those have been further discussed during the HP and Safety workshop.

Evidences collected for abnormal and failure conditions are partially subjective feedback from operational people involved in the project and in the validation exercises, together with some scenarios that were simulated but that do not cover all cases. This feedback has been collected by questionnaires and group discussions in a Safety and Human Performance workshop with ATCOs in Naples, 07-08 June 2022.

Results are provided in the following documents:

- PJ.05-W2-35 Validation Report V3
- PJ.05-W2-35 SPR-INTEROP/OSED Part II V3 (Safety assessment report)

4.3.3 Extrapolation to ECAC wide

An extrapolation is not possible based on the nature of the results, but it can be concluded that subjective feedback and objective measures indicate that safety is maintained.

4.3.4 Discussion of Assessment Result

Results and conclusions were mainly based on the results of the Post Exercise Questionnaires and the Post Simulation Questionnaire. The analysis shows that safety level can be maintained after implementation of the Solution. The results of the simulation along with experts' judgment can be a formal confirmation of this statement. Quantifiable indicators such as numbers of imminent taxiway infringements, numbers of runway incursions and number of mid-air infringements can show a trend of increasing safety which corroborates the subjective feedback given by controllers.

4.3.5 Additional Comments and Notes

No additional comments or notes.

4.4 Cost Efficiency

Does the Solution 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:

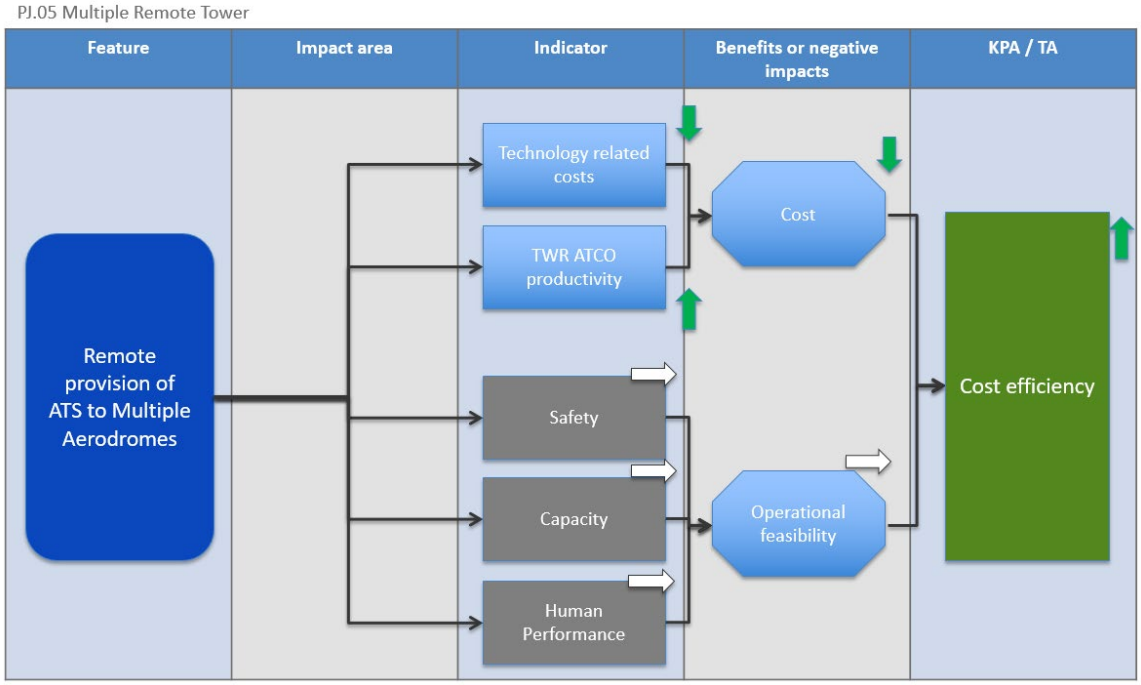
- ATCO Productivity improvement (%) – En-Route or TWR/APP, assessing the reduction of workload per controlled flight hour.
- Technology Related Cost-Efficiency Improvement (%) – by assessing the contributions of the technology enablers to a change in asset costs and/or operating costs (maintenance, etc),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

4.4.1 Performance Mechanism

Is there a Benefit Mechanism available? Yes.

The main driver for Remote Provision of ATS for multiple aerodromes is Cost Effectiveness. However, this is not directly measured through the validation activities, but measured indirectly by using the reduction of the ATCO workload.

Figure below illustrates the logic for how the project hopes to assess CEF through operational feasibility.



Technology related TWR costs comprise of operational engineering staff costs, system-related capital and operating costs. It is envisaged that these costs will decrease due to the centralisation of resources and systems.

TWR Controller Productivity involves increasing safe throughput for a given level of operational resourcing. The remote provision of ATS for multiple aerodromes involves raising the number of flights that an individual controller can handle safely. The technical enablers within the RTM are designed to help the controller increase their situational awareness and decrease the workload.

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In order to assess Cost Effectiveness, the Operational Feasibility of the Multiple Remote Tower concept shall be assessed (the grey boxes in Figure above). In order to prove the concept is operationally feasible the validation activities primarily assess the KPAs safety, human performance and capacity. The validation activities therefore look at these performance areas rather than cost effectiveness directly. These are detailed in the sections below.

4.4.2 Assessment Data (Exercises and Expectations)

The assessment of ATCO Productivity is based on workload assessment. In this case, a comparison between the reference and the solution scenarios has been done to calculate the reduction of ATCO workload. All the exercises of PJ05.35 have used Bedford Scale to measure the workload in all the scenarios performed. With the information extracted from the VALR [9], the values used to calculate are the following ones:

Scenario	WL
Reference	3.6
Solution	3.1

With these values, the percentual reduction of workload is 13.89%, and applying the calculation of the increase in productivity the result is the following one:

$$Increase\ in\ productivity = \frac{1}{\frac{1 - 0.75 * Workload\ Reduction}{2}} - 1 = 5.49\%$$

OI step	Relative benefits contribution to CEF2	Relative benefits contribution to CEF3	Relative benefits contribution to CEF1
SDM-0210 Highly Flexible Allocation of Aerodromes to Remote Tower Modules	100%	N/A	N/A
TOTAL	100%	N/A	N/A

Table 10: Cost Efficiency relative benefit per OI step

4.4.3 Extrapolation to ECAC wide

No extrapolation of CEF2 to ECAC level is needed, since all the exercises in PJ05.35 were performed in small airports.

4.4.4 Discussion of Assessment Result

As stated in section 4.4.2, the benefit in CEF2 for solution PJ05-W2-35 is 5.49%, following the calculations expressed in that section and using the numbers extracted from the VALR [9]. Furthermore, according to de Validation Targets document [7] produced by PJ19 and PJ20, the defined threshold for PJ05-W2-35 impact (Level 2) corresponds to a 0.98 %.

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4.4.5 Additional Comments and Notes

None.

4.5 Human Performance

4.5.1 HP arguments, activities and metrics

PIs	Activities & Metrics	Second level indicators	Covered
HP1 Consistency of human role with respect to human capabilities and limitations	**RTS, Passive Shadow Mode & Workshops:** **Situation awareness / HMI subjective feedback / SIM LOG and INDICATORS / Acceptability / Task prioritisation subjective feedback / Workload / Trust**	**HP1.1** Clarity and completeness of role and responsibilities of human actors	closed
		HP1.2 Adequacy of operating methods (procedures) in supporting human performance	closed
		HP1.3 Capability of human actors to achieve their tasks in a timely manner, with limited error rate and acceptable workload level	closed
HP2 Suitability of technical system in supporting the tasks of human actors	**RTS, Passive Shadow Mode & Workshops:** **Usability /Subjective Feedback / SIM LOG and INDICATORS / Situation awareness / Team Situation awareness / Potential for Human Error / HMI subjective feedback / Trust**	**HP2.1** Adequacy of allocation of tasks between the human and the machine (i.e. level of automation).	closed
		HP2.2 Adequacy of technical systems in supporting Human Performance with respect to timeliness of system responses and accuracy of information provided	closed
		HP2.3 Adequacy of the human machine interface in supporting the human in carrying out their tasks.	closed
		HP3.1 Adequacy of team composition in terms of identified roles	closed

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PIs	Activities & Metrics	Second level indicators	Covered
HP3 Adequacy of team structure and team communication in supporting the human actors	**RTS, Passive Shadow Mode & Workshops:** **Subjective Feedback / Communication Load / SIM LOG and INDICATORS / Situation awareness**	**HP3.2** Adequacy of task allocation among human actors	closed
		HP3.3 Adequacy of team communication with regard to information type, technical enablers and impact on situation awareness/workload	closed
HP4 Feasibility with regard to HP-related transition factors	**RTS, Passive Shadow Mode & Workshops:** **Subjective Feedback**	**HP4.1** User acceptability of the proposed solution	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.	closed
		HP4.4 Feasibility in relation to changes in recruitment and selection requirements .	closed
		HP4.5 Feasibility in terms of changes in training needs with regard to its contents, duration and modality.	closed

Table 11: HP arguments, activities and metrics

4.5.2 Extrapolation to ECAC wide

There is no ECAC wide extrapolation required for this KPI.

4.5.3 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	2	48	28
HP2 Suitability of technical system in supporting the tasks of human actors	0		
HP3 Adequacy of team structure and team communication in supporting the human actors	0		
HP4 Feasibility with regard to HP-related transition factors	0		

Table 12: Open HP issues/ recommendations and requirements

4.5.4 Concept interaction

No interactions identified in the HPAR.

4.5.5 Most important HP issues

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

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

PIs	Most important issue of the solution	Most important issues due to solution interdependencies
HP1 Consistency of human role with respect to human capabilities and limitations	Fatigue tends to accumulate toward the end of the shift and might not be properly assessed in V3	NONE
	Coordination workload especially for VFR might be simplified in V3 and might need further assessment in next phases	
HP2 Suitability of technical system in supporting the tasks of human actors	All issues have been judged as closed and Requirements and Recommendations have been established in order to mitigate them.	

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PIs	Most important issue of the solution	Most important issues due to solution interdependencies
HP3 Adequacy of team structure and team communication in supporting the human actors		
HP4 Feasibility with regard to HP-related transition factors		

Table 13: Most important HP issues

4.5.6 Additional Comments and Notes

None.

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4.6 Gap Analysis

KPI	Validation Targets – Network Level (ECAC Wide)	Performance Benefits at Network Level (ECAC Wide or Local depending on the KPI)[5]	Rationale[6]
SAF1: Safety - Total number of estimated accidents with ATM Contribution per year	Low	NA	NA
FEFF1: Fuel Efficiency - Actual average fuel burn per flight	NA	NA	NA
CAP1: TMA Airspace Capacity - TMA throughput, in challenging airspace, per unit time.	NA	NA	NA
CAP2: En-Route Airspace Capacity - En-route throughput, in challenging airspace, per unit time	NA	NA	NA
CAP3: Airport Capacity – Peak Runway Throughput (Mixed mode).	NA	NA	NA
TEFF1: Gate-to-gate flight time	NA	NA	NA
PRD1: Predictability – Average of Difference	NA	NA	NA

[5] Negative impacts are indicated in red.

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

KPI	Validation Targets – Network Level (ECAC Wide)	Performance Benefits at Network Level (ECAC Wide or Local depending on the KPI)[5]	Rationale[6]
in actual & Flight Plan or RBT durations			
PUN1: Punctuality – Average departure delay per flight	NA	NA	NA
CEF2: ATCO Productivity – Flights per ATCO -Hour on duty	Medium	5.49%	-
CEF3: Technology Cost – Cost per flight	NA	NA	NA

Table 14: 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)[7]

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

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

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

Content Integration

[6] SESAR ATM Lexicon

Performance Management

[7] PJ19.04 D4.1 Validation Targets - Wave 2 (2020)[8]

Validation

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

[9] SESAR Solution PJ05-35 VALR (August 2022)

Safety

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

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

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

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

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

[13]Accident Incident Models – AIM, release 2017

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Human Performance

[14]16.06.05 D 27 HP Reference Material D27

[15]16.04.02 D04 e-HP Repository - Release note

Environment Assessment

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

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

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

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

Security

[18]16.06.02 D103 SESAR Security Ref Material Level

[19]16.06.02 D137 Minimum Set of Security Controls (MSSCs).

[20]16.06.02 D131 Security Database Application (CTRL_S)

Appendix A Detailed Description and Issues of the OI Steps

OI Step ID	Title	Consistency with latest Dataset
SDM-0210	Highly Flexible Allocation of Aerodromes to Remote Tower Modules	DS19

Table 15: OI Steps allocated to the Solution