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SESAR Solution PJ.05-W2-97.1, 97.2 - TS/IRS for TRL4 - Final version

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DIGITAL TOWER TECHNOLOGY

This TS/IRS document 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

This TS/IRS document encompasses two solutions covering the following areas:

- PJ.05-W2-97.1 "Virtual/Augmented Reality applications for Tower"
- PJ.05-W2-97.2 "ASR at the TWR CWP supported by AI and Machine Learning"

Both solutions address the development of new human machine interface (HMI) interaction modes and technologies at the Controller Working Position, with the aim to minimise the load and mental strain on the Tower controllers (especially under high traffic density situations, low visibility conditions, etc.) in several airport sub-operating Environments. These improvements may be applicable in current operations and/or in future operational concepts still under development within the scope of other SESAR solutions.

The objective of this TS/IRS document is to present the functional and non-functional requirements of these technologies as well as the impact on the current EATMA architecture.

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1 Executive summary

This TS/IRS document includes the development of the following solutions within PJ.05-W2 framework:

- PJ.05-W2-97.1, addressing Virtual/Augmented Reality applications for Tower;
- PJ.05-W2-97.2, addressing ASR at the TWR CWP supported by AI and Machine Learning;

These solutions focus on the development of new human machine interface (HMI) interaction modes and technologies at the Controller Working Position, aiming to minimise the load and mental strain on the Tower controllers (especially under high traffic density situations, low visibility conditions, etc.) in several airport sub-operating Environments. These improvements may be applicable in current operations and/or in future operational concepts still under development within the scope of other SESAR solutions.

The solutions consider the work already performed during Wave 1, continuing to provide significant improvements thanks to advanced interaction methods with HMI. As a result of Wave 2 activities, both solutions aim to achieve TRL4 maturity level.

The main objectives of this TS/IRS document are:

- Enhancement of the EATMA architecture, by creating or developing Enablers, Functional Blocks and Functions, through the appropriate Change Requests (CR), and
- Identification of impacts on the overall architecture, and
- Development of functional and non-functional requirements.

Impacts and imposed changes on the architecture are detailed, as well as technical specifications, implementation options, and assumptions.

The scope of the TS/IRS in terms of relevant EATMA elements covering the solutions is presented in the following table:

Capability Configuration	Role	Technical System	SESAR Solution	Functional Block
TWR	Tower Clearance Delivery Controller Tower Ground Controller Tower Runway Controller	Aerodrome ATC	PJ.05-W2-97.1	Attention Guidance
				Air Gestures Detector
				Virtual and Augmented Reality Display
			PJ.05-W2-97.2	Automatic Speech Recognition
				Controller Human Machine Interaction Management Aerodrome ATC

Table 1. EATMA elements relevant for the Architecture and Modelling activities within PJ.05-W2-97.1 and 97.2

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The objective of this TS/IRS document is to present the functional and non-functional requirements of these technologies, addressing the “what” and not the “how”. The TS/IRS does not aim to specify the physical design of the systems, but the functional description.

Solution PJ.05-W2-97.3 - Interacting with tower CWP by means of touch screen (multi touch input), was part of PJ.05-W2 as well, but it was terminated prior to its fully development.

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2 Introduction

2.1 Purpose of the document

This document provides the requirements specification, covering functional, non-functional and interface requirements related to SESAR Solution 97 at a Technology Readiness Level 4 (TRL 4) [1]

This Technical Specification addresses the "what" and not the "how", therefore it doesn't aim at specifying the physical design of the functional block (which remains a task for the industry), but the functional description and the necessary logical interfaces with other functional blocks.

This document is one of the PMP deliverables for the TRL 4 phase.

This document also specifies the target architecture by defining a set of domain level "systems" that will be further broken down into functional blocks based on performance requirements. The target architecture will be maintained in EATMA while the further breakdown will be done in this TS/IRS for each of the ATM functional blocks.

2.2 Scope

The Technical Specification Requirements describe the functions that the system must fulfil to satisfy the Operational, Safety, Performance and Interoperability requirements. System requirements lie in the solution domain and are captured in the TS document.

The Technical Specification Requirements describe functional and capabilities specifications, covering performance, physical characteristics, environmental and facility conditions under which the functional blocks enabling a SESAR Solution have to perform, requirements to interfaces and data definitions, security specifications as well as design constraints.

2.3 Intended readership

This document is mainly intended for:

- **SESAR 3 JOINT UNDERTAKING (S3JU)** as SESAR 2020 Programme coordinator.
- **SESAR 2020 PJ.05-W2** consortium members in order to be aware of activities and methods developed, so that coherency, consistency and comparability of the validation results are ensured through all SESAR 2020 solutions within the project.
- **SESAR 2020 Solution PJ.10-W2-96 AG** Solution members in order to have a common and shared view on the Attention Guidance technology.
- **SESAR 2020 Solution PJ.10-W2-96 ASR** Solution members in order to have a common and shared view on the Automatic Speech Recognition technology.

[1] The opinions herein reflect the author's view only. Under no circumstances shall the SESAR Joint Undertaking be responsible for any use that may be made of the information contained herein

- **SESAR 2020 PJ.19 Content Integration** that aims at assuring coherency, consistency, and comparability of the validation results throughout all SESAR2020 Solutions.
- Any **SESAR 2020 solution**, which wants to use aspects of any development in SOL 97
- **ER4 Project HAAWAII** members, in order to have a common and shared view on the Automatic Speech Recognition technology.
- **Academic Researchers** in the fields of the four main concepts developed as part of PJ.05-W2-97.1 and 97.2:
    - Virtual and Augmented Reality
    - Air Gestures
    - Attention Guidance
    - Automatic Speech Recognition
- Representatives of civil stakeholders: **ANSPs**.

2.4 Background

PJ.05-W2-97.1 and 97.2 begin taking into account the work performed during SESAR 1 in project 10.10.02 (CWP Human Factors Design) [24][25][26] and P6.7.1 – Airport Safety Support Tools for Pilots, Vehicle Drivers and Controllers [29]. In addition, it is built over the outcome provided by the RETINA [27] and MALORCA [28] projects, executed in the context of Exploratory Research.

RETINA project investigated the potential and applicability of Synthetic Vision (SV) tools and Virtual/Augmented Reality (V/AR) display techniques for the Air Traffic Control (ATC) service provision from the airport control tower. During the two-year project lifecycle, the concept was developed, implemented and validated through human in the loop simulations, where the external view was provided to the user in a semi-immersive virtual environment [31][32]. The results showed that the RETINA concept provides quantified benefits in terms of mental workload, temporal workload, performance, effort, frustration, information accessibility, and head-down time. Moreover, the concept leads to the removal of some restrictions in low visibility conditions with positive effect on airport capacity and resiliency. Finally, it contributes to safety improvement as it enhances situational awareness [33].

MALORCA project focused on the Automatic Speech Recognition, aiming to significantly reduce controller's workload and increase ATM efficiency. The results achieved consisted in command error rates between 2% and 5%, resulting in command recognition rates between 90% and 95%. These recognition rates were, however, only achieved with assistant based speech recognition i.e. an AMAN dynamically generating context information to increase the recognition rate. Without context generation the recognition rate ranged between 50 and 80%. Besides, the speech recognition was deemed as the more reliable input sensor, at least in the simulation setup.

In SESAR 2020 Wave 1 industrial research project PJ.16-04 dealt with new methods of controller interaction with the Human Machine Interface (HMI) at the Controller Working Position (CWP). The solution developed guidance and assessment methods regarding HMI, investigated new HMI needs and interaction modes in relation with SESAR solutions (including new user interface technologies such as speech recognition, multi-touch, and gaze detection).

PJ16-04 focused on En-Route and Approach environments. The only concept assessed for the Tower environment was ASR. However, part of the material developed in this solution will be used as a baseline for Solution 97.

PJ.05 in Wave 1, which dealt with Remote Tower for Multiple Airports, included aircraft label information in the OTW panoramic view of a remote tower working position.

In Wave 2, PJ.05-W2-97.1 and 97.2 starting maturity level is TRL 2, and it targets to reach TRL 4 maturity at the end of Wave 2 activities.

2.5 Structure of the document

The document is divided into seven sections. For chapter 3, 4 and 5, two different sections have been created in order to cover the two solutions (97.1 and 97.2) described in this document:

- Chapter 1: Executive Summary
- Chapter 2: Introduction. This chapter contains a general introduction, the scope and purpose of the document. This chapter provides also the glossary of terms, acronyms and terminology used in this TS IRS document.
- Chapter 3: SESAR Solution Impacts on Architecture. This chapter describes the architecture and relationships with EATMA.
- Chapter 4: Technical Specifications. This chapter forms the majority of the document. It includes EATMA views and the functional and non-functional requirements.
- Chapter 5: Recommendation for Implementation
- Chapter 6 Assumptions
- Chapter 7: References and Applicable Documents. This chapter lists the resources used throughout this document.
- Appendix A: Ontology Command Types
- Appendix B: Security Tasks
- Appendix C: Content produced for Solution 97.3 before the solution's termination

Appendix D Service Description Document (SDD) from the template is not applicable as this solution does not introduce new services.

2.6 Glossary of terms

Term	Definition	Source of the definition
AIR-REPORT	A report from an aircraft in flight prepared in conformity with requirements for position, and operational and/or meteorological reporting.	*ICAO Annex 3*
Air Gesture	Gesture recognition is a type of perceptual computing user interface that allows computers to capture and interpret human gestures as commands via mathematical algorithms. Gestures can originate from any bodily motion or state but commonly originate from the face	SOL 97

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	or hand. Users can use simple gestures to control or interact with devices without physically touching them.	
Attention Guidance	The Attention Guidance function uses perceptual cues to direct the attention of air traffic controllers towards an event. The function is triggered by relevant events determined by an Attention Guidance Logic that receives input from external sources, such as a particular safety net, an overall alerting system prioritization logic, or a particular sensor at the airport. The Attention Guidance Logic determines how the attention of the controller will be guided.	SOL 97
Automatic Speech Recognition	An Automatic Speech Recognition (ASR) system gets an audio signal as input and transforms it into a sequence of words, i.e. “speech-to-text” following the recognition process. The sequence of words is transcribed into a sequence of ATC concepts (“text-to-concepts”) using an ontology. E.g: The word sequence “Lufthansa two alpha altitude four thousand feet on qnh one zero one four reduce one eight zero knots or less turn left heading two six zero” is transcribed into “DLH2A ALTITUDE 4000 ft, DLH2A INFORMATION QNH 1014, DLH2A REDUCE 180 OR_LESS, DLH2A HEADING 260 LEFT”. The resulting concepts can be used for further applications such as visualization on an HMI.	PJ.16-04
Command (Recognition) Error Rate	The number of controller commands which are wrongly recognized by ASR and which are not rejected divided by number of total given commands; in other words: the percentage of given commands wrongly shown on the controllers’ HMI.	See definition in [31]
Command (Recognition) Rejection Rate	The number of recognized controller commands which are correctly or wrongly rejected (plus number of given controller commands which are not recognized at all) divided by number of total given commands.	See definition in [31]

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Command Hypotheses Predictor	Components needed for Assistant Based Speech Recognition which predicts a set of possible commands.	PJ.16-04
Command Prediction Error Rate	The number of controller commands which are not predicted by the Command Hypotheses Predictor divided by number of total given commands.	PJ.16-04
Command Recognition Rate	The number of controller commands which are correctly recognized by ASR and are not rejected before divided by number of total given commands; in other words: the percentage of given commands correctly shown on the controllers' HMI.	See definition in [31]
Controller Clearance Verification (CCV):	Functionality evaluated for Munich Approach Area: Each spoken controller clearance shall be verified with the related controller system input. Any deficiency shall be shown to the controller (both executive and planning Controller). The executive controller needs to correct the deficiency either by changing the system input or by giving a new clearance.	
Conventional Input devices	This sentence is used to identify the current, legacy devices as keyboard, mouse and trackball. It is used as the reference system.	PJ.16-04
Direct Interaction	When touching the object directly	PJ.16-04
Drag	Move fingertip over surface without losing contact	PJ.16-04
Functional Block	A logical and cohesive grouping of automated Functions in a Technical System	EATMA Guidance Material [1]
Gesture	Movement or posture, of the whole body or parts of the body	ISO/IEC 30113-1, 3.1
Gesture command	Instruction to the system resulting from a gesture input by the user, e.g. select, move, delete	ISO/IEC 14574:1999, 4.5
Gesture interface	User interface that provides information and controls for a user to accomplish specific tasks with the interactive system by his/her gestures	ISO 9241-171:2008, 3.29

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Gesture set	Grouping of gestures and their mapping to gesture commands	PJ.16-04
Indirect Interaction	When not touching the object directly	PJ.16-04
Interaction	Variety of ways users interact with an app, including touch, keyboard, mouse, and so on	PJ.16-04
Multi-Touch Inputs	The Multi-Touch Inputs activity will use a touch input device (a trackpad or touchscreen) as a new interaction means with the ASD of the CWP (e.g. replace the keyboard with a virtual keyboard, new HMI concept with touch events and gesture...) By using multi-touch, data inputs into the system by the controller shall be faster, more efficient and without increasing the failure rate.	PJ.16-04
Panning	Touch surface and move fingertip over surface to move an object (e.g. a map)	PJ.16-04
Pinch	Touch surface with two fingers and bring them close together	PJ.16-04
Press	Touch surface for extended period of time	PJ.16-04
Spread	Touch surface with two fingers and move them apart	PJ.16-04
Swipe	Quickly brush surface with fingertip	PJ.16-04
Tap	Briefly touch surface with fingertip	PJ.16-04
Target Location Assistance (TLA):	Functionality evaluated for Munich Approach Area: With each spoken controller clearance the callsign shall be recognized and highlighted so that the controller can easily identify which aircraft is spoken to. The highlighting of the target will be displayed on the Executive and Planning Controller's ASW.	PJ.16-04
Technical System	A collection of Functional Blocks or Functions.	EATMA Guidance Material [1]
Touch	Refers to using one or more fingers to provide input through a device display and interact with windows and apps	PJ.16-04

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Touch area	Part of the user interface that is sensitive for touch events	ISO 9241-161:2016, 3.17
Touch screen	Display device that allows the user to interact with a data processing system by touching an area on its screen	ISO/IEC 2382:2015
Virtual/Augmented Reality	V/AR in ATC Tower environment supports the Air Traffic Controllers by blending real world images with computer-generated data (augmented reality) in real-time, so that visual information can be enhanced to improve identification and tracking of aircraft (or vehicles) on the airport surface. Moreover, in low visibility conditions, the lack of visual information provided by the out-of-the-tower windows view can be compensated by the massive use of synthetic vision to show digital georeferenced data that supplement the missing real vision (virtual reality). Airport operations can benefit from this kind of advanced technologies, capable to provide beneficial automation support under low visibility conditions, but also, in good visibility situations, to present additional information in the labels to the controllers so to help in case of physical obstacles that obstruct vision or by reducing head-down time.	SOL 97

Table 2: Glossary

2.7 Acronyms and Terminology

Term	Definition
ABSR	Assistance Based Speech Recognition
ADD	Architecture Description Document
AG	Attention Guidance
AI	Artificial Intelligence
ANSP	Air Navigation Service Provider

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AR	Augmented Reality
ASR	Automatic Speech Recognition
ATC	Air Traffic Control
ATCO	Air Traffic Controller
ATM	Air Traffic Management
A-SMGCS	Advanced Surface Movement Guidance and Control System
CC	Capability Configuration
COTS	Commercial Off-The-Shelf
CWP	Controller Working Position
DTT	Digital Tower Technology
EATMA	European ATM Architecture
EFS	Electronic Flight Strips
EN	Enabler
E-OCVM	European Operational Concept Validation Methodology
ER	En-Route
E-ATMS	European Air Traffic Management System
FAA	Federal Aviation Administration
FB	Functional Block
GND	Ground
HMD	Head-Mounted-Display
HMI	Human Machine Interface
IER	Information Exchange Requirement
INTEROP	Interoperability Requirements
IRS	Interface Requirements Specification
ISRM	Information Services Reference Model
LVC	Low Visibility Conditions

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ML	Machine Learning
MTI	Multi-touch Interaction
NAF	NATO Architecture Framework
NFR	Non- Functional Requirements
NSOV	NAF Service Oriented View
NOV	NAF Operational View
NSV	NAF System View
PTT	Press-To-Talk
POI	Performance Operational Improvement
OSED	Operational Service and Environment Definition
OTW	Out-The-Window
QoS	Quality of Service
RWY	Runway
SDD	Service Description Document
SESAR	Single European Sky ATM Research Programme
S3JU	SESAR3 Joint Undertaking (Agency of the European Commission)
SoaML	Service Oriented Architecture Modelling Language
SPR	Safety and Performance Requirements
SPR-INTEROP/OSED	Safety and Performance Requirements – Interoperability Requirements / Operational Service and Environment Definition
SUT	System Under Test
SWIM	System Wide Information Model
TRL	Technology Readiness Level
TS	Technical Specification
TS/IRS	Technical Specification/Interface Requirements Specification
TSAP	Technical Safety Assessment Plan

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TVALP	Technological Validation Plan
TVALR	Technological Validation Report
TWR	Tower
UC	Use Case
UML	Unified Modelling Language
V&V	Validation and Verification
VALS	Validation Strategy
VCS	Voice Communication System
VR	Virtual Reality
V/AR	Virtual/Augmented Reality
WSDL	Web Services Definition Language
XSD	XML Schema Definition

Table 3: Acronyms and terminology

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3 SESAR Solution Impacts on Architecture

This section provides a brief description of the impact made by the solutions on the EATMA framework. A different section has been created for each of the two solutions in order to see the impact caused by each of them.

3.1 Solution PJ.05-W2-97.1: Virtual/Augmented Reality applications for Tower

3.1.1 Target Solution Architecture

3.1.1.1 SESAR Solution(s) Overview

This section covers the Solution 97.1, which deals with Virtual/Augmented Reality devices at the tower CWP.

Progresses that have been done in synthetic vision and Virtual and Augmented Reality (V/AR) fields have been applied in a number of different aviation areas (from the flight deck to aircraft maintenance, Figure 1), including air traffic control towers, with the aim to ease the job of involved staff and to enable more seamless operations.

Figure 1: Use of Augmented Reality Devices in Aircraft Maintenance

V/AR in an ATC Tower environment supports the Air Traffic Controllers by blending real world images with computer-generated data (augmented reality) in real-time, so that visual information can be enhanced to improve identification and tracking of aircraft (or vehicles) on the airport surface. Moreover, in low visibility conditions, the lack of visual information provided by the out-of-the-tower windows view can be compensated by the massive use of synthetic vision to show digital georeferenced data that supplement the missing real vision (virtual reality).

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Airport operations can benefit from this kind of advanced technologies, capable to provide beneficial automation support under low visibility conditions, but also, in good visibility situations, to present additional information in the labels to the controllers to reduce head-down time or help in case of physical obstacles that obstruct vision.

Figure 2: V/AR in use in a control tower environment

When applying V/AR, the auxiliary information is merged with the OTW view and presented as an overlay on top of the real-world visual information. In this way, the controller is no longer forced to divide his/her attention between the primary visual field (e.g. out-the-window (OTW) view) and the auxiliary tools (such as paper or electronic flight strips, surface movement radar, gap-filler camera streams and alert indications), consequently reducing the so-called head-down time and increasing the Situational Awareness (SA).

In particular, alerts that are currently given in an aerodrome tower environment, such as Runway Incursion Alerting or Stop Bar Violations can be generated and the differences in attention getting in comparison with traditional tower control as well as the advantages of attention guidance can be evaluated. The optimal way to guide attention can be assessed by exposing controllers to different presentations of alert information, different symbology and/or audio alerts within an AR device. The AR device can be used in different scenarios with different traffic situations, different types of alerting with different levels of severity at selected locations in the airport movement areas. Controller reaction times, attention distribution and decision-making effectiveness for the situation to be solved can be measured and compared.

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V/AR also addresses a problem related to the availability of an increased number of remote camera video feeds in the ATC tower environment. These video feeds all need to be displayed on monitors, possibly blocking important line-of-sights or in other ways obscuring the outside view. Providing the camera feeds on a Head-Mounted-Display (HMD) or a similar device could potentially solve this problem.

Hence, suitable applications of V/AR for air traffic control tower so far identified consist in visualisation tools, either based on wearable devices, e.g. Microsoft HoloLens (Figure 2) either in see-through spatial displays, investigated, as a first step, during Exploratory Research phase.

In this context, the integration of Tracking Labels in an Augmented Reality environment is considered: the label is attached to the real aircraft object and displays the most important information; the tracking label displays additional information in the case of detection of any potential conflict by the Airport Safety Net Service.

A Tracking Label integrated with the Airport Safety Nets Service allows to display advisories to the ATCO that allow him to solve a current conflict as quickly as possible. E.g. some EFS features, such as highlighting of the strip bay in case of use of the runway, can be transferred to all labels that may use the runway in the next defined lapse of time, or a square around the callsign becomes orange. In any case the current Airport Safety Net Service is preventing safety related issues.

Moreover, the user will be able to interact with the virtual interface by means of air gesture. Gesture recognition can be seen as a way for computers to begin to understand human body language, thus building a richer bridge between machines and humans than primitive text user interfaces or even GUIs (graphical user interfaces). These interfaces still limit the majority of input to a keyboard and mouse. Using the concept of air gesture recognition, it is possible to make the user interact with tracking labels when performing not time critical tasks, such as clearing push back. The concept is also intended to be used for navigating through the information and menus displayed, allowing the controller to perform actions such as picking, dragging and dropping AR elements, filtering the number of aircraft presented or enabling/disabling LVC display.

Additional computer-generated overlays such as ground vehicles, weather display, runway and taxiway layout and parking stands are adaptively displayed based on the specific working position and visibility condition. As the visibility conditions get worse, the number of information displayed by means of synthetic vision increases.

The Solution is aimed to operate in the Airport Operating Environment, including all types of airports that this category comprises (Very Large, Large, Medium, Small and Other).

The Solution is an enabling solution in the S2020 framework. The following POI and Enablers conform the Solution in EATMA. The corresponding Change Requests will be endorsed in (DS21).

OI Step	OI description	Open CR
POI-0039-SDM	This OI will make use of V/AR technology to present additional information to the aerodrome tower controllers when watching aircraft in approach, when taxiing and when at the gate/stand.	CR 04200 has been raised in order to create POI-0039-SDM.

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EN code	EN description	Open CR
AERODROME-ATC-103	Introduction of new Augmented Reality vision systems with tracking labels for aircraft and vehicles for improving the controller productivity through increasing head-up vision.	CR 04203 has been raised in order to create AERODROME-ATC-103, as well as to update the EATMA elements (links to Functions). Afterwards, CR 06700 has been raised in order to add new links to Functions.
AERODROME-ATC-104	Introduction of new automated functions for Air Gestures for V/AR element control for improving the controller productivity.	CR 04204 has been raised in order to create AERODROME-ATC-104, as well as to update the EATMA elements (links to Functions). Afterwards, CR 06699 has been raised in order to add new links to Functions.
AERODROME-ATC-105	Introduction of new automated functions for Attention Guidance in V/AR applications for improving the controller productivity.	CR 04205 has been raised in order to create AERODROME-ATC-105, as well as to update the EATMA elements (links to Functions).

Table 4: SESAR Solution PJ.05-W2-97.1 POI and EN

The following Functional Blocks are the building blocks of the Architecture and modelling in EATMA, and justify the coverage of the Enablers in the Solution through the Functions included in the diagrams summarising the Use Cases.

SESAR Solution ID and Title	Functional Blocks/Role impacted by the SESAR Solution (from EATMA)	Enabler ID (from EATMA)	Enabler Title (from EATMA)	Enabler coverage	Required /Optional
Solution 97.1 Virtual/Augmented Reality applications for tower	Virtual and Augmented Reality Display	AERODROME-ATC-103	Virtual and Augmented Reality systems for Tower ATC	**Fully**	**Required**

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	Air Gestures Detector	AERODROME-ATC-104	Controller productivity enhancements by Air gestures for Tower ATC	**Fully**	**Optional**
	Attention Guidance	AERODROME-ATC-105	Attention Guidance in V/AR applications for aerodrome tower operations	**Fully**	**Optional**

Table 5: SESAR Solution PJ.05-W2-97.1 scope and related Functional Blocks/roles & Enablers

3.1.1.1.1 Deviations with respect to the SESAR Solution(s) definition

No deviations.

3.1.1.1.2 Relevant Use Cases

Table 6 provides an overview on the use cases that have been identified in the context of use of the V/AR concept, and that are described in detail in the sections below.

Name	Description
UC-97-TRL4-TS-101	Guiding ATCO's attention via perceptual cues in case of potentially critical ATC situation *In case of a potentially critical ATC situation, the ATCO's attention will be raised via visual and optionally also via auditory cues on the augmented reality interface.*
UC-97-TRL4-TS-102	Guiding ATCO's attention via perceptual cues in case of potentially missed command actions *Several situations are possible:* *a) In case the ATCO acknowledges an attention cue but then disregards the area of attention and the situation persists, new cues will appear on the interface to raise the controller's attention to a higher level.* *b) The same will occur when the controller acknowledges the attention cue, keeps focussing on the area of attention and the seriousness (depending e.g. on different alerting levels for a conflict) of the situation increases.* *c) The same will also occur when the controller does not acknowledge the cue within a given time period.*
UC-97-TRL4-TS-103	Retrieve of information by means of V/AR *Use V/AR (including tracking labels) to retrieve all relevant positioning, identification, flight status, and weather*

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Name	Description
	information needed for the specific RWY and GND tasks in the specific condition.
UC-97-TRL4-TS-104	Tracking labels in Augmented Reality for landing/departing aircraft *Use tracking labels in AR device so that a clear distinction between different aircraft lined up for landing can be made*
UC-97-TRL4-TS-105	Tracking labels for conflict detection alerts *Use tracking labels inside an AR device to present safety warnings such as conflict detection alerts, runway incursions, and conflicting clearances that give a clear indication to the controller that a situation requires some attention while looking outside in a mainly head-up situation.* *In case of a critical ATC situation, the ATCO's attention will be more easily associated with the concerned aircraft via visually associated call sign data tagging.*
UC-97-TRL4-TS-106	Clearance issue by means of Air Gestures *Use tracking labels air gesture interaction to issue clearances for not-time-critical tasks (start-up, push-back)*

Table 6: Virtual/Augmented Reality Use Cases

Technical diagrams have been created under the EATMA framework in order to summarise the Use Cases, so that the operation and how the systems interact is presented. The technical modelling is included in section 4.1.1.

3.1.1.1.2.1 UC-97-TRL4-TS-101 / Guiding ATCO's attention via perceptual cues in case of potentially critical ATC situation

Scope/Description

In case of a potentially critical ATC situation, when a safety net provides an alert on a conflict, the ATCO's attention will be raised via visual and optionally also via auditory cues on the augmented reality interface.

Actors

TWR Ground ATCO, TWR Runway ATCO (depending on the critical ATC situation).

Preconditions

Radar, flight plan and other relevant external data are available to be used by the Attention Guidance Logic. The Attention Logic Guidance is fed with the level of priority for each potentially critical ATC situation.

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The airport is equipped with Airport Safety Nets. V/AR devices can be used by the ATCO and are capable of displaying attention guidance information triggered by relevant safety nets and sensors. ATCO is provided with means to acknowledge the V/AR perceptual cues.

Post conditions

The attention of the ATCO has been guided towards the critical ATC situation at the airport via perceptual cues and the controller has resolved the critical situation.

Trigger

The Attention Guidance Logic determines a relevant event.

Nominal Flow

1. The Attention Guidance Logic determines a relevant event, such as a safety net alert.
2. The V/AR device presents visual and (optionally) also auditory cues to the controller to guide the controller's attention.
3. The controller acknowledges the cues (comparable to alert acknowledgement in a safety net).
4. The controller notices the critical ATC event and resolves the situation.

Alternative Flow

4a. The V/AR device presents additional operational information to the controller to increase the situational awareness and help resolve the situation.

Failure Flow

2. A failure in the attention guidance logic or the V/AR device is identified.
3. ATCO changes to conventional operating method by working head-down or looking outside without making use of the V/AR device.

Sub Use Case(s)

UC-97-TRL4-TS-102

3.1.1.1.2.2 UC-97-TRL4-TS-102 / Guiding ATCO's attention via perceptual cues in case of potentially missed command actions

Scope/Description

Several situations are possible:

a) In case the ATCO acknowledges an attention cue but then disregards the area of attention and the situation persists, new cues will appear on the interface to raise the controller's attention to a higher level.

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b) The same will occur when the controller acknowledges the attention cue, keeps focussing on the area of attention and the seriousness (depending e.g. on different alerting levels for a conflict) of the situation increases.

c) The same will also occur when the controller does not acknowledge the cue within a given time period (depending on the alerting system used).

Actors

TWR Ground ATCO, TWR Runway ATCO (depending on the critical ATC situation).

Preconditions

Radar, flight plan and other relevant external data are available to be used by the Attention Guidance Logic. The Attention Logic Guidance is fed with the level of priority for each potentially critical ATC situation.

The airport is equipped with Airport Safety Nets. V/AR devices can be used by the ATCO and are capable of displaying attention guidance information triggered by relevant safety nets and sensors.

The V/AR device has presented visual and (optionally) also auditory cues to the ATCO to guide the controller's attention to a potentially critical ATC situation.

Post conditions

The attention of the ATCO has been guided towards the critical ATC situation at the airport via different levels of perceptual cues and the controller has resolved the critical situation. ATCO is provided with means to acknowledge the V/AR perceptual cues.

Trigger

a) The ATCO disregards the area of attention but the situation persists.

b) The seriousness (depending e.g. on different alerting levels for a conflict) of the situation increases.

c) No timely acknowledgement is given (time period depending on the situation).

Nominal Flow

1a) The controller acknowledges the cues (comparable to alert acknowledgement in a safety net) but then disregards the area of attention and the situation persists.

1b) The seriousness (depending e.g. on different alerting levels for a conflict) of the situation increases.

1c) The controller does not acknowledge the cue within a given time period (depending on the situation).

2) New cues, depending on how the situation developed, will appear on the interface to raise the controller's attention to a higher level.

3) The controller notices the critical ATC event and resolves the situation.

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Alternative Flow

N/A

Failure Flow

N/A

3.1.1.1.2.3 UC-97-TRL4-TS-103 / Retrieve of information by means of V/AR

Scope/Description

Use V/AR (including tracking labels) to retrieve all relevant positioning, identification, flight status, and weather information needed for the specific RWY and GND tasks in the specific condition.

Actors

TWR Ground ATCO, TWR Runway ATCO.

Preconditions

Radar, flight plan and/or other relevant external data are available and fed into the system. V/AR systems are available for the ATCO and are able to display tracking labels.

Post conditions

ATCO situational awareness is raised due to the retrieved information from V/AR.

Trigger

ATCO needs to retrieve information for RWY or GND tasks.

Nominal Flow

1. ATCO looks for information for the specific RWY or GND task.
2. The V/AR device provides the ATCO with the relevant information to perform the RWY or GND tasks.

Alternative Flow

1. Low visibility conditions procedures are applied for the airport.
2. Low visibility conditions procedures are automatically activated in the V/AR device by the system.
3. The V/AR device provides the ATCO with enough information to continue operations following the LVC procedures. This information consists on the previously provided information (i.e. when good visibility conditions applied), plus specific information needed when LVC procedures apply, such as the airport layout and runways. This information can be static and

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optionally a dynamic picture (e.g. runway colour changes according to its status, or whether it is occupied by a vehicle, etc.)

Failure Flow 1

1. V/AR device fails to provide the relevant information.
2. The ATCO stops using the V/AR device and returns to conventional procedures for the retrieve of information.

Failure Flow 2

1. Low Visibility Conditions procedures are not automatically activated in the V/AR device.
2. The ATCO activates the Low Visibility Conditions procedures manually in the V/AR device.

3.1.1.1.2.4 UC-97-TRL4-TS-104 / Tracking labels in Augmented Reality for landing/departing aircraft

Scope/Description

Use tracking labels in AR so that a clear distinction between different aircraft lined up for landing and/or take off can be made.

Actors

TWR Runway ATCO.

Preconditions

Radar, flight plan and other relevant external data are available and fed into the system. V/AR systems are available for the ATCO and are able to display tracking labels.

Post conditions

ATCO clearly distinguish aircraft lined up for landing or take off.

Trigger

Aircraft are lined up for landing or take off.

Nominal Flow

1. Augmented reality identifies aircraft that are lined up for landing or take off, taking into account the surveillance and flight plan data.
2. Tracking labels are displayed in augmented reality distinguishing each lined up aircraft (either for landing or take off), using the label antioverlapping feature.
3. a) Once the aircraft has landed and is on ground, the label changes to the ground mode.

   b) Once the aircraft is airborne, the label changes to the airborne mode.

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Alternative Flow

2. The label antioverlapping feature is not enabled, and the A/R presents labels overlapping.
3. ATCO performs air gestures to separate manually the labels and distinguishing each landing aircraft.
4. a) Once the aircraft has landed and is on ground, the label changes to the ground mode.

   b) Once the aircraft is airborne, the label changes to the airborne mode.

Failure Flow 1

2. The label antioverlapping feature fails, and the A/R presents labels overlapping.
3. ATCO performs air gestures to separate manually the labels and distinguishing each landing/departing aircraft.
4. a) Once the aircraft has landed and is on ground, the label changes to the ground mode.

   b) Once the aircraft is airborne, the label changes to the airborne mode.

Failure Flow 2

1. Augmented reality identifies aircraft that are lined up for landing, taking into account the surveillance and flight plan data.
2. Tracking labels are displayed in augmented reality for each landing aircraft. The label antioverlapping feature fails or it is not enabled, and the A/R presents labels overlapping.
3. Controller takes off the A/R system.

3.1.1.1.2.5 UC-97-TRL4-TS-105 / Tracking labels for conflict detection alerts

Scope/Description

Use tracking labels inside an AR device to present safety warnings such as conflict detection alerts, runway incursions, and conflicting clearances that give a clear indication to the controller that a situation requires some attention while looking outside in a mainly head-up situation (good weather/visibility)..

In case of a critical ATC situation, the ATCO's attention will be more easily associated with the concerned aircraft via visually associated call sign data tagging.

Actors

TWR Runway ATCO, TWR Ground ATCO.

Preconditions

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Radar, flight plan and other relevant external data are available and fed into the system. Airport is equipped with Airport Safety Nets. V/AR systems are available for the ATCO and are able to display tracking labels.

There is good weather/visibility in the airport and vicinity.

Post conditions

ATCO's attention to a conflict is raised via means of tracking labels in a mainly head-up situation.

Trigger

A conflict occurs in the airport.

Nominal Flow

1. Airport Safety Nets detect a conflict in the airport (e.g. taxiway conflict, runway incursion, conflicting clearances, etc.).
2. A tracking label is presented in the Augmented Reality overlay to indicate that the situation requires ATCO's attention.

Alternative Flow

N/A

Failure Flow

2. ATCO notices that tracking labels indicating that the situation requires ATCO's attention fail to be displayed.
3. ATCO stops relying on tracking labels and returns to conventional procedures for identifying conflicts.

3.1.1.1.2.6 UC-97-TRL4-TS-106 / Clearance issue by means of Air Gestures

Scope/Description

Use air gesture interaction to issue clearances for not-time-critical tasks (start-up, push-back).

Actors

TWR Ground ATCO.

Preconditions

Radar, flight plan and other relevant external data are available and fed into the system. V/AR systems are available for the ATCO and are able to display tracking labels. Tracking labels air gesture interaction is available. Clearance request by means of CPDLC is available.

Post conditions

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A clearance is issued by the ATCO by means of Air Gestures.

Trigger

A clearance for not-time-critical task is requested or ready to be issued.

Nominal Flow

1. The label linked to a specific clearance is triggered when the pilot sends the clearance request to the ATCO by means of CPDLC.
2. ATCO selects the label corresponding to the clearance that is ready to be issued, e.g. by means of gazing.
3. The label corresponding to the clearance that is ready to be issued is activated.
4. ATCO issues the clearance by means of Air Gestures interacting with the label.

Alternative Flow

N/A

Failure Flow

1. There is a failure in either the label selection or the clearance issue by means of Air Gestures.

ATCO stops performing Air Gestures and continues working with conventional methods for the issue of clearances.

3.1.1.1.3 Applicable standards and regulations

As stated in the PJ.16-04 TRL4 TVALR for AG [19], it would be beneficial if input and output channels are standardized. On the input side, ASTERIX is already a standardized format for radar data. However, this is not true for eye-tracking data. The format for ET data that is going to be developed and used in the AG exercise might influence a later standard. On the output side, a standardized interface between the HMI and the support system e.g. in case of highlighting aircraft labels would ease communication between different hardware/software manufacturers.

Colours and appearance of visual cues should remain in the hands of ATM system providers to be unique selling points for delivering their own CWP user experience. If an eye-tracking system is used, it will be a COTS product. Hence, it is difficult/not needed to influence the external hardware manufacturer. Hence, there can be recommendations (refer also to section 5.2.3 of PJ.16-04 TRL 4 TVALR [19]) for the design, but probably no standard.

As part of PJ.05-W2-97.1 activities, a communication of the findings and results of the Solution to EUROCAE Technical Advisory Committee has been carried out. As a result of this coordination, some guidance has been provided with regards to the standardisation needs:

- EUROCAE ED-87E “MASPS for A-SMGCS including Airport Safety Support Service Routing Service and Guidance Service” should be considered for the Virtual and Augmented Reality functionalities, e.g. for the identification and alignment of elements in the V/AR devices.

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- EUROCAE ED 255 “MASPS for a combined vision systems for rotorcraft operations” may contain relevant information for the safety critical requirements to comply with.
- The usage of COTS products in safety critical operations could imply some risks. It is recommended that a specific prototype for ATM is developed, or the existing COTS products are improved in a way that comply with the safety requirements for this environment.

3.1.1.2 Capability Configurations required for the SESAR Solution

The following table lists the Capability Configurations (CCs) required by the SESAR Solution, the relevant (sub)-Operating Environments where the CCs operate, and the links between CCs and Capabilities, Nodes and Stakeholders:

SESAR Solution ID and Title	Capability Configurations (CCs) (from EATMA)	Sub-Operating Environment(s) where the CCs operate	Capabilities (from EATMA)	Nodes (from EATMA)	Stakeholders (from EATMA)
PJ.05-W2-97.1: Virtual/Augmented Reality applications for tower	TWR	Airport	Controller Machine Interface Design	Aerodrome ATS	Civil ATS Aerodrome Service Provider

Table 7: List of Capability Configuration required for the SESAR Solution PJ.05-W2-97.1

3.1.2 Changes imposed by the SESAR Solution on the baseline Architecture

This section describes which system changes are needed compared to the baseline architecture in EATMA to deliver the Capabilities improvements (using the EATMA architecture elements such as Technical Systems, Functional Blocks, Functions and Roles).

The baseline EATMA architecture is modified in order to reflect the improvements brought in operation by the Solution.

The information is provided by Enablers, listing the changes applied to their definition or the EATMA elements related to them, e.g. new Functions introduced and allocated to a Functional Block in order to support the development of a system Enabler.

Enabler ID (from EATMA)	Enabler Title (from EATMA)	Changes
AERODROME-ATC-103	Virtual and Augmented Reality systems for Tower ATC	Introduction of new Augmented Reality vision systems superimposed onto the out of the tower view stimulate the ATCO to work in head-up position resulting in an improvement of the controller situational awareness and productivity in any visibility conditions.

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		Virtual and Augmented Reality is able to perform the following Functions (documented in CR 04203 and CR 06700): - Activate Clearance Label - Change Label Mode - Display Aircraft Information in the Tracking Labels - Display Alert in the Tracking Label - Display Clearance in the Tracking Label - Display Information in LVC Mode - Display Information Menu - Display Requested Information - Display Relevant Airport, Weather and Flight Information - Identify Aircraft - Implement Change on the Tracking Label - Initiate LVC Mode
AERODROME-ATC-104	Controller productivity enhancements by Air gestures for Tower ATC	Air Gesture interactions with V/A-R interface will reduce the need for head-down, resulting in improvement of ATCO human performance. Air Gestures Detector is able to perform the following Functions (documented in CR 04204 and CR 06699): - Detect Clearance Issued - Detect Information Menu Navigation Request - Detect Label Selection - Separate Labels
AERODROME-ATC-105	Attention Guidance in V/AR applications for aerodrome tower operations	Introduction of new automated functions for attention guidance in V/AR applications for improving situational awareness of aerodrome tower controllers. Attention Guidance is able to perform the following Functions (documented in CR 04205): - Attention Guidance Logic (Aerodrome) - Attention Guidance Measures (Aerodrome) - Monitor ATCO's Activity

Table 8: List of changes due to the SESAR Solution

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3.2 Solution PJ.05-W2-97.2: ASR at the TWR CWP supported by AI and Machine Learning

3.2.1 Target Solution Architecture

3.2.1.1 SESAR Solution(s) Overview

This section covers the Solution 97.2, particularly the Automatic Speech Recognition at Tower CWP. An Automatic Speech Recognition (ASR) system gets an audio signal from the controller working position (CWP) as input and transforms it into a sequence of words, i.e. “speech-to-text” following the recognition process. The sequence of words is transcribed into a sequence of air traffic control (ATC) concepts (“text-to-concepts”). For example, the word sequence “bonjour Air France two four eight six line up and wait runway two seven left” is transformed into “AFR2486 LINEUP RW27L”.

The ASR system may benefit from surveillance data, flight plans, meteorological data, routing information etc. - a so called Assistant Based Speech Recognition (ABSR) system. The ABSR derives command hypotheses from the contextual knowledge to support the speech recognition engine in choosing the right recognition hypotheses. This increases the command recognition rate and minimizes the command recognition error rate. The functionality chain is described in the next section[2].

The AI/ML applied to ASR function, supports the “Command Hypotheses Predictor” that periodically receives contextual information updates such as surveillance data, flight plan data, route information, clearance information, weather information etc. This information is used to predict possible future controller commands based on a machine learned command prediction model on historical surveillance and speech data.

The ASR function consists of the following major capabilities:

- Word Sequence Extraction

  The recorded verbal utterances from the controller pilot communications are input into the automatic speech recognition engine, which outputs a list of recognized words (transcription).

- Concept Extraction

  The above described extracted word sequence is the input for the extraction of concepts, i.e. the extraction of ATC commands following the defined ontology (annotation).

- Post Evaluation

[2] ABSR systems shall provide accurate output to be provided to ATCO HMIs if needed. The ABSR algorithms can simply be rule-based, but it is strongly recommended to use AI and ML techniques to learn from existing data.

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The extracted controller commands constitute a hypothesis, which needs to be checked against any relevant contextual information. Hence, there should be a check against the currently predicted controller command hypotheses and against mouse or keyboards inputs if available. The finally checked controller commands, i.e. the most reasonable hypotheses due to the ABSR functionality chain, can then be used for further ASR applications such as presenting the recognized commands on a human machine interface (HMI).

Additional Capabilities, belonging to a specific technical implementation:

- Command Prediction

  The "Command Hypotheses Predictor" periodically receives contextual information updates such as surveillance data, flight plan data, route information, clearance information, weather information etc. This information is used to predict possible future controller commands based on a machine learned command prediction model on historical surveillance and speech data.

The Automatic Speech Recognition is denominated as a Functional Block in EATMA and it performs a series of Functions, which are described later in the document.

The Automatic Speech Recognition at the Tower CWP targets to operate in the Airport Operating Environment, including all categories that are part of this group (Very Large/Large/Medium/Small/Other). The functionality can be deployed in both conventional and (multiple) remote Tower.

With regards to the potential link with remote tower concept at the end of the lifecycle, it is worth to note that PJ.05-W2-35 (Multiple Remote Tower and Remote Tower Centre) can introduce another use case for validation of ABSR technology, which does not strictly depend on the operational scenario it is used in. In fact, Multiple Remote Towers. Irrespective of monitored airports size, can be a setting for further validation of ABSR. In the previous PAGAR campaign, the relation between PJ.05-W2-97.2 and PJ.05-W2-35 was declared as Compatible/Independent/No Cross Effect.

The Solution is an enabling solution in the S2020 framework. The following POI and Enablers conform the Solution in EATMA. The corresponding Change Requests will be endorsed in (DS21).

OI Step	OI description	Open CR
POI-0040-SDM - Automatic Speech Recognition with AI/ML at the TWR CWP	ATCOs will be supported by introducing innovative human machine interaction such as Automatic Speech Recognition that can be enhanced by the use of Machine Learning. The goal is to automatically support certain tasks of the ATCO, which are not done or done manually today in today's systems/ CWPs.	CR 04201 has been raised and endorsed in order to create POI-0040-SDM.
EN code	EN description	Open CR

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AERODROME-ATC-106	Introduction of new automated functions for Automatic Speech Recognition using AI and Machine Learning Techniques at the Aerodrome CWP/HMI for improving the controller workload.	CR 04206 has been raised in order to create AERODROME-ATC-106, as well as to update the EATMA elements (links to Functions)
AERODROME-ATC-50	Advanced Airport Tower CWP integrating updates on current HMI functionalities	

Table 9: SESAR Solution PJ.05-W2-97.2 POI and EN

The following Functional Blocks are the building blocks of the Architecture and modelling in EATMA, and justify the coverage of the Enablers in the Solution through the Functions included in the diagrams summarising the Use Cases.

SESAR Solution ID and Title	Functional Blocks/Role impacted by the SESAR Solution (from EATMA)	Enabler ID (from EATMA)	Enabler Title (from EATMA)	Enabler coverage	Required /Optional
Solution 97.2 ASR at the TWR CWP supported by AI and Machine Learning	Automated Speech Recognition	AERODROME-ATC-106	Automatic Speech Recognition supported by AI and ML algorithms for aerodrome tower operations	**Fully**	**Required**
	Controller Human Machine Interaction Aerodrome ATC	AERODROME-ATC-50	Advanced Airport Tower Controller Working Position (A-CWP)	**Use**	**Required**

Table 10: SESAR Solution PJ.05-W2-97.2 scope and related Functional Blocks/roles & Enablers

3.2.1.1.1 Deviations with respect to the SESAR Solution(s) definition

No deviations.

3.2.1.1.2 Relevant Use Cases

Table 11 provides an overview on the Use Cases that have been identified in the context of use of the ASR concept, and that are described in detail in the sections below.

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Name	Description
UC-97-TRL4-TS-201	Highlighting of recognized callsign *The ASR recognizes a callsign from the verbal controller pilot communication and highlights it in the controllers' HMI for the relevant time duration. This helps the controller to check further information (if any) extracted from the complete utterance displayed in the HMI later on.*
UC-97-TRL4-TS-202	Showing full recognized utterance/command in HMI *The ASR system recognizes the complete utterance/command issued by the controller and shows it on the controllers' HMI in a compact format. This includes recognition of the callsign, command types, command values, units, qualifiers and conditions if applicable (e.g., DLH123 PUSHBACK, DLH123 TAXI VIA A B, DLH123 LINEUP RW23R).*
UC-97-TRL4-TS-203	Manual manipulation of an ASR output *If the controller decides that the output of the ASR system is not correct, he/she has to correct the recognized command types and/or the recognized values or even the recognized callsign.*
UC-97-TRL4-TS-204	Automatic Acceptance of ASR output *When a command is recognized by the ASR system, it is then shown to the controller. If the controller does not reject the command within an (adjustable) time frame (e.g. 10 seconds), the recognition result is automatically accepted.*

Table 11: Automatic Speech Recognition Use Cases

Technical diagrams have been created under the EATMA framework in order to summarise the Use Cases, so that the operation and how the systems interact is presented. The technical modelling is included in section 4.2.1.1.

3.2.1.1.2.1 UC-97-TRL4-TS-201 / Highlighting recognized callsign

Scope/Description

The ASR recognizes a callsign from the verbal controller pilot communication and highlights it in the controllers' HMI for the relevant time duration. This helps the controller to check further information (if any) extracted from the complete utterance displayed in the HMI later on.

Actors

TWR Clearance Delivery ATCO, TWR Ground ATCO, TWR Runway ATCO.

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Preconditions

Tower and Voice systems relevant for the ATCO are available and running with Automatic Speech Recognition functionalities equipped. Radar, flight plan and other relevant external data are available and fed to the ASR.

Post conditions

The correct callsign identified as part of the ATCO's utterance is highlighted.

Trigger

An aircraft identified with a Callsign is ready to receive a command.

Nominal Flow

1. Command Predictor forecasts possible future ATCO's commands, taking into account relevant external data.
2. ATCO emits utterance containing a callsign.
3. Verbal ATCO utterance is transformed into a sequence of words.
4. The sequence of words is transformed into a sequence of ATC concepts, based on a predefined ontology.
5. A callsign, which is being considered by the system, is recognised as part of ATCO's utterance.
6. Recognised callsign is highlighted in the CWP HMI.

Alternative Flow 1 / ATCO emits an utterance without a callsign

2. ATCO emits an utterance without a callsign.
3. Verbal ATCO utterance is transformed into a sequence of words.
4. The sequence of words is transformed into a sequence of ATC concepts, based on a predefined ontology.
5. No callsign is recognized, hence no callsign is highlighted.

Failure Flow 1

5. Existing wrong callsign is recognized.

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6. Wrong callsign is highlighted in the CWP HMI.[3]

Failure Flow 2

5. Wrong callsign, not matching to anyone considered by the system, is recognized.
6. No existing callsign is highlighted. A message may be displayed informing about the callsign non-conformity.

3.2.1.1.2.2 UC-97-TRL4-TS-202 / Showing full recognized utterance/command in HMI

Scope/Description

The ASR system recognizes the complete utterance/command issued by the controller and shows it on the controllers' HMI in a reasonable format. This includes recognition of the callsign, command types, command values, units, qualifiers and conditions if applicable (e.g., DLH123 PUSHBACK, DLH123 TAXI VIA A B, DLH123 LINEUP RW23R).

Actors

TWR Clearance Delivery ATCO, TWR Ground ATCO, TWR Runway ATCO.

Preconditions

Tower and Voice systems relevant for the ATCO are available and running with Automatic Speech Recognition functionalities equipped. Radar, flight plan and other relevant external data are available and fed to the ASR.

Post conditions

The correct command identified as part of the ATCO's utterance is displayed in HMI.

Trigger

ASR Command Predictor receives external data to forecast potential ATCO's commands.

Nominal Flow

1. Command Predictor forecasts possible future ATCO's commands, taking into account relevant external data.
2. ATCO emits utterance containing a command (e.g. DLH123 TAXI VIA A B).
3. Verbal ATCO utterance is transformed into a sequence of words.

[3] In this case, ATCO just disregards this information by ignoring it. There is not a need to perform any action when this happens.

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4. The sequence of words is transformed into a sequence of ATC concepts, based on a predefined ontology.
5. A command is recognised as part of ATCO's utterance.
6. Recognised command is displayed in the CWP HMI.

Failure Flow 1 / Wrong command is recognized

7. Wrong intended command is recognized (either wrong callsign, clearance, value or units).
8. Wrong command is displayed in the CWP HMI.

Sub Use Cases

UC-97-TRL4-TS-201 / Highlighting recognized callsign

UC-97-TRL4-TS-203 / Manual manipulation of an ASR output

3.2.1.1.2.3 UC-97-TRL4-TS-203 / Manual manipulation of an ASR output

Scope/Description

If the controller decides that the output of the ASR system is not correct, he/she has to correct the recognized command types and/or the recognized values or even the recognized callsign.

Actors

TWR Clearance Delivery ATCO, TWR Ground ATCO, TWR Runway ATCO.

Preconditions

Tower and Voice systems relevant for the ATCO are available and running with Automatic Speech Recognition functionalities equipped. Radar, flight plan and other relevant external data are available and fed to the ASR.

A command has been recognised by the ASR and displayed in the CWP HMI.

Post conditions

The displayed command is correctly manually manipulated by the ATCO.

Trigger

A recognized command, which ATCO considers that is incorrect, is displayed in the CWP HMI.

Nominal Flow

1. ATCO identifies the error in the recognized command and manually manipulates it (either command types, callsign, values or units) in order to correct it.
2. Correct intended command is displayed.

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Alternative Flow 1 / Reject of recognized command

1. ATCO identifies the error in the recognized command and decides to reject the command.
2. Recognized command is rejected and discarded.

3.2.1.1.2.4 UC-97-TRL4-TS-204 / Automatic Acceptance of ASR Output

Scope/Description

When a command is recognized by the ASR system, it is then shown to the controller. If the controller does not reject the command within an (adjustable) time frame (e.g. 10 seconds), the recognition result is automatically accepted.

Actors

TWR Clearance Delivery ATCO, TWR Ground ATCO, TWR Runway ATCO.

Preconditions

Tower and Voice systems relevant for the ATCO are available and running with Automatic Speech Recognition functionalities equipped. Radar, flight plan and other relevant external data are available and fed to the ASR.

A command has been recognised by the ASR the CWP HMI.

Post conditions

The recognized and displayed command is automatically accepted and implemented.

Trigger

A recognized command is displayed in the CWP HMI.

Nominal Flow

1. The recognized and displayed command is considered as correct by the ATCO.
2. The ATCO does not reject the command within an adjustable timeframe.
3. The command is automatically accepted.

3.2.1.1.3 Applicable standards and regulations

As stated in the PJ.16-04 TRL2 TVALR of ASR [19], to enhance interoperability, there are a few interfaces that would benefit from standardization. This comprises all input and output channels from the ASR component.

The voice input channel still differs in its sampling rate (kHz) and might be harmonized. Some exercises use 8 kHz and some use 16 kHz sampling rate. A transformation is always possible, but each transformation loses information. If the training is done with 8 kHz and the tests are done with 16 kHz, always a slight performance decrease should be expected. The radar data have the defined ASTERIX

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standard. Thus, there is no strong need to force using the same format versions. However, the command hypotheses that may feed the ASR component are completely unstandardized.

The same is true for the recognized text output. There are a few rules from the ASR community on how to transcribe word-by-word. However, the content of these words (e.g. ignoring greetings) was far from being defined in the ATC domain. PJ.16-04 developed an ontology for the transcription of controller commands (En-Route, approach, tower) that can be used for both purposes, the hypotheses input and output transcription standard. As all major European ANSPs, ATM system providers, and important research and consulting institution agreed on a quite full set of commands (ontology), this can serve as a good basis for a future standard.

The ontology for ATC commands have been further enhanced during PJ.05-W2-97.2 ASR lifecycle.

As part of PJ.05-W2-97.2 activities, a communication of the findings and results of the Solution to EUROCAE Technical Advisory Committee has been carried out. As a result of this coordination, some guidance has been provided with regards to the standardisation needs for ASR:

- There is not an existing standard for Voice Recognition in the ATM environment. An assessment of this need should be performed in further stages of the developments.
- Outside the ATM environment, there is an existing standard that is relevant for the solution: ISO/IEC 30122-2:2017 [35], which provides the technical criterions and test methods of voice commands and its speech recognition engine. It is recommended that this standard is taken into account when developing the ASR functionality for ATM.
- Proposals for standardisation of the content and the format for input and output of assistant based speech recognition systems should be identified, i.e., speech-to-text with a number of word sequence hypotheses, text-to-concept based on the ontology for ATC utterances and preparations in order to feed succeeding applications such as runway error detection, formats such as JSON for content transmission, and many aspects more to enable comparability and interoperability.
- The usage of commercial-off-the-shelf products are not feasible for the ATM environment. Therefore, dedicated products developed for this environment would match better the expectations and requirements for deploying the concept in ATM.

3.2.1.2 Capability Configurations required for the SESAR Solution

SESAR Solution ID and Title	Capability Configurations (CCs) (from EATMA)	Sub-Operating Environment(s) where the CCs operate	Capabilities (from EATMA)	Nodes (from EATMA)	Stakeholders (from EATMA)
PJ.05-W2-97.2: ASR at the TWR CWP supported by AI and	TWR	Airport	Controller Machine Interface Design	Aerodrome ATS	Civil ATS Aerodrome Service Provider

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Machine Learning					

Table 12: List of Capability Configuration required for the SESAR Solution PJ.05-W2-97.2

3.2.2 Changes imposed by the SESAR Solution on the baseline Architecture

This section describes which system changes are needed compared to the baseline architecture in EATMA to deliver the Capabilities improvements (using the EATMA architecture elements such as Technical Systems, Functional Blocks, Functions and Roles).

The baseline EATMA architecture is modified in order to reflect the improvements brought in operation by the Solution.

The information is provided by enablers, listing the changes applied to their definition or the EATMA elements related to them, e.g. new Functions introduced and allocated to a Functional Block in order to support the development of a system Enabler.

Enabler ID (from EATMA)	Enabler Title (from EATMA)	Changes
AERODROME-ATC-106	Automatic Speech Recognition supported by AI and ML algorithms for aerodrome tower operations	Introduction of new automated functions for Automatic Speech Recognition at the Aerodrome Controller HMI for improving the controller productivity using Machine Learning Techniques to improve the speech recognition. Automatic Speech Recognition is able to perform the following Functions (documented in CR 04206): - Command Prediction (TWR) - Concept Extraction (TWR)
AERODROME-ATC-50	Advanced Airport Tower Controller Working Position (A-CWP)	Advanced Airport Tower CWP integrating updates on current HMI functionalities

Table 13: List of changes due to the SESAR Solution PJ.05-W2-97.2

4 Technical Specifications

4.1 Solution PJ.05-W2-97.1: Virtual/Augmented Reality applications for Tower

4.1.1 Functional architecture overview (general introduction for all solutions)

This solution impacts the EATMA Dataset 21 Architecture, by introducing the following Functional Blocks, which are the main actors of PJ.05-W2-97.1:

Functional Block	Description
Virtual and Augmented Reality Display	V/AR in an ATC Tower environment supports the Air Traffic Controllers by blending real world images with computer-generated data (augmented reality) in real-time, so that visual information can be enhanced to improve identification and tracking of aircraft (or vehicles) on the airport surface. Moreover, in low visibility conditions, the lack of visual information provided by the out-of-the-tower windows view can be compensated by the massive use of synthetic vision to show digital georeferenced data that supplement the missing real vision (virtual reality).
Attention Guidance	The Attention Guidance analyses the traffic situation as well as all additionally available input data to calculate needed attention guidance measures. In case of a potentially critical ATC situation, the controller's attention is raised and guided via visual and optionally also via auditory cues.
Air Gestures Detector	The Air Gestures Detector allows the controller to perform not-time-critical (e.g. start-up or push-back clearance issue) and/or navigation (interact with menu, separate tracking or enlarge labels) tasks by means of air gestures.

Table 14. Functional Blocks introduced by PJ.05-W2-97.1

New Functions are defined for the abovementioned Functional Blocks, in order to improve them so that the Solution concept can be implemented.

4.1.1.1 Resource Connectivity view (one section per NSV-1)

N/A since the Solution is just affecting one Technical system, hence no new interactions between Capability Configurations are introduced.

4.1.1.1.1 Resource Infrastructure view (of the NSV-2)

N/A as it is just affecting one Technical system, hence no new interactions between Capability Configurations are introduced.

4.1.1.1.2 Resource Orchestration view (all NSV-4s linked to the NSV-1)

This section describes the sequence of how the resources interact. This must be consistent with the content defined at EATMA level and available in the latest applicable version in EATMA.

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NSV-4 diagrams have been created in order to describe the resource orchestration summarising the Use Cases from section 3.1.1.1.2. These diagrams are modelled in MEGA.

4.1.1.1.2.1 [NSV-4][UC-101-102] Guiding ATCO's attention via perceptual cues

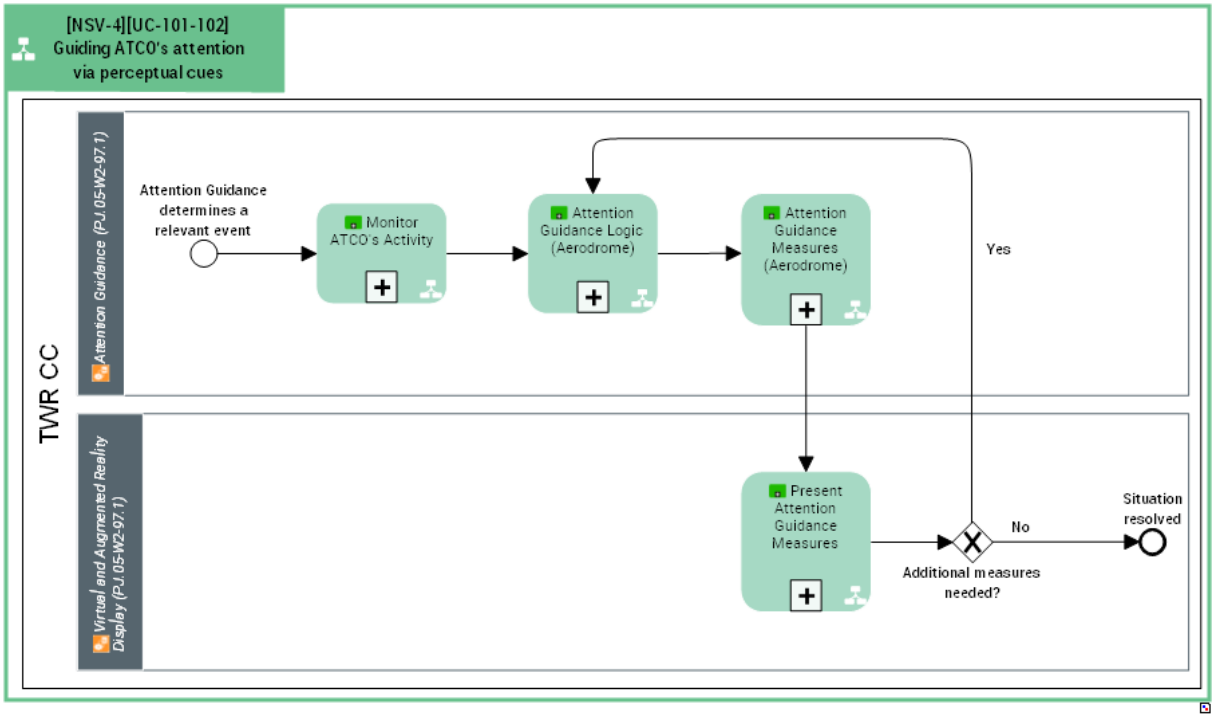

Figure 3. [NSV-4] [UC-101-102] Guiding ATCO's attention via perceptual cues in case of potentially critical ATC situation and/or potentially missed command actions

The following table presents the Functions performed by the system as part of the Use Case depicted above, along with their descriptions, which are included in EATMA.

Function	Description
Monitor ATCO's Activity	The controller's activity is analysed in order to monitor his/her attention.
Attention Guidance Logic (Aerodrome)	Attention Guidance Logic determines a relevant event, such as a safety net alert. Radar, flight plan and other relevant external data are available to be used by the Attention Guidance Logic. The Attention Logic Guidance is fed with the level of priority for each potentially critical ATC situation.
Attention Guidance Measures (Aerodrome)	The system determines that a relevant event requires Attention Guidance measures in order to claim the controller's attention
Present Attention Guidance Measures	The V/AR device presents visual and (optionally) also auditory cues to the controller on the augmented reality interface to guide the controller's attention.

Table 15. [NSV-4][UC-101-102] Functions description

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4.1.1.1.2.2 [NSV-4][UC-103] Retrieve of information by means of V/AR

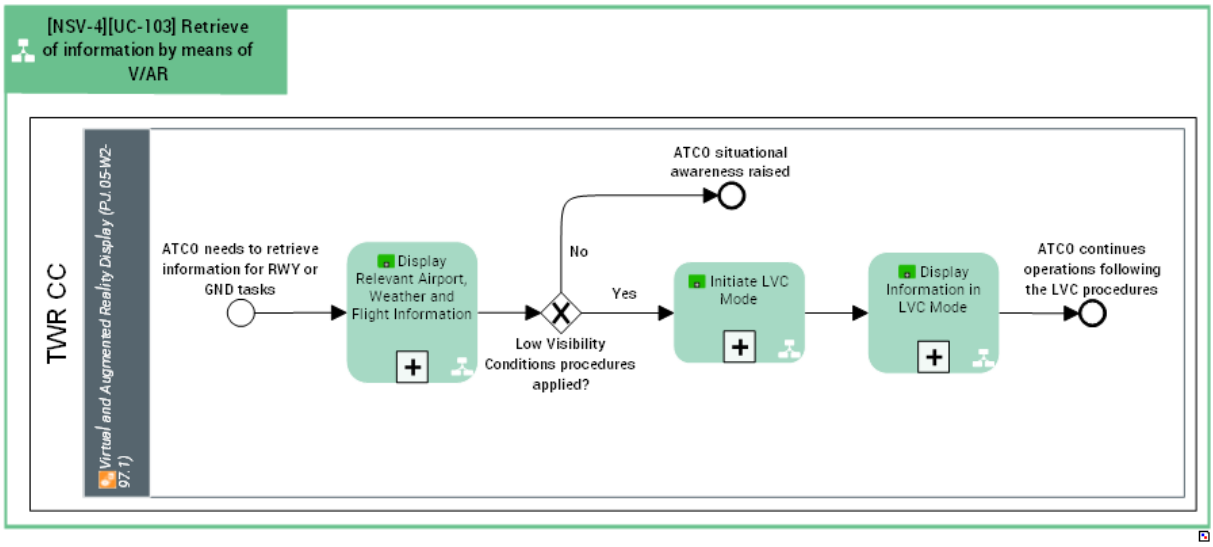

Figure 4. [NSV-4] [UC-103] Retrieve of information by means of V/AR

The following table presents the Functions performed by the system as part of the Use Case depicted above, along with their descriptions, which are included in EATMA.

Function	Description
Display Relevant Airport, Weather and Flight Information	The V/AR device provides the controller with the relevant airport, weather and flight information to perform the RWY or GND tasks.
Initiate LVC Mode	When LVC procedures are applied for the airport. Low visibility conditions procedures are automatically or manually activated in the V/AR device by the system
Display Information in LVC Mode	The V/AR device provides the ATCO with enough information to continue operations following the LVC procedures. This information consists on the previously provided information (i.e. when good visibility conditions applied), plus specific information needed when LVC procedures apply, such as the airport layout and runways. This information can be static and optionally a dynamic picture (e.g. runway colour changes according to its status, or whether it is occupied by a vehicle, etc.)

Table 16. [NSV-4][UC-103] Functions description

4.1.1.1.2.3 [NSV-4][UC-104] Tracking labels in Augmented Reality for landing/departing aircraft

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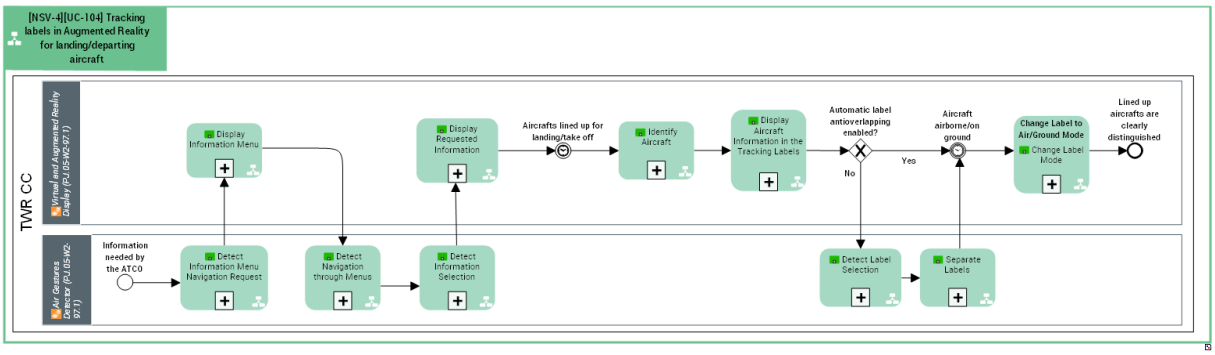

Figure 5. [NSV-4] [UC-104] Tracking labels in Augmented Reality for landing/departing aircraft

The following table presents the Functions performed by the system as part of the Use Case depicted above, along with their descriptions, which are included in EATMA.

Function	Description
Detect Information Menu Navigation Request	Controller uses Air Gestures to open the information menu and/or interact with the AR elements displayed, by picking, dragging and dropping.
Display Information Menu	The information is opened and displayed to the Controller. When open, it is possible to navigate through it in order to retrieve information.
Detect Navigation through Menus	The Controller navigates through menus by means of Air Gestures.
Detect Information Selection	The Controller selects a piece of information by means of Air Gestures (e.g. filtering aircraft by distance, selection of a certain callsign, activation of LVP measures, etc.)
Display Requested Information	The menus and information provided by V/AR are updated according to the request made by the controller, e.g. by means of Air Gestures. For instance, some aircraft disappear, only the one with the selected callsign is presented, the runway and/or the buildings are outlined, etc.
Identify Aircraft	Augmented reality identifies all active aircraft on the airport, i.e. aircraft that are lined up for landing or take off, aircraft moving over the surface and aircraft on the gate about to depart. For this purpose, the surveillance and flight plan data is taken into account. For instance, the surveillance data provided by the ADS-B surveillance is fed into the system and associated to the aircraft out-the-window images so that this information is correlated.
Display Aircraft Information in the Tracking Labels	Tracking labels are displayed in augmented reality distinguishing each active aircraft, using the label antioverlapping feature.
Detect Label Selection	The label is selected by the controller, e.g. by means of gazing.

Function	Description
Separate Labels	In case the label antioverlapping feature is not enabled, and the A/R presents labels overlapping, the Air Gestures Detector allows the controller to separate manually the labels and distinguish each landing/departing aircraft.
Change Label Mode	The label is updated taking into account the new aircraft status: a) Once the aircraft has landed and is on ground, the label changes to the ground mode b) Once the aircraft is airborne, the label changes to the airborne mode c) Description on clearance displayed

Table 17. [NSV-4][UC-104] Functions description

4.1.1.1.2.4 [NSV-4][UC-105] Tracking labels for conflict detection alerts

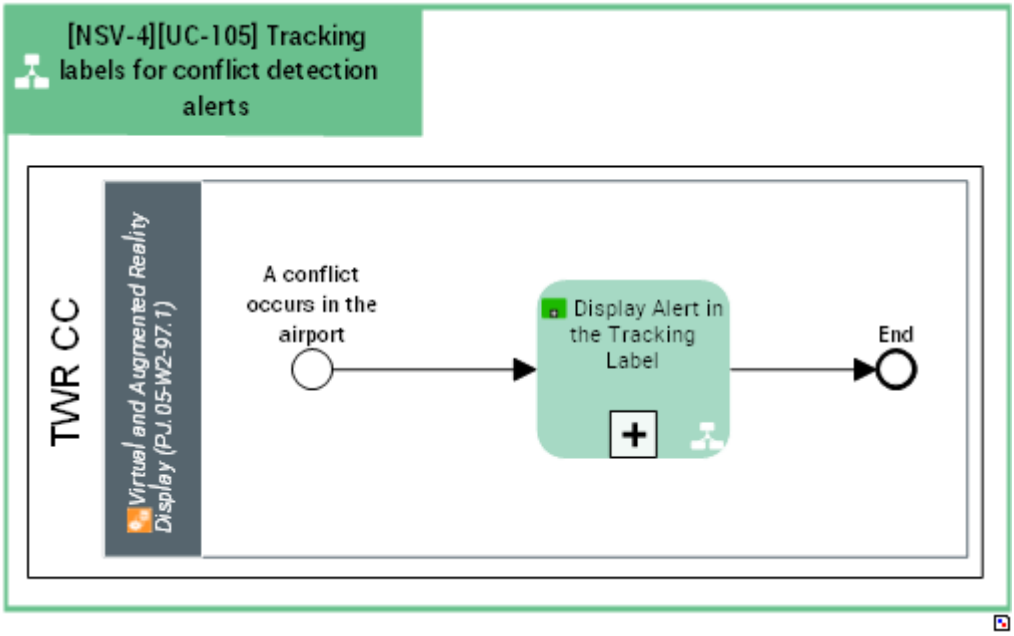

Figure 6. [NSV-4] [UC-105] Tracking labels for conflict detection alerts

The following table presents the Functions performed by the system as part of the Use Case depicted above, along with their descriptions, which are included in EATMA.

Function	Description
Display Alert in the Tracking Label	A tracking label is either presented, or an existing one is highlighted, in the Augmented Reality overlay to indicate that an alert corresponding to a potential conflict or hazard (e.g. runway incursion, conflicting clearances) requires ATCO's attention.

Table 18. [NSV-4][UC-105] Functions description

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4.1.1.1.2.5 [NSV-4][UC-106] Clearance issue by means of Air Gestures

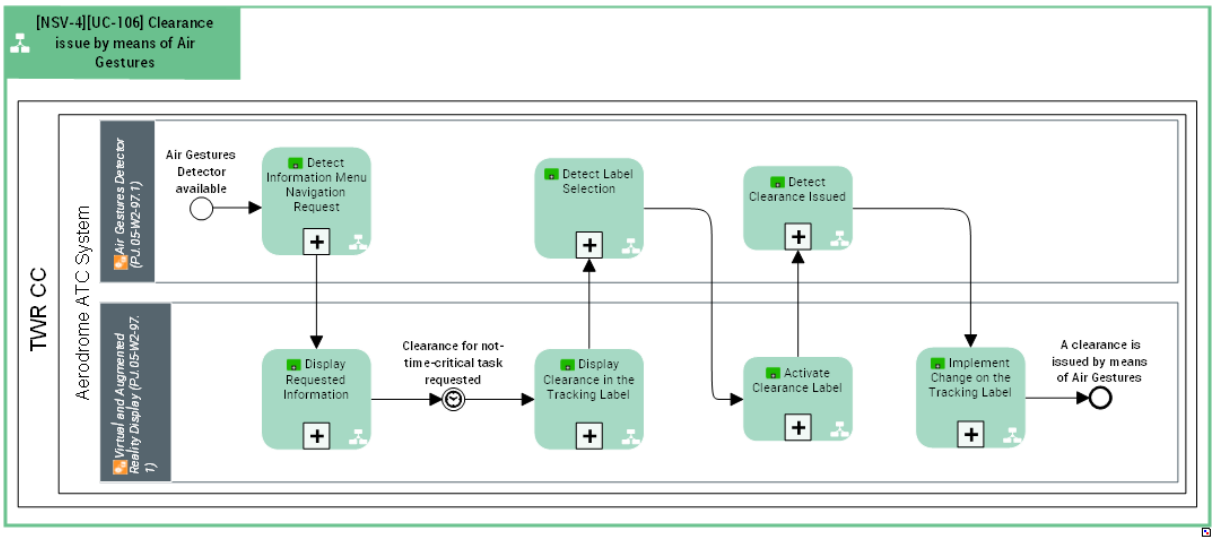

Figure 7. [NSV-4] [UC-106] Clearance issue by means of Air Gestures

The following table presents the Functions performed by the system as part of the Use Case depicted above, along with their descriptions, which are included in EATMA.

Function	Description
Detect Information Menu Navigation Request	Controller uses Air Gestures to open the information menu and/or interact with the AR elements displayed, by picking, dragging and dropping.
Display Requested Information	The menus and information provided by V/AR are updated according to the request made by the controller, e.g. by means of Air Gestures. For instance, some aircraft disappear, only the one with the selected callsign is presented, the runway and/or the buildings are outlined, etc.
Display Clearance in the Tracking Label	A clearance for not-time-critical task (e.g. start-up, push-back) is displayed in the tracking label if that clearance is requested or ready to be issued.
Detect Label Selection	The label is selected by the controller, e.g. by means of air gesture.
Activate Clearance Label	The label corresponding to the clearance that is ready to be issued is activated.
Detect Clearance Issued	The system detects the clearance issued by the controller by means of Air Gestures interacting with the interface.
Implement Change on the Tracking Label	The change is implemented on the tracking label once the clearance issued is detected.

Table 19. [NSV-4][UC-106] Functions description

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4.1.1.2 Resource Composition

New Functional Blocks have been created in EATMA, so that the system is able to perform the new Functions introduced by the Solution. These Functional Blocks are:

a) Virtual and Augmented Reality Display

b) Attention Guidance

c) Air Gestures Detector

All of them are included within the Aerodrome ATC Technical System. A duplication of this system has been created for PJ.05-W2-97.1 in order to introduce the newly created FBs.

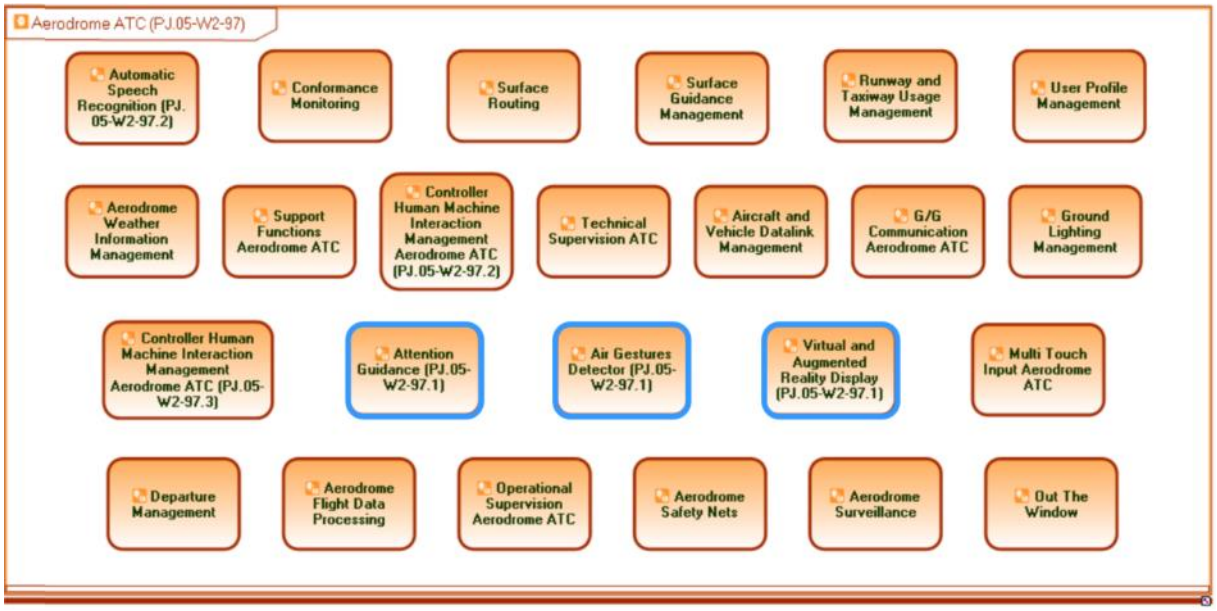

Figure 8. Aerodrome ATC (PJ.05-W2-97) Artifact Assembly Diagram

Please, be aware that the Functional Blocks created as part of PJ.05-W2-97.2 Solution framework are included as well, since the Solution impacts the same Aerodrome ATC Technical System element. The Technical System's suffix has been set to PJ.05-W2-97, so that it encompasses PJ.05-W2-97.2 new FBs as well, for common understanding and consolidation purposes.

4.1.1.3 Service view

N/A as it is just affecting one Technical system, hence no new interactions between Capability Configurations are introduced.

4.1.2 Functional and non-Functional Requirements

This section contains the Functional and non-Functional requirements, developed according to the SESAR Requirements and Validation Guidelines. The set of requirements has been built upon the work performed during the project lifecycle, including the outcomes of the validation exercises, which have been captured as well in the different parts of the TS/IRS (e.g. Part II – SAR and Part IV – HPAR) and fed into the TS/IRS Part I.

4.1.2.1 Functional Requirements

4.1.2.1.1 Attention Guidance Requirements

[REQ]

Identifier	REQ-05-W2-97.1-TS-AG02.0001
Title	Detection of Operator's Attention
Requirement	The Attention Guidance system shall identify the operator's attention focus on the airport traffic situation.
Status	<in progress>
Rationale	Knowing of the operator's attention focus is essential to enable further assessment of attention guidance measures. The method of the detection is hereby up to the specific implementation.
Category	<Functional> , <Performance> , <HMI>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-105_Attention Guidance in V/AR applications for aerodrome tower operations
<ALLOCATED_TO>	<Functional block>	Attention Guidance (PJ.05-W2-97.1)
<ALLOCATED_TO>	<Function>	Monitor ATCO's Activity
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-101-102] Guiding ATCO's attention via perceptual cues

[REQ]

Identifier	REQ-05-W2-97.1-TS-AG02.0002
Title	Priority of Critical Events Input
Requirement	The Attention Guidance system shall receive a set of events that are critical to be noted by the operator, with its corresponding severity/priority.
Status	<in progress>

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Rationale	To assess the gap between the operator's attention focus and the events that have to be noted immediately, the latter have to be determined by the system. This can be achieved by the information exchange from the other HMI functions that provide this information. The severity/priority for each conflict alert is an input received from the system in charge of this task (most commonly the alerting system in the tower).
Category	<Functional> , <HMI> , <Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-105_Attention Guidance in V/AR applications for aerodrome tower operations
<ALLOCATED_TO>	<Functional block>	Attention Guidance (PJ.05-W2-97.1)
<ALLOCATED_TO>	<Function>	Attention Guidance Logic (Aerodrome)
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-101-102] Guiding ATCO's attention via perceptual cues

[REQ]

Identifier	REQ-05-W2-97.1-TS-AG02.0003
Title	Application of Attention Guidance Measures to the Operator
Requirement	The Attention Guidance system shall adapt and/or trigger the display of visual elements on the situation data display to the controller.
Status	<in progress>
Rationale	To guide the operator's attention, the display of visual cues is a common approach. The attention guidance function shall therefore trigger the corresponding HMI function.
Category	<HMI> , <Functional>

[REQ Trace]

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Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-105_Attention Guidance in V/AR applications for aerodrome tower operations
<ALLOCATED_TO>	<Functional block>	Attention Guidance (PJ.05-W2-97.1)
<ALLOCATED_TO>	<Function>	Attention Guidance Measures (Aerodrome)
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-101-102] Guiding ATCO's attention via perceptual cues

[REQ]

Identifier	REQ-05-W2-97.1-TS-AG02.0004
Title	Identification of a safety relevant event
Requirement	The Attention Guidance Logic shall determine a safety relevant event based on the input coming from: • the relevant safety tools, • radar, • flight plan, and • other relevant external data available to be used by the Attention Guidance Logic.
Status	<in progress>
Rationale	To take the proper action in order to guide the attention of the operator to the event. (requirement created within the TS/IRS Part II - SAR framework)
Category	<Functional> , <Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-105_Attention Guidance in V/AR applications for aerodrome tower operations

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<ALLOCATED_TO>	<Functional block>	Attention Guidance (PJ.05-W2-97.1)
<ALLOCATED_TO>	<Function>	Attention Guidance Logic (Aerodrome)
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-101-102] Guiding ATCO's attention via perceptual cues

[REQ]

Identifier	REQ-05-W2-97.1-TS-AG01.0004
Title	Ensuring Safety and User Comfort
Requirement	The Attention Guidance system shall provide a toggle mode (to switch on/off Attention Guidance functionality) in order to not disturb regular controller operations, to allow a clear interpretation of the information displayed, and to enable easy interaction for the user.
Status	<in progress>
Rationale	The system shall provide a toggle mode (to switch on/off Attention Guidance functionality). If the controller does not need support of the Attention Guidance system in any specific moment due to controller comfort, the activity is too low, more than 1 out of 20 alerts presented to the controller are false alerts, or the activity is so high that the controller feels disturbed by the amounts of warnings that can come to hide existing systems functions, the system must offer a function for switching the visible Attention Guidance elements off/on by the controller.
Category	<Performance> , <HMI> , <Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-105_Attention Guidance in V/AR applications for aerodrome tower operations
<ALLOCATED_TO>	<Functional block>	Attention Guidance (PJ.05-W2-97.1)
<ALLOCATED_TO>	<Function>	Attention Guidance Measures (Aerodrome)
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-101-102] Guiding ATCO's attention via perceptual cues

[REQ]

Identifier	REQ-05-W2-97.1-TS-AG02.0005
Title	Attention Guidance not overshadowing
Requirement	The Attention Guidance system shall display the visual elements in a way that do not overshadow the final approach path and initial climbing path.
Status	<in progress>
Rationale	Final approach path and initial departure path shall be free to allow ATCOs monitoring. (requirement created within the TS/IRS Part IV - HPAR framework)
Category	<HMI>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-105_Attention Guidance in V/AR applications for aerodrome tower operations
<ALLOCATED_TO>	<Functional block>	Attention Guidance (PJ.05-W2-97.1)
<ALLOCATED_TO>	<Function>	Attention Guidance Measures (Aerodrome)
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-101-102] Guiding ATCO's attention via perceptual cues

[REQ]

Identifier	REQ-05-W2-97.1-TS-AG02.0006
Title	Attention Guidance alert repetition
Requirement	The Attention Guidance system shall not repeat alerts once it is switched off by end user.
Status	<in progress>

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Rationale	Attention Guidance alerts shall not be repeated once switched off by end user as they can annoy. (requirement created within the TS/IRS Part IV - HPAR framework)
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-105_Attention Guidance in V/AR applications for aerodrome tower operations
<ALLOCATED_TO>	<Functional block>	Attention Guidance (PJ.05-W2-97.1)
<ALLOCATED_TO>	<Function>	Attention Guidance Measures (Aerodrome)
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-101-102] Guiding ATCO's attention via perceptual cues

4.1.2.1.2 V/AR Requirements

[REQ]

Identifier	REQ-05-W2-97.1-TS-VAR1.0001
Title	Conformal Information
Requirement	The V/AR system shall depict conformal information as overlapped to the real object it is associated to.
Status	<in progress>
Rationale	The user can rely on the head-up conformal view when it is consistent with the real out-of-the tower view. Misalignment producing big offset of V/AR objects would make the system not acceptable. Thus, the capability to display conformal data is crucial for the V/AR system.
Category	<Performance> , <Functional> , <HMI>

[REQ Trace]

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Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-103_Virtual and Augmented Reality systems for Tower ATC
<ALLOCATED_TO>	<Functional block>	Virtual and Augmented Reality Display (PJ.05-W2-97.1)
<ALLOCATED_TO>	<Function>	Display Alert in the Tracking Label Display Aircraft Information in the Tracking Labels Present Attention Guidance Measures Display Relevant Airport, Weather and Flight Information Display Clearance in the Tracking Label
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-103] Retrieve of information by means of V/AR

[REQ]

Identifier	REQ-05-W2-97.1-TS-VAR1.0002
Title	Clear field of view
Requirement	The V/AR system shall not obstruct the natural field of view of the ATCO with augmented reality elements.
Status	<in progress>
Rationale	In good visibility conditions, the V/AR system is intended to enhance the real view perceived by the ATCO and not to replace it, thus the augmented reality elements should not reduce the natural field of view of the ATCO.
Category	<Performance> , <HMI> , <Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-103_Virtual and Augmented Reality systems for Tower ATC

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<ALLOCATED_TO>	<Functional block>	Virtual and Augmented Reality Display (PJ.05-W2-97.1)
<ALLOCATED_TO>	<Function>	Present Attention Guidance Measures
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-101-102] Guiding ATCO's attention via perceptual cues [NSV-4][UC-103] Retrieve of information by means of V/AR

[REQ]

Identifier	REQ-05-W2-97.1-TS-VAR1.0003
Title	Decluttering
Requirement	The V/AR system shall be able to declutter the synthetic elements in view as much as possible to prevent obstruction of the real view or overlap with other information
Status	<in progress>
Rationale	Clutter is an important issue in HMI design, especially when Augmented Reality Technology is considered. Decluttering functions can be implemented in order to display the information without disturbing the view of other objects within the user's field of view. Sizing and transparency of overlays can be set according to the level of cluttering that can be tolerated.
Category	<Performance> , <HMI>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-103_Virtual and Augmented Reality systems for Tower ATC
<ALLOCATED_TO>	<Functional block>	Virtual and Augmented Reality Display (PJ.05-W2-97.1)
<ALLOCATED_TO>	<Function>	Display Relevant Airport, Weather and Flight Information Present Attention Guidance Measures
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-103] Retrieve of information by means of V/AR

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		[NSV-4][UC-101-102] Guiding ATCO's attention via perceptual cues

[REQ]

Identifier	REQ-05-W2-97.1-TS-VAR1.0004
Title	Tracking label update
Requirement	The tracking label shall be updated taking into account the new aircraft status. a) Once the aircraft has landed and is on ground, the label changes to the ground mode. b) Once the aircraft is airborne, the label changes to the airborne mode. c) Description on clearance displayed.
Status	<in progress>
Rationale	To present the information corresponding to the updated situation. (requirement created within the TS/IRS Part II – SAR and Part IV – HPAR framework)
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-103_Virtual and Augmented Reality systems for Tower ATC
<ALLOCATED_TO>	<Functional block>	Virtual and Augmented Reality Display (PJ.05-W2-97.1)
<ALLOCATED_TO>	<Function>	Change Label Mode
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-104] Tracking labels in Augmented Reality for landing/departing aircrafts

[REQ]

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Identifier	REQ-05-W2-97.1-TS-VAR1.0005
Title	Suitability of the safety alert display
Requirement	The V/AR system shall remove a safety alert if the criticality of the situation decreases (it will reappear in case that the criticality continues to evolve).
Status	<in progress>
Rationale	To remove the alert once the controller has taken action to solve the critical event, unless the event continues to evolve (e.g. if the mobile involved deviates from the given instructions). (requirement created within the TS/IRS Part II - SAR framework)
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-103_Virtual and Augmented Reality systems for Tower ATC
<ALLOCATED_TO>	<Functional block>	Virtual and Augmented Reality Display (PJ.05-W2-97.1)
<ALLOCATED_TO>	<Function>	Display Alert in the Tracking Label
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-105] Tracking labels for conflict detection alerts

[REQ]

Identifier	REQ-05-W2-97.1-TS-VAR1.0006
Title	Depth of conformal information
Requirement	The V/AR system shall indicate the depth of the real object by its presentation as part of the conformal information associated to it.
Status	<in progress>
Rationale	To help the clear identification of displayed objects.

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	(requirement created within the TS/IRS Part II – SAR and Part IV - HPAR framework)
Category	<HMI>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-103_Virtual and Augmented Reality systems for Tower ATC
<ALLOCATED_TO>	<Functional block>	Virtual and Augmented Reality Display (PJ.05-W2-97.1)
<ALLOCATED_TO>	<Function>	Display Relevant Airport, Weather and Flight Information
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-103] Retrieve of information by means of V/AR

[REQ]

Identifier	REQ-05-W2-97.1-TS-VAR1.0007
Title	Limits of V/AR system
Requirement	The V/AR system shall display a visual indication of the limit of the augmented reality field of view in the Head-up display.
Status	<in progress>
Rationale	To help the end user to identify the field where the V/AR elements may be displayed. (requirement created within the TS/IRS Part II - SAR and Part IV – HPAR framework)
Category	<HMI>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1

<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-103_Virtual and Augmented Reality systems for Tower ATC
<ALLOCATED_TO>	<Functional block>	Virtual and Augmented Reality Display (PJ.05-W2-97.1)
<ALLOCATED_TO>	<Function>	Display Relevant Airport, Weather and Flight Information
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-103] Retrieve of information by means of V/AR

[REQ]

Identifier	REQ-05-W2-97.2-TS-VAR1.0008
Title	Information based on actual data
Requirement	The V/AR system shall display information in the Head-up HMI based on actual data.
Status	<in progress>
Rationale	The tracking labels and relevant aircraft information such as aircraft altitude, speed etc. shall be based on actual data to avoid misleading end-user. (requirement created within the TS/IRS Part IV - HPAR framework)
Category	<Functional> , <Interface>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-103_Virtual and Augmented Reality systems for Tower ATC
<ALLOCATED_TO>	<Functional block>	Virtual and Augmented Reality Display (PJ.05-W2-97.1)
<ALLOCATED_TO>	<Function>	Display Aircraft Information in the Tracking Labels Display Relevant Airport, Weather and Flight Information
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-103] Retrieve of information by means of V/AR

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[REQ]

Identifier	REQ-05-W2-97.2-TS-VAR1.0009
Title	Airport layers alignment
Requirement	The V/AR system shall display the airport layers in the Head-up HMI aligned with real world elements (e.g. RUNWAY, TAXIWAY, etc.).
Status	<in progress>
Rationale	To ensure V/A-R HMI is adequate to support ATCO in low visibility conditions. (requirement created within the TS/IRS Part IV - HPAR framework)
Category	<HMI> , <Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-103_Virtual and Augmented Reality systems for Tower ATC
<ALLOCATED_TO>	<Functional block>	Virtual and Augmented Reality Display (PJ.05-W2-97.1)
<ALLOCATED_TO>	<Function>	Display Relevant Airport, Weather and Flight Information
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-103] Retrieve of information by means of V/AR

[REQ]

Identifier	REQ-05-W2-97.2-TS-VAR1.0010
Title	Tracking labels not overshadowing
Requirement	The V/AR system shall display the tracking labels in a way that do not overshadow final approach path and initial climbing path.
Status	<in progress>

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Rationale	Final approach path and initial departure path shall be clear to allow ATCOs monitoring. (requirement created within the TS/IRS Part IV - HPAR framework)
Category	<HMI>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-103_Virtual and Augmented Reality systems for Tower ATC
<ALLOCATED_TO>	<Functional block>	Virtual and Augmented Reality Display (PJ.05-W2-97.1)
<ALLOCATED_TO>	<Function>	Display Aircraft Information in the Tracking Labels
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-104] Tracking labels in Augmented Reality for landing/departing aircrafts [NSV-4][UC-103] Retrieve of information by means of V/AR

[REQ]

Identifier	REQ-05-W2-97.2-TS-VAR1.0011
Title	Tracking labels for not active traffic
Requirement	The V/AR system shall not display tracking labels for not active traffic in the Head-up display.
Status	<in progress>
Rationale	Tracking labels of traffic not in contact can disturb ATCOs wit not needed information. (requirement created within the TS/IRS Part IV - HPAR framework)
Category	<HMI>

[REQ Trace]

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Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-103_Virtual and Augmented Reality systems for Tower ATC
<ALLOCATED_TO>	<Functional block>	Virtual and Augmented Reality Display (PJ.05-W2-97.1)
<ALLOCATED_TO>	<Function>	Display Aircraft Information in the Tracking Labels
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-104] Tracking labels in Augmented Reality for landing/departing aircrafts [NSV-4][UC-103] Retrieve of information by means of V/AR

[REQ]

Identifier	REQ-05-W2-97.2-TS-VAR1.0012
Title	V/AR status
Requirement	The V/AR system status shall be displayed (e.g. operational, malfunction, failure, etc).
Status	<in progress>
Rationale	To ensure that the ATCO is aware if a technical problem occurs. (requirement created within the TS/IRS Part IV - HPAR framework)
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-103_Virtual and Augmented Reality systems for Tower ATC
<ALLOCATED_TO>	<Functional block>	Virtual and Augmented Reality Display (PJ.05-W2-97.1)

[REQ]

Identifier	REQ-05-W2-97.2-TS-VAR1.0013
Title	V/AR alerts for conflicting aircraft
Requirement	The V/AR system may provide alerts for conflicting aircraft.
Status	<in progress>
Rationale	Head-up display of conflict improving user experience not having to search for information about where the conflict is and which a/c (call signs) are involved. (requirement created within the TS/IRS Part IV - HPAR framework)
Category	<Functional>, <HMI>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-103_Virtual and Augmented Reality systems for Tower ATC
<ALLOCATED_TO>	<Functional block>	Virtual and Augmented Reality Display (PJ.05-W2-97.1)

[REQ]

Identifier	REQ-05-W2-97.2-TS-VAR1.0014
Title	V/AR alerts for runway incursion
Requirement	The V/AR system may provide alerts for runway incursion.
Status	<in progress>
Rationale	Head-up display of runway incursion improving user experience not having to search for information about where the conflict is and which a/c (call signs) are involved. (requirement created within the TS/IRS Part IV - HPAR framework)
Category	<Functional>, <HMI>

[REQ Trace]

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Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-103_Virtual and Augmented Reality systems for Tower ATC
<ALLOCATED_TO>	<Functional block>	Virtual and Augmented Reality Display (PJ.05-W2-97.1)

4.1.2.1.3 Air Gestures Requirements

[REQ]

Identifier	REQ-05-W2-97.1-TS-AIRG.0001
Title	Type of Gestures
Requirement	The Air Gestures system shall be able to recognize different gestures and assign each of them to a specific function.
Status	<in progress>
Rationale	It is needed to assign each command to a specific gesture pattern, so to allow the interaction with the Virtual/Augmented Reality system interface, eventually used for providing clearances.
Category	<Functional>, <Interface>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-104_Controller productivity enhancements by Air gestures for Tower ATC
<ALLOCATED_TO>	<Functional block>	Air Gestures Detector (PJ.05-W2-97.1)
<ALLOCATED_TO>	<Function>	Detect Clearance Issued
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-106] Clearance issue by means of Air Gestures

[REQ]

Identifier	REQ-05-W2-97.1-TS-AIRG.0002

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Title	Multimodal Interaction
Requirement	The Air Gestures system shall be able to point at an object and command it by means of air gesture.
Status	<in progress>
Rationale	When air gesture is used to provide non time critical clearances (i.e. push back and start up) it is needed to select the flight the gesture command will be applied to. The multimodal interaction (gaze+gesture) is believed to be the most effective way to achieve this, but only gesture interaction has been implemented.
Category	<Functional> , <HMI>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-104_Controller productivity enhancements by Air gestures for Tower ATC
<ALLOCATED_TO>	<Functional block>	Air Gestures Detector (PJ.05-W2-97.1)
<ALLOCATED_TO>	<Function>	Detect Label Selection
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-106] Clearance issue by means of Air Gestures

[REQ]

Identifier	REQ-05-W2-97.1-TS-AIRG.0003
Title	Contactless Air Gesture
Requirement	The Air Gestures system shall be able to provide contactless interaction (as opposed to multi touch interaction).
Status	<in progress>
Rationale	Air gestures is intended as the possibility to recognize the movement of any part of the body (hand, fingers, arms, legs) and assign a command to a specific movement pattern. In the solution, hand/fingers gestures will be used to contactless interact with the V/AR objects.

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Category	<HMI> , <Performance> , <Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-104_Controller productivity enhancements by Air gestures for Tower ATC
<ALLOCATED_TO>	<Functional block>	Air Gestures Detector (PJ.05-W2-97.1)
<ALLOCATED_TO>	<Function>	Detect Clearance Issued
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-106] Clearance issue by means of Air Gestures

4.1.2.2 Non-Functional Requirements

[REQ]

Identifier	REQ-05-W2-97.1-TS-AG01.0002
Title	Display of Attention Guidance Elements with Varying Intensity
Requirement	The Attention Guidance shall set different escalation (intensity) levels for the critical events under consideration (e.g. conflicts).
Status	<in progress>
Rationale	In order to make sure that the most important information catches the controller's attention before anything else, the Attention Guidance shall comprise different escalation levels for the visual elements. The Attention Guidance approach does not intend to create new alarms or alerts but to adapt existing visual alerts tailored to the traffic situation and the controller's attention focus. The different escalation levels are based on input from the existing alerting system that prioritizes all incoming safety net alerts.
Category	<HMI> , <Performance> , <Safety>

[REQ Trace]

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Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-105_Attention Guidance in V/AR applications for aerodrome tower operations
<ALLOCATED_TO>	<Functional block>	Attention Guidance (PJ.05-W2-97.1)
<ALLOCATED_TO>	<Function>	Attention Guidance Logic (Aerodrome)
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-101-102] Guiding ATCO's attention via perceptual cues

[REQ]

Identifier	REQ-05-W2-97.1-TS-AG01.0003
Title	Attention Guidance alert visibility
Requirement	The Attention Guidance alerts shall be visible from all the angles in the tower.
Status	<in progress>
Rationale	To ensure Safety and User comfort, by allowing the visualization of the information from any place in the tower. (requirement created within the TS/IRS Part II - SAR and Part IV - HPAR framework)
Category	<HMI>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-105_Attention Guidance in V/AR applications for aerodrome tower operations
<ALLOCATED_TO>	<Functional block>	Attention Guidance (PJ.05-W2-97.1)
<ALLOCATED_TO>	<Function>	Present Attention Guidance Measures Attention Guidance Measures (Aerodrome)
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-101-102] Guiding ATCO's attention via perceptual cues

[REQ]

Identifier	REQ-05-W2-97.2-TS-VAR2.0001
Title	Available sources of data
Requirement	The V/AR system shall be fed by primary identification tools (e.g. radar, ADS-B).
Status	<in progress>
Rationale	To enable the usual detection of flights, as well as the detection of unexpected flights in the area of responsibility where ATC service is being provided. (requirement created within the TS/IRS Part II - SAR and Part IV - HPAR framework)
Category	<Interface>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-103_Virtual and Augmented Reality systems for Tower ATC
<ALLOCATED_TO>	<Functional block>	Virtual and Augmented Reality Display (PJ.05-W2-97.1)
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-103] Retrieve of information by means of V/AR

[REQ]

Identifier	REQ-05-W2-97.2-TS-VAR2.0002
Title	V/AR display elements brightening
Requirement	The V/AR system shall allow the customisation of the brightness of the V/AR displayed elements and the saving in a user set profile.
Status	<in progress>

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Rationale	Such as Tracking Labels background and the text. V/AR displayed elements may appear too brightly on top of the background, disturbing the operator. (requirement created within the TS/IRS Part II - SAR and Part IV - HPAR framework)
Category	<HMI>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-103_Virtual and Augmented Reality systems for Tower ATC
<ALLOCATED_TO>	<Functional block>	Virtual and Augmented Reality Display (PJ.05-W2-97.1)
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-103] Retrieve of information by means of V/AR

[REQ]

Identifier	REQ-05-W2-97.2-TS-VAR2.0003
Title	Customisation of Tracking Labels information
Requirement	The V/AR system shall allow the customisation of the information provided in the Tracking Labels from a list of predefined set of information and the saving in a user profile.
Status	<in progress>
Rationale	In a way that the user can choose options from few available. Full customisation is not recommended due to safety issues / certification. (requirement created within the TS/IRS Part II - SAR and Part IV - HPAR framework)
Category	<HMI>

[REQ Trace]

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Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-103_Virtual and Augmented Reality systems for Tower ATC
<ALLOCATED_TO>	<Functional block>	Virtual and Augmented Reality Display (PJ.05-W2-97.1)
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-104] Tracking labels in Augmented Reality for landing/departing aircrafts [NSV-4][UC-105] Tracking labels for conflict detection alerts

[REQ]

Identifier	REQ-05-W2-97.1-TS-VAR2.0004
Title	Minimum field of view
Requirement	The V/AR system shall have a 30° x 15° minimum field of view for the augmented viewing port.
Status	<in progress>
Rationale	The field of view of the augmented viewport should be large enough (30° x 15° minimum FOV) to intersect a wide portion of the out of the tower view in order to avoid excessive movements of the user's head.
Category	<HMI> , <Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-103_Virtual and Augmented Reality systems for Tower ATC
<ALLOCATED_TO>	<Functional block>	Virtual and Augmented Reality Display (PJ.05-W2-97.1)
<ALLOCATED_TO>	<Function>	Present Attention Guidance Measures
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-101-102] Guiding ATCO's attention via perceptual cues

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		[NSV-4][UC-103] Retrieve of information by means of V/AR

[REQ]

Identifier	REQ-05-W2-97.1-TS-VAR2.0005
Title	Contingency procedures for LVC
Requirement	The V/AR system failure shall be considered in the contingency procedures, in case the V/AR is used as in LVC operations.
Status	<in progress>
Rationale	To be prepared for a V/AR system failure. (requirement created within the TS/IRS Part II - SAR framework)
Category	<Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-103_Virtual and Augmented Reality systems for Tower ATC
<ALLOCATED_TO>	<Functional block>	Virtual and Augmented Reality Display (PJ.05-W2-97.1)

[REQ]

Identifier	REQ-05-W2-97.1-TS-VARH.0008
Title	V/AR display in all visibility conditions
Requirement	The V/AR system shall provide Tracking Labels and additional elements locally established in the Head-up display in all visibility conditions.
Status	<in progress>
Rationale	To ensure V/AR HMI is adequate to support ATCO in all visibility conditions.

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	(requirement created within the TS/IRS Part II - SAR and Part IV - HPAR framework)
Category	<HMI>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-103_Virtual and Augmented Reality systems for Tower ATC
<ALLOCATED_TO>	<Functional block>	Virtual and Augmented Reality Display (PJ.05-W2-97.1)
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-103] Retrieve of information by means of V/AR

[REQ]

Identifier	REQ-05-W2-97.1-TS-VARH.0019
Title	Information size customisation
Requirement	The V/AR system shall allow the customization of the information presented size and the saving in a user setting profile.
Status	<in progress>
Rationale	V/AR elements may appear too big or too small for the operator and they need to be customisable by the end-user. (requirement created within the TS/IRS Part IV - HPAR framework)
Category	<HMI>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-103_Virtual and Augmented Reality systems for Tower ATC
<ALLOCATED_TO>	<Functional block>	Virtual and Augmented Reality Display (PJ.05-W2-97.1)

[REQ]

Identifier	REQ-05-W2-97.1-TS-VARH.0006
Title	Tracking labels background colour
Requirement	The V/AR system shall display the tracking labels and attention guidance alerts with a background colour that do not overshadow the real world view.
Status	<in progress>
Rationale	It shall be avoided that the ATCOs does not see manoeuvring area. (requirement created within the TS/IRS Part IV - HPAR framework)
Category	<HMI>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-105_Attention Guidance in V/AR applications for aerodrome tower operations
<ALLOCATED_TO>	<Functional block>	Virtual and Augmented Reality Display (PJ.05-W2-97.1)
<ALLOCATED_TO>	<Function>	Display Aircraft Information in the Tracking Labels
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-101-102] Guiding ATCO's attention via perceptual cues [NSV-4][UC-104] Tracking labels in Augmented Reality for landing/departing aircrafts

[REQ]

Identifier	REQ-05-W2-97.1-TS-VARH.0018
Title	Non-intrusive alerts

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Requirement	The V/AR system shall present conflicting clearances and runway incursion alerts in a non-intrusive manner (if available) in the Head-up display
Status	<in progress>
Rationale	It shall be prevented to provide intrusive alerts to ATCOs. (requirement created within the TS/IRS Part IV - HPAR framework)
Category	<HMI>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-104_Controller productivity enhancements by Air gestures for Tower ATC
<ALLOCATED_TO>	<Functional block>	Virtual and Augmented Reality Display (PJ.05-W2-97.1)
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-105] Tracking labels for conflict detection alerts

[REQ]

Identifier	REQ-05-W2-97.1-TS-VARH.0023
Title	Non-intrusive attention guidance measures
Requirement	The V/AR system shall present attention guidance measures in a non-intrusive and non-repetitive manner.
Status	<in progress>
Rationale	It shall be prevented to provide intrusive alerts to ATCOs. (requirement created within the TS/IRS Part IV - HPAR framework)
Category	<HMI>

[REQ Trace]

Relationship	Linked Element Type	Identifier

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<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-105_Attention Guidance in V/AR applications for aerodrome tower operations
<ALLOCATED_TO>	<Functional block>	Attention Guidance (PJ.05-W2-97.1)
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-101-102] Guiding ATCO's attention via perceptual cues

[REQ]

Identifier	REQ-05-W2-97.1-TS-VARH.0022
Title	V/AR dark display
Requirement	Dark and coated V/AR Head-up display shall not affect real world visibility in good visibility conditions.
Status	<in progress>
Rationale	The fact that the V/AR device lens may be dark (like sunglasses) might reduce the ability to quickly view head down information. (requirement created within the TS/IRS Part IV - HPAR framework)
Category	<Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-103_Virtual and Augmented Reality systems for Tower ATC
<ALLOCATED_TO>	<Functional block>	Virtual and Augmented Reality Display (PJ.05-W2-97.1)

[REQ]

Identifier	REQ-05-W2-97.1-TS-VARH.0029
Title	Tracking labels consideration

Requirement	Tracking labels shall not be considered as primary source of information.
Status	<in progress>
Rationale	Tracking labels are not considered as primary source of information. The system should be considered as a supporting tool. (requirement created within the TS/IRS Part IV - HPAR framework)
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-103_Virtual and Augmented Reality systems for Tower ATC
<ALLOCATED_TO>	<Functional block>	Virtual and Augmented Reality Display (PJ.05-W2-97.1)

[REQ]

Identifier	REQ-05-W2-97.1-TS-VARH.0021
Title	V/AR display limitations
Requirement	Limitations of use of V/AR Head-Up display shall be assessed and defined.
Status	<in progress>
Rationale	V/AR Head-Up display may be not usable at night due to the darkness of the display. (requirement created within the TS/IRS Part IV - HPAR framework)
Category	<Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier

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<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-103_Virtual and Augmented Reality systems for Tower ATC
<ALLOCATED_TO>	<Functional block>	Virtual and Augmented Reality Display (PJ.05-W2-97.1)

[REQ]

Identifier	REQ-05-W2-97.1-TS-AIRG.0004
Title	Markerless Air Gesture
Requirement	The Air Gestures system shall be able to provide markerless tracking of the hand/fingers.
Status	<in progress>
Rationale	The new generation of air gesture systems is able to provide gesture interaction without applying markers on hands/fingers. The solution is targeting markerless air gesture as it is less invasive.
Category	<HMI> , <Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-104_Controller productivity enhancements by Air gestures for Tower ATC
<ALLOCATED_TO>	<Functional block>	Air Gestures Detector (PJ.05-W2-97.1)
<ALLOCATED_TO>	<Function>	Detect Clearance Issued Detect Label Selection
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-106] Clearance issue by means of Air Gestures

4.1.2.2.1 Performance Requirements

[REQ]

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Identifier	REQ-05-W2-97.1-TS-PERF.0003
Title	Latency for surveillance position
Requirement	If A-SMGCS surveillance data are used, the latency and validation of surveillance position data for aircraft and vehicles in the V/AR system should not exceed 1.5 seconds
Status	<in progress>
Rationale	The V/AR device will update aircraft information with rates similar to the feeding signal. A maximum of 0.5 extra seconds for the display on the V/AR system is proposed. This extra time is added on top of the latency allowed for A-SMGCS, which should not exceed 1 second (A-SMGCS Manual Doc 9830 AN/452, chapter 4.2.5).
Category	<Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-103_Virtual and Augmented Reality systems for Tower ATC
<ALLOCATED_TO>	<Functional block>	Virtual and Augmented Reality Display (PJ.05-W2-97.1)

[REQ]

Identifier	REQ-05-W2-97.1-TS-PERF.0004
Title	Latency for identification data
Requirement	The latency and validation of identification data for aircraft and vehicles in the V/AR system should not exceed 3.5 seconds.
Status	<in progress>
Rationale	The V/AR device will update aircraft information with rates similar to the feeding signal. A maximum of 0.5 extra seconds for the display on the V/AR system is proposed. This extra time is added on top of the latency allowed for A-SMGCS, which should not exceed 3 second (A-SMGCS Manual Doc 9830 AN/452, chapter 4.2.5).

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Category	<Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-103_Virtual and Augmented Reality systems for Tower ATC
<ALLOCATED_TO>	<Functional block>	Virtual and Augmented Reality Display (PJ.05-W2-97.1)

[REQ]

Identifier	REQ-05-W2-97.1-TS-PERF.0005
Title	A-SMGCS data refresh rate
Requirement	If A-SMGCS surveillance data are used, the refresh rate of information in the V/AR system should not exceed 2.5 seconds 85% of the time.
Status	<in progress>
Rationale	The V/AR device will update information with rates similar to the feeding signal. A maximum of 0.5 extra seconds for the display on the V/AR system is proposed. This extra time is added on top of the refresh rate for ADS-B, which is equal to 2 seconds 85% of the times.
Category	<Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-103_Virtual and Augmented Reality systems for Tower ATC
<ALLOCATED_TO>	<Functional block>	Virtual and Augmented Reality Display (PJ.05-W2-97.1)

[REQ]

Identifier	REQ-05-W2-97.1-TS-PERF.0006
Title	Smooth presentation of real data
Requirement	The V/AR system should present the information associated to real data in a smooth way.
Status	<in progress>
Rationale	The update of real data following the source refresh rate (e.g. ADS-B refresh rate) may result in jumps on the elements displayed. A smooth algorithm should be implemented in order to avoid annoying jumps and drop outs in the display.
Category	<Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-103_Virtual and Augmented Reality systems for Tower ATC
<ALLOCATED_TO>	<Functional block>	Virtual and Augmented Reality Display (PJ.05-W2-97.1)

Identifier	REQ-05-W2-97.1-TS-PERF.0007
Title	Smoothing of conformal information presentation
Requirement	The V/AR system shall enhance the presentation of the object localization data, including flight tag, by a data smoothing interpretation algorithm.
Status	<in progress>
Rationale	To support the clear identification of information and to improve the user comfort. (requirement created within the TS/IRS Part II - SAR framework)
Category	<Performance> , <HMI>

[REQ Trace]

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Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-103_Virtual and Augmented Reality systems for Tower ATC
<ALLOCATED_TO>	<Functional block>	Virtual and Augmented Reality Display (PJ.05-W2-97.1)

[REQ]

Identifier	REQ-05-W2-97.1-TS-PERF.0008
Title	Frequency of system failure
Requirement	The frequency of failure of the V/AR system (freezing or Tracking Labels or perceptual cues complete loss) shall be lower that 1E-04 [per ops hour].
Status	<in progress>
Rationale	To prevent the system unresponsiveness potentially impacting trajectory management and associated safety nets. (requirement created within the TS/IRS Part II - SAR framework)
Category	<Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-103_Virtual and Augmented Reality systems for Tower ATC
<ALLOCATED_TO>	<Functional block>	Virtual and Augmented Reality Display (PJ.05-W2-97.1)

[REQ]

Identifier	REQ-05-W2-97.1-TS-PERF.0009
Title	Frequency of Tracking Labels wrongly associated

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Requirement	The frequency of Tracking Labels erroneously associated to an aircraft (wrong information) shall be lower that 1E-04 [per ops hour].
Status	<in progress>
Rationale	To prevent the ATCO from focusing on a wrong aircraft and issuing a clearance intended for another aircraft. (requirement created within the TS/IRS Part II - SAR framework)
Category	<Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-103_Virtual and Augmented Reality systems for Tower ATC
<ALLOCATED_TO>	<Functional block>	Virtual and Augmented Reality Display (PJ.05-W2-97.1)

[REQ]

Identifier	REQ-05-W2-97.1-TS-PERF.0010
Title	Frequency of failure in input identification
Requirement	The frequency of the V/AR system failing to identify inputs (gestures) - no response, shall be lower that 1E-04 [per ops hour].
Status	<in progress>
Rationale	To prevent the ATCO from distracting from primary tasks when the system does not identify correctly issued gestures. This may result in temporary workload increase and a reduction of situational awareness. (requirement created within the TS/IRS Part II - SAR framework)
Category	<Performance>

[REQ Trace]

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Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-104_Controller productivity enhancements by Air gestures for Tower ATC
<ALLOCATED_TO>	<Functional block>	Air Gestures Detector (PJ.05-W2-97.1)

[REQ]

Identifier	REQ-05-W2-97.1-TS-PERF.0011
Title	Frequency of erroneous input identification
Requirement	The frequency of the V/AR system erroneously identifying inputs (gestures) shall be lower that 1E-04 [per ops hour].
Status	<in progress>
Rationale	To prevent the ATCo from having to manually correct the identified input, which may cause a disruption to the expected workflow and cognitive process. (requirement created within the TS/IRS Part II - SAR framework)
Category	<Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-104_Controller productivity enhancements by Air gestures for Tower ATC
<ALLOCATED_TO>	<Functional block>	Air Gestures Detector (PJ.05-W2-97.1)

[REQ]

Identifier	REQ-05-W2-97.1-TS-PERF.0012
Title	Conflicting clearances and runway incursions alerts reliability

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Requirement	Reliability and timeliness of conflicting clearances and runway incursions alerts shall be ensured if available in the HMI V/AR head up display.
Status	<in progress>
Rationale	To ensure Reliability and responsiveness of V/AR system. Acceptable values to be investigated. (requirement created within the TS/IRS Part IV - HPAR framework)
Category	<Reliability> , <Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-103_Virtual and Augmented Reality systems for Tower ATC
<ALLOCATED_TO>	<Functional block>	Virtual and Augmented Reality Display (PJ.05-W2-97.1)

[REQ]

Identifier	REQ-05-W2-97.1-TS-PERF.0013
Title	Air Gestures reliability
Requirement	Reliability and timely responsiveness of Air Gesture interactions shall be ensured.
Status	<in progress>
Rationale	To ensure Reliability and responsiveness of V/AR system. (requirement created within the TS/IRS Part IV - HPAR framework)
Category	<Reliability> , <Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1

<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-104_Controller productivity enhancements by Air gestures for Tower ATC
<ALLOCATED_TO>	<Functional block>	Air Gestures Detector (PJ.05-W2-97.1)

[REQ]

Identifier	REQ-05-W2-97.1-TS-PERF.0014
Title	Attention Guidance measures reliability
Requirement	Reliability and timely responsiveness of V/AR attention Guidance measures shall be ensured.
Status	<in progress>
Rationale	To ensure timely and reliable alerts of Attention Guidance. Acceptable values to be investigated. (requirement created within the TS/IRS Part IV - HPAR framework)
Category	<Reliability> , <Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-103_Virtual and Augmented Reality systems for Tower ATC
<ALLOCATED_TO>	<Functional block>	Attention Guidance (PJ.05-W2-97.1)

4.1.2.2.2 Human Performance Requirements

[REQ]

Identifier	REQ-05-W2-97.1-TS-VARH.0001
Title	Operating methods for V/AR
Requirement	Operating methods for V/AR shall be established for normal, abnormal and degraded mode.
Status	<in progress>

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Rationale	There is the need to define operating methods for all operating conditions and especially in low visibility conditions. (requirement created within the TS/IRS Part IV - HPAR framework)
Category	<Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-103_Virtual and Augmented Reality systems for Tower ATC
<ALLOCATED_TO>	<Functional block>	Virtual and Augmented Reality Display (PJ.05-W2-97.1)

[REQ]

Identifier	REQ-05-W2-97.1-TS-VARH.0016
Title	Recovery operating procedures
Requirement	Recovery operating procedures shall be defined in case of failure of V/AR in all operating conditions.
Status	<in progress>
Rationale	It must be avoided that failure of V/AR negatively affects the situation awareness. (requirement created within the TS/IRS Part IV - HPAR framework)
Category	<Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-103_Virtual and Augmented Reality systems for Tower ATC
<ALLOCATED_TO>	<Functional block>	Virtual and Augmented Reality Display (PJ.05-W2-97.1)

[REQ]

Identifier	REQ-05-W2-97.1-TS-VARH.0031
Title	V/AR training
Requirement	ATOCs shall be extensively trained and exposed to the new system functionalities provided by V/AR.
Status	<in progress>
Rationale	Training requirements. (requirement created within the TS/IRS Part IV - HPAR framework)
Category	<Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-103_Virtual and Augmented Reality systems for Tower ATC
<ALLOCATED_TO>	<Functional block>	Virtual and Augmented Reality Display (PJ.05-W2-97.1)

4.1.2.2.3 Security Requirements

The list of Security requirements presented below has been validated via the Security Assessment Report (SAR).

[REQ]

Identifier	REQ-05-W2-97.1-TS-SEC0.0001
Title	Network components segregation
Requirement	The V/AR system linked to the controllers' working positions shall operate within a segregated network.
Status	<validated>
Rationale	Segregated components will make transmissions more secure as well as protect reducing the likelihood of specific attacks.

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Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-103_Virtual and Augmented Reality systems for Tower ATC
<ALLOCATED_TO>	<Functional block>	Virtual and Augmented Reality Display (PJ.05-W2-97.1)

[REQ]

Identifier	REQ-05-W2-97.1-TS-SEC0.0002
Title	Backup data saving
Requirement	For data stored in V/AR system linked to the controllers' working positions there shall be a periodic backup procedure in place in order to guarantee recovery of corrupted or lost data.
Status	<validated>
Rationale	Regular backup will mitigate effectiveness of specific attacks or disasters reducing the amount of lost data. Furthermore, using backup procedures will allow to restore systems more quickly making them more resilient.
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-103_Virtual and Augmented Reality systems for Tower ATC
<ALLOCATED_TO>	<Functional block>	Virtual and Augmented Reality Display (PJ.05-W2-97.1)

[REQ]

Identifier	REQ-05-W2-97.1-TS-SEC0.0003
Title	Anti-Malware
Requirement	The V/AR system linked to the controllers' working positions shall be protected with appropriate Anti-Malware software or policies to avoid installation of malicious software.
Status	<validated>
Rationale	Anti-malware software or policies will reduce the likelihood of malicious software operations impacting the specified systems.
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-103_Virtual and Augmented Reality systems for Tower ATC
<ALLOCATED_TO>	<Functional block>	Virtual and Augmented Reality Display (PJ.05-W2-97.1)

[REQ]

Identifier	REQ-05-W2-97.1-TS-SEC0.0004
Title	Data protection
Requirement	Data stored in the V/AR system linked to the controllers' working positions shall be protected through encryption procedures.
Status	<validated>
Rationale	Specific control on the data stored by the above systems will prevent unauthorized entities from obtaining, clearly understanding and modifying confidential data in a consistent and detrimental way.
Category	<Security>

[REQ Trace]

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Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Functional block>	Virtual and Augmented Reality Display (PJ.05-W2-97.1)

[REQ]

Identifier	REQ-05-W2-97.1-TS-SEC0.0005
Title	Communications Assurance
Requirement	Communication between involved actors, through radio and data links, shall be always ensured to prevent ground conflicts.
Status	<validated>
Rationale	Implementation of specific controls to ensure communication channels availability will prevent failures or hacker attacks such as jamming, message injection or wilful disturbances.
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.1
<ALLOCATED_TO>	<Functional block>	Air Gestures Detector (PJ.05-W2-97.1) Virtual and Augmented Reality Display (PJ.05-W2-97.1) Attention Guidance (PJ.05-W2-97.1)

4.2 Solution PJ.05-W2-97.2: ASR at the TWR CWP supported by AI and Machine Learning

4.2.1 Functional architecture overview (general introduction for all solutions)

The Solution impacts the ATM environment by the introduction of the Automatic Speech Recognition Functional Block. It also adds new Functions to the Controller Human Machine interaction Management Aerodrome ATC FB so that full advantages can be taken from the ASR.

Functional Block	Description
Automatic Speech Recognition (PJ.05-W2-97.2)	The Automatic Speech Recognition Functional Block gets an audio signal as input and transforms it into a sequence of words, i.e. “speech-to-text” following the recognition process. The sequence of words is transcribed into a sequence of ATC concepts (“text-to-concepts”) using an ontology. The resulting concepts can be used for further applications such as visualization on an HMI.
Controller Human Machine Interaction Management Aerodrome ATC (PJ.05-W2-97.2)	This functional block provides controllers with a graphical user interface and with the means to interact with the Aerodrome ATC system. The CHMIM Functional Block collects and integrates different Human Machine Interfaces developed for the different airport systems into just one homogenous set of configurable and customisable Tower Human Machine Interfaces. Note: This Functional Block has been duplicated in order to include Functions which are result of the interaction with the Automatic Speech Recognition.

Table 20. Functional Blocks introduced by PJ.05-W2-97.2

Inside the Automatic Speech Recognition, new Functions have been defined in order to represent the functionality of this FB.

4.2.1.1 Resource Connectivity view (NSV-1)

N/A since the Solution is just affecting one Technical system, hence no new interactions between Capability Configurations are introduced.

4.2.1.1.1 Resource Infrastructure view (NSV-2)

N/A as it is just affecting one Technical system, hence no new interactions between Capability Configurations are introduced.

4.2.1.1.2 Resource Orchestration view (NSV-4s)

This section describes the sequence of how the resources interact. This must be consistent with the content defined at EATMA level and available in the latest applicable version in EATMA.

The Solution focuses on the Automatic Speech Recognition Functional Block. Some Functions have been created in order to improve the ASR Functional Block so that the Solution concept can be implemented.

NSV-4 diagrams have been created in order to describe the resource orchestration summarising the Use Cases from section 3.2.1.1.2. These diagrams have been modelled in MEGA.

4.2.1.1.2.1 [NSV-4][UC-201] Highlighting recognized callsign

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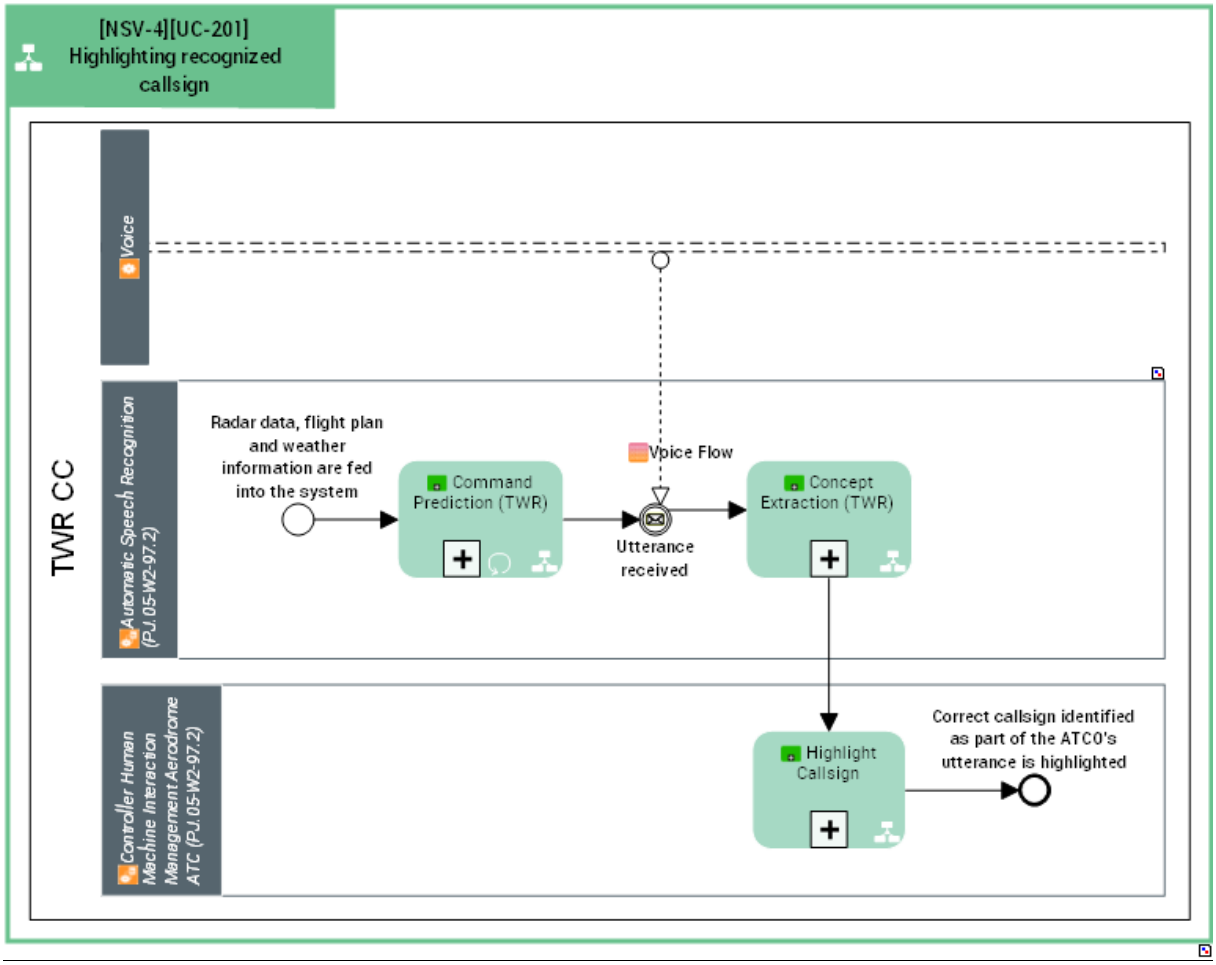

Figure 9. [NSV-4][UC-201] Highlighting recognized Callsign

The following table presents the Functions performed by the system as part of the Use Case depicted above, along with their descriptions, which are included in EATMA.

Function	Description
Command Prediction (TWR)	Forecasts possible future controller commands for the Tower environment, taking into account periodically received contextual information updates. This external data can be surveillance data, flight plan data, route information, clearance information, weather data, airspace data, and also historical data of those types. This information is used to predict possible future controller commands that may be supported by AI/ML, through a machine learned command prediction model on historical surveillance and speech data.
Concept Extraction (TWR)	The verbal controller utterance (e.g. wav-file) is transformed into a sequence of spoken words. The Concept extraction function transforms the sequence of spoken words into the corresponding ATC concepts (more general speech information), which are further combined to ATC commands. The output of Command Prediction could be used to ease both

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Function	Description
	tasks (extraction of word sequence and extraction of ATC commands) and also/or for checking if the extracted ATC commands makes sense in the current situation (Checker task).
Highlight Callsign	A callsign, which is being considered by the system, is highlighted in the CWP HMI, after being recognised as part of ATCO's utterance.

Table 21. [NSV-4][UC-201] Functions description

4.2.1.1.2.2 [NSV-4][UC-202-203-204] Recognized commands through ASR

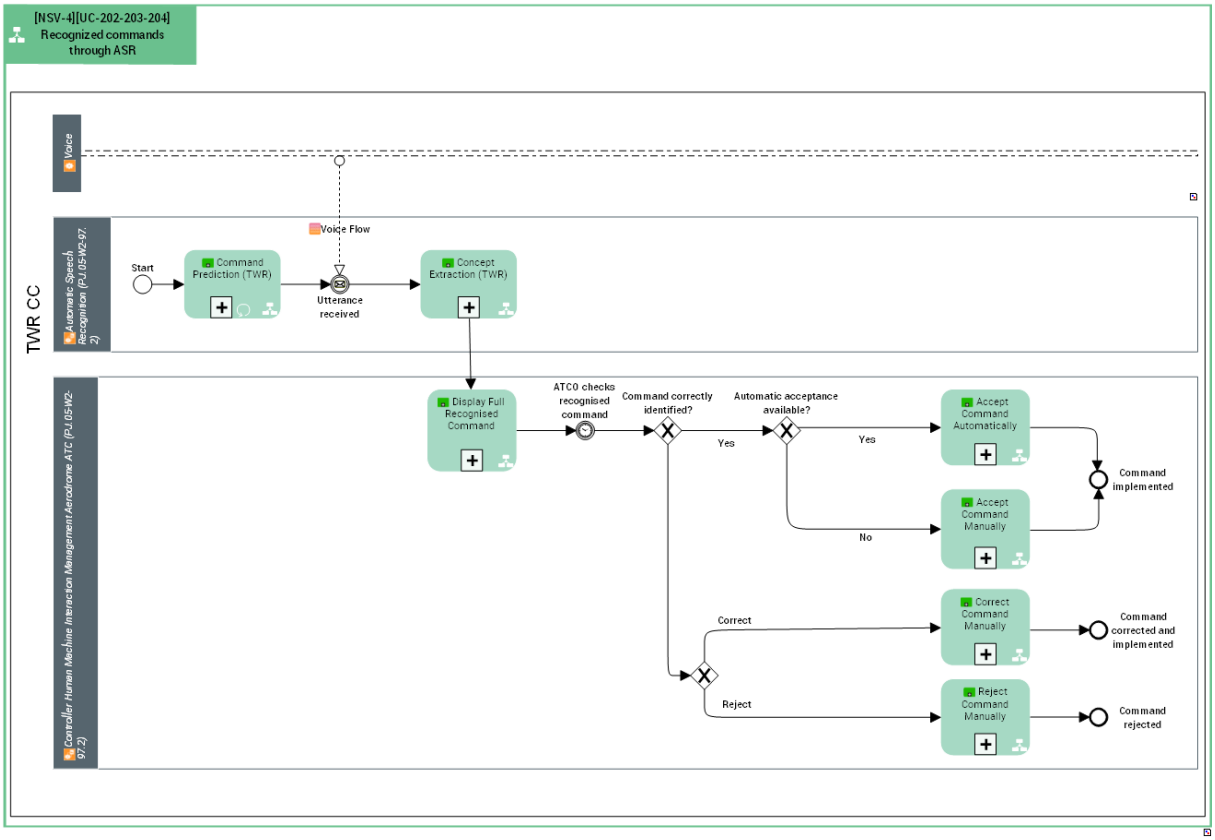

Figure 10. [NSV-4] UC-202-203-204] Recognized commands through ASR

The following table presents the Functions performed by the system as part of the Use Case depicted above, along with their descriptions, which are included in EATMA.

Function	Description
Command Prediction (TWR)	Forecasts possible future controller commands for the Tower environment, taking into account periodically received contextual information updates. This external data can be surveillance data, flight plan data, route information, clearance information, weather data, airspace data, and also historical data of those types. This information is used to predict possible future controller commands

Function	Description
	that may be supported by AI/ML, through a machine learned command prediction model on historical surveillance and speech data.
Concept Extraction (TWR)	The verbal controller utterance (e.g. wav-file) is transformed into a sequence of spoken words. The Concept extraction function transforms the sequence of spoken words into the corresponding ATC concepts (more general speech information), which are further combined to ATC commands. The output of Command Prediction could be used to ease both tasks (extraction of word sequence and extraction of ATC commands) and also/or for checking if the extracted ATC commands makes sense in the current situation (Checker task).
Display Full Recognised Command	A command recognised as part of ATCO's utterance is displayed in the CWP HMI
Accept Command Automatically	The recognized and displayed command is automatically accepted, if the controller does not reject it within an adjustable timeframe.
Accept Command Manually	Command recognized by the Automatic Speech Recognition is manually accepted by the ATCO.
Correct Command Manually	A recognized command is identified by the controller as incorrect, and manually manipulated afterwards (either command types, callsign, values or units) in order to correct it. The corrected command is displayed.
Reject Command Manually	ATCO rejects the command identified by ASR manually, mainly when the ASR output is a garbled utterance.

Table 22. [NSV-4][UC-202-203-204] Functions description

4.2.1.2 Resource Composition

A new Functional Blocks has been created in EATMA, so that the system is able to perform the new Functions introduced by the Solution. This Functional Block is:

d) Automatic Speech Recognition

Automatic Speech Recognition is included within the Aerodrome ATC Technical System. A duplication of this system has been created for PJ.05-W2-97.2 in order to introduce the newly created FBs.

The Solution has an impact on Controller Human Machine Interaction Management Aerodrome ATC as well, so this Functional Block has also been duplicated from the Common Libraries, so that new Functions can be allocated to it.

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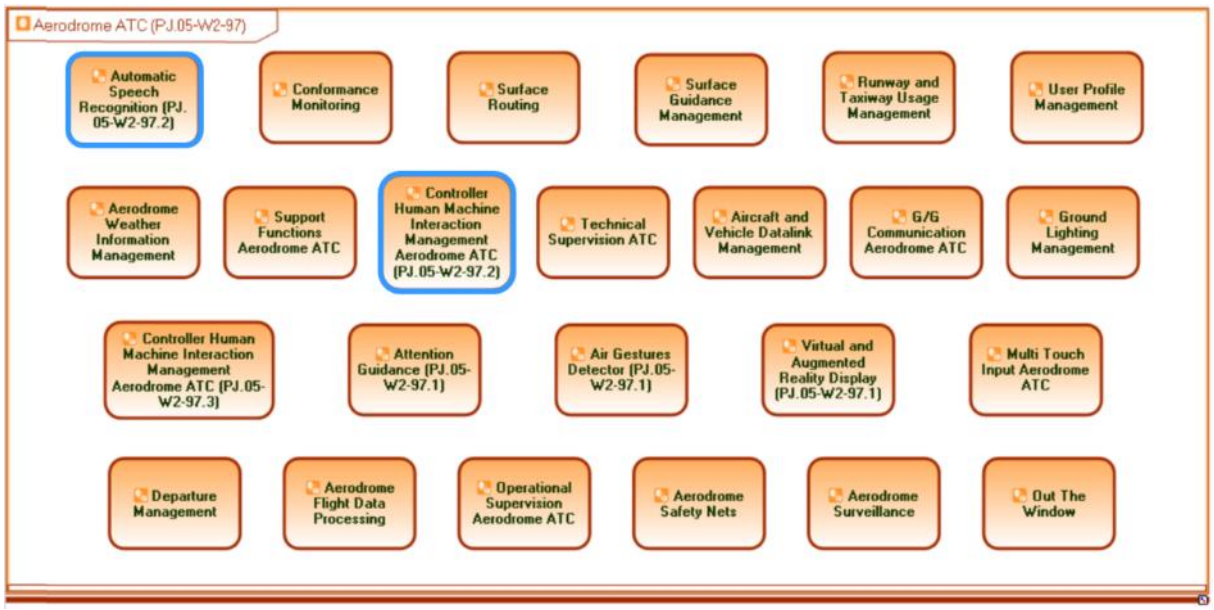

Figure 11. Aerodrome ATC (PJ.05-W2-97) Artifact Assembly Diagram

Please, be aware that the Functional Blocks created as part of PJ.05-W2-97.1 Solution framework are included as well, since the Solution impacts the same Aerodrome ATC Technical System element. The Technical System's suffix has been set to PJ.05-W2-97, so that it encompasses PJ.05-W2-97.1 new FBs as well, for common understanding and consolidation purposes.

4.2.1.3 Service view

No Services have been created, since the Solution impacts just one Capability Configuration, and no new interactions between CCs are introduced.

4.2.2 Functional and non-Functional Requirements

This section contains the Functional and non-Functional requirements, developed according to the SESAR Requirements and Validation Guidelines. The set of requirements has been built upon the work performed during the project lifecycle, including the outcomes of the validation exercises, which have been captured as well in the different parts of the TS/IRS (e.g. Part II – SAR and Part IV – HPAR) and fed into the TS/IRS Part I.

4.2.2.1 Functional Requirements

4.2.2.1.1 Automatic Speech Recognition Function Requirements

[REQ]

Identifier	REQ-05-W2-97.2-TS-ASR0.0001
Title	Area of interest

EUROPEAN PARTNERSHIP

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Requirement	ASR shall be able to process different traffic flows within the Area of Interest of the Control Unit.
Status	<in progress>
Rationale	To cover the whole traffic within the Area of Interest. The different traffic flows are: - Arrivals - Departures - Ground movements
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.2
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-106_Automatic Speech Recognition supported by AI and ML algorithms for aerodrome tower operations
<ALLOCATED_TO>	<Functional block>	Automatic Speech Recognition (PJ.05-W2-97.2)
<ALLOCATED_TO>	<Function>	Command Prediction (TWR) Concept Extraction (TWR)
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-202-203-204] Recognized commands through ASR [NSV-4][UC-201] Highlighting recognized callsign

[REQ]

Identifier	REQ-05-W2-97.2-TS-ASR0.0002
Title	Recognition of Commands
Requirement	ASR shall recognize commands of different command categories.
Status	<in progress>

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Rationale	Recognition of commands is the basic functionality of a speech recognizer used in ATC applications. The different command categories are provided in the appendix.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.2
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-106_Automatic Speech Recognition supported by AI and ML algorithms for aerodrome tower operations
<ALLOCATED_TO>	<Functional block>	Automatic Speech Recognition (PJ.05-W2-97.2)
<ALLOCATED_TO>	<Function>	Command Prediction (TWR) Concept Extraction (TWR)
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-201] Highlighting recognized callsign [NSV-4][UC-202-203-204] Recognized commands through ASR

[REQ]

Identifier	REQ-05-W2-97.2-TS-ASR0.0003
Title	Multiple Commands
Requirement	ASR should be able to process ATCO utterances containing multiple commands.
Status	<in progress>
Rationale	To be able to process multiple commands in single utterance.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.2

<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-106_Automatic Speech Recognition supported by AI and ML algorithms for aerodrome tower operations
<ALLOCATED_TO>	<Functional block>	Automatic Speech Recognition (PJ.05-W2-97.2)
<ALLOCATED_TO>	<Function>	Concept Extraction (TWR)
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-202-203-204] Recognized commands through ASR

[REQ]

Identifier	REQ-05-W2-97.2-TS-ASR0.0005
Title	Multiple Callsigns
Requirement	ASR should be able to process ATCO utterances containing more than one callsign.
Status	<in progress>
Rationale	To be able to process multiple callsign in single utterance, recognition rate will increase if controller user ICAO phraseology with “break, break”.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.2
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-106_Automatic Speech Recognition supported by AI and ML algorithms for aerodrome tower operations
<ALLOCATED_TO>	<Functional block>	Automatic Speech Recognition (PJ.05-W2-97.2)
<ALLOCATED_TO>	<Function>	Concept Extraction (TWR)
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-202-203-204] Recognized commands through ASR [NSV-4][UC-201] Highlighting recognized callsign

[REQ]

Identifier	REQ-05-W2-97.2-TS-ASR0.0006
Title	ASR interoperability with VCS
Requirement	ASR shall be able to interact with Voice Communication Systems in an interoperable manner.
Status	<in progress>
Rationale	In order to ease interoperability with existing VCS systems, so that the commands uttered by the ATCO are fed into the ASR function.
Category	<Functional> <Interoperability>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.2
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-106_Automatic Speech Recognition supported by AI and ML algorithms for aerodrome tower operations
<ALLOCATED_TO>	<Functional block>	Automatic Speech Recognition (PJ.05-W2-97.2)
<ALLOCATED_TO>	<Function>	Concept Extraction (TWR)
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-202-203-204] Recognized commands through ASR [NSV-4][UC-201] Highlighting recognized callsign

[REQ]

Identifier	REQ-05-W2-97.2-TS-ASR0.0007
Title	ASR input/output content
Requirement	ASR shall have clearly defined input and output content.
Status	<in progress>
Rationale	For instance, the ontology for ATC utterance annotation.
Category	<Interface>

[REQ Trace]

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Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.2
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-106_Automatic Speech Recognition supported by AI and ML algorithms for aerodrome tower operations
<ALLOCATED_TO>	<Functional block>	Automatic Speech Recognition (PJ.05-W2-97.2)

[REQ]

Identifier	REQ-05-W2-97.2-TS-ASR0.0008
Title	ASR input/output transmission format
Requirement	ASR shall have clearly defined input and output transmission format (e.g. JSON).
Status	<in progress>
Rationale	To ensure the successful data transmission.
Category	<Interface>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.2
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-106_Automatic Speech Recognition supported by AI and ML algorithms for aerodrome tower operations
<ALLOCATED_TO>	<Functional block>	Automatic Speech Recognition (PJ.05-W2-97.2)

[REQ]

Identifier	REQ-05-W2-97.2-TS-ASR0.0009
Title	ASR switch off/on
Requirement	ASR shall provide the ATCO with a switch on/switch off function.
Status	<in progress>

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Rationale	If the ASR recognition rate drops down, ATCO's workload might be higher than without using an ASR system. Therefore the switch on/off functionality is needed.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.2
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-106_Automatic Speech Recognition supported by AI and ML algorithms for aerodrome tower operations
<ALLOCATED_TO>	<Functional block>	Automatic Speech Recognition (PJ.05-W2-97.2)
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-202-203-204] Recognized commands through ASR [NSV-4][UC-201] Highlighting recognized callsign

[REQ]

Identifier	REQ-05-W2-97.2-TS-ASR0.0010
Title	Silent/passive acknowledgement
Requirement	ASR should acknowledge the clearance uttered in a silent/passive manner with the time out.
Status	<in progress>
Rationale	To avoid disrupting the workflow when the automatic acceptance is available. (requirement created within TS/IRS Part II - SAR framework)
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.2

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<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-106_Automatic Speech Recognition supported by AI and ML algorithms for aerodrome tower operations
<ALLOCATED_TO>	<Functional block>	Automatic Speech Recognition (PJ.05-W2-97.2)
<ALLOCATED_TO>	<Function>	Accept Command Automatically
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-202-203-204] Recognized commands through ASR

[REQ]

Identifier	REQ-05-W2-97.2-TS-ASR0.0011
Title	ASR based on real OPS data
Requirement	ASR recognition system engine should be based on real OPS data.
Status	<in progress>
Rationale	Real OPS data are needed because ATCOs behave (and speak) differently in simulation and in real ops. (requirement created within the TS/IRS Part IV - HPAR framework)
Category	<Design>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.2
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-106_Automatic Speech Recognition supported by AI and ML algorithms for aerodrome tower operations
<ALLOCATED_TO>	<Functional block>	Automatic Speech Recognition (PJ.05-W2-97.2)

4.2.2.1.2 HMI Requirements for ASR

[REQ]

Identifier	REQ-05-W2-97.2-TS-HMI0.0001

Title	Callsign highlighting
Requirement	The ASR HMI shall highlight the Track Label (Electronic Flight Strips or A-SMGCS, depending on the implementation) after recognizing the corresponding callsign or clicking on the callsign.
Status	<in progress>
Rationale	If the recognized callsign is highlighted while the ATCO is speaking, he/she may already know that the command will not be recognized correctly and that a manual input is needed. In that case, ATCO can reduce the number of commands he/she wants to give in the utterance.
Category	<Functional> <HMI>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.2
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-106_Automatic Speech Recognition supported by AI and ML algorithms for aerodrome tower operations
<ALLOCATED_TO>	<Functional block>	Controller Human Machine Interaction Management Aerodrome ATC (PJ.05-W2-97.2)
<ALLOCATED_TO>	<Function>	Highlight Callsign
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-201] Highlighting recognized callsign

[REQ]

Identifier	REQ-05-W2-97.2-TS-HMI0.0002
Title	AI feed callsign recognition levels visualisation
Requirement	The ASR HMI shall highlight the recognised callsign in a different colour in case of uncertainty in callsign recognition in a range of percentage to be assessed.
Status	<in progress>
Rationale	The color coding for the case when the ARS has fully recognized the input must be different than if there was some AI input – this should be further investigated.

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	(requirement created within TS/IRS Part II - SAR and TS/IRS Part IV - HPAR framework)
Category	<Functional> , <HMI>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.2
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-106_Automatic Speech Recognition supported by AI and ML algorithms for aerodrome tower operations
<ALLOCATED_TO>	<Functional block>	Controller Human Machine Interaction Management Aerodrome ATC (PJ.05-W2-97.2)
<ALLOCATED_TO>	<Function>	Highlight Callsign
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-201] Highlighting recognized callsign

[REQ]

Identifier	REQ-05-W2-97.2-TS-HMI0.0003
Title	Input acceptance
Requirement	The ASR HMI should enable acceptance of automatically inserted value by ATCO clicking on the value by enabling automatic acceptance of recognized command values if the controller does not correct them within a predefined time frame to be locally established (e.g. 10 seconds).
Status	<in progress>
Rationale	The controller should be able to decide whether he/she wants to explicitly accept recognitions or whether he/she wants to explicitly reject recognitions. In the first case recognized commands are automatically rejected if they are not explicitly accepted by the ATCO within a predefined time frame (e.g. 10 seconds). In the second case recognized commands are automatically accepted if they are not explicitly rejected by the ATCO within a predefined time frame (e.g. 10 seconds).
Category	<Functional> <HMI>

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[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.2
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-106_Automatic Speech Recognition supported by AI and ML algorithms for aerodrome tower operations
<ALLOCATED_TO>	<Functional block>	Controller Human Machine Interaction Management Aerodrome ATC (PJ.05-W2-97.2)
<ALLOCATED_TO>	<Function>	Accept Command Automatically
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-202-203-204] Recognized commands through ASR

[REQ]

Identifier	REQ-05-W2-97.2-TS-HMI0.0004
Title	Manual correction
Requirement	The ASR HMI shall enable manual correction/update of automatically proposed command value/type.
Status	<in progress>
Rationale	If a command is not correctly recognized ATCO needs the possibility to manually correct it (e.g. by mouse or keyboard). ATCO is not able to repeat the clearance via voice. The manual input of ATCO (e.g. correction/update of command) SHALL have priority over automatically proposed command value/type within related utterance. Manual correction even makes sense, if recognized commands are manually confirmed, e.g. if four commands are given, all recognized command could be first accepted and then one is manually corrected. That is easier than rejecting all of them and then manual inserting all four.
Category	<Functional> <HMI>

[REQ Trace]

Relationship	Linked Element Type	Identifier

<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.2
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-106_Automatic Speech Recognition supported by AI and ML algorithms for aerodrome tower operations
<ALLOCATED_TO>	<Functional block>	Controller Human Machine Interaction Management Aerodrome ATC (PJ.05-W2-97.2)
<ALLOCATED_TO>	<Function>	Correct Command Manually
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-202-203-204] Recognized commands through ASR

[REQ]

Identifier	REQ-05-W2-97.2-TS-HMI0.0005
Title	ASR failure indication
Requirement	The ASR HMI shall display the ASR status (e.g. operational, malfunction, failure).
Status	<in progress>
Rationale	If the ASR completely fails, the controller needs to be informed about this as workflows might be affected and a higher level of manual input might be required. ASR failure is not related to misrecognitions, but to a complete shutdown of ASR support.
Category	<Functional> <HMI>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.2
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-106_Automatic Speech Recognition supported by AI and ML algorithms for aerodrome tower operations
<ALLOCATED_TO>	<Functional block>	Controller Human Machine Interaction Management Aerodrome ATC (PJ.05-W2-97.2)
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-202-203-204] Recognized commands through ASR [NSV-4][UC-201] Highlighting recognized callsign

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[REQ]

Identifier	REQ-05-W2-97.2-TS-HMI0.0006
Title	Callsign recognition uncertainty
Requirement	The ASR HMI shall not highlight any callsign in case of uncertainty callsign recognition is above a percentage to be defined locally.
Status	<in progress>
Rationale	In case of the system recognising a wrong callsign it's better to not show anything rather the wrong recognized callsign. (requirement created within TS/IRS Part IV - HPAR framework)
Category	<Functional> , <HMI>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.2
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-106_Automatic Speech Recognition supported by AI and ML algorithms for aerodrome tower operations
<ALLOCATED_TO>	<Functional block>	Controller Human Machine Interaction Management Aerodrome ATC (PJ.05-W2-97.2)
<ALLOCATED_TO>	<Function>	Highlight Callsign
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-201] Highlighting recognized callsign

[REQ]

Identifier	REQ-05-W2-97.2-TS-HMI2.0002
Title	HMI for Command Values
Requirement	The ASR HMI shall present the recognized command types together with the command values in the Electronic Flight Strip or in a dedicated place on the HMI.
Status	<in progress>

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Rationale	The controller needs the information of the given command value in the Electronic Flight Strip or in a dedicated place on the HMI. Otherwise he has to manually input them.
Category	<Functional> <HMI>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.2
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-106_Automatic Speech Recognition supported by AI and ML algorithms for aerodrome tower operations
<ALLOCATED_TO>	<Functional block>	Controller Human Machine Interaction Management Aerodrome ATC (PJ.05-W2-97.2)
<ALLOCATED_TO>	<Function>	Display Full Recognised Command
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-201] Highlighting recognized callsign [NSV-4][UC-202-203-204] Recognized commands through ASR

[REQ]

Identifier	REQ-05-W2-97.2-TS-HMI0.0007
Title	ASR integration in CWP HMI
Requirement	The ASR HMI shall be integrated in CWP HMI (EFPS or other locally established HMI) in a coherent and visible way.
Status	<in progress>
Rationale	ASR HMI must be in the scan path of the end user and shall be coherently integrated. (requirement created within TS/IRS Part IV - HPAR framework)
Category	<Interface> <HMI>

[REQ Trace]

Relationship	Linked Element Type	Identifier

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<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.2
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-106_Automatic Speech Recognition supported by AI and ML algorithms for aerodrome tower operations
<ALLOCATED_TO>	<Functional block>	Automatic Speech Recognition (PJ.05-W2-97.2) Controller Human Machine Interaction Management Aerodrome ATC (PJ.05-W2-97.2)

4.2.2.2 Non-Functional Requirements

[REQ]

Identifier	REQ-05-W2-97.2-TS-ASRH.0009
Title	ASR HMI colours and brightness
Requirement	The ASR HMI colours and brightness shall be locally established following HF principles and local implementation needs.
Status	<in progress>
Rationale	ASR colours and brightness need to be consistent with local environment (e.g. LOCAL CWP colours shall be used to define the HMI Highlight background colour that shall be evident respect to not highlighted callsigns). (requirement created within TS/IRS Part IV - HPAR framework)
Category	<HMI>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.2
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-106_Automatic Speech Recognition supported by AI and ML algorithms for aerodrome tower operations
<ALLOCATED_TO>	<Functional block>	Controller Human Machine Interaction Management Aerodrome ATC (PJ.05-W2-97.2)

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4.2.2.2.1 Performance Requirements

[REQ]

Identifier	REQ-05-W2-97.2-TS-ReTi.0001
Title	Provide callsign information immediately
Requirement	ASR should give a response not later than 1.0 second after the controller has pressed the push-to-talk-button, by sending the recognized callsign to the cooperating ATC system. Remark: If the callsign is not recognized after the callsign is said, ASR MAY send recognized callsign together with the whole recognized command even if it is recognized during the utterance (e.g. if ASR needs the other contextual information to recognize the callsign properly or the controller gives the callsign information at the end of the utterance). If a command is not started with a callsign, the callsign information may be sent first followed by the rest of the recognized command. If an utterance contains more than one callsign (break, break), only the first callsign may be sent first.
Status	<in progress>
Rationale	Callsign is one of the most important information. If a long command is given (e.g. duration > 3 seconds), the controller wants an early feedback, that ASR has recognized the correct callsign. This could be immediately displayed by highlighting the aircraft label on the CWP HMI.
Category	<Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.2
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-106_Automatic Speech Recognition supported by AI and ML algorithms for aerodrome tower operations
<ALLOCATED_TO>	<Functional block>	Automatic Speech Recognition (PJ.05-W2-97.2)
<ALLOCATED_TO>	<Function>	Concept Extraction (TWR)

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<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-202-203-204] Recognized commands through ASR [NSV-4][UC-201] Highlighting recognized callsign

[REQ]

Identifier	REQ-05-W2-97.2-TS-ReTi.0002
Title	Reaction Time
Requirement	For the ATCO utterances except callsign itself, on average, the system should be able to give the final speech-to-text and text-to-concept result latest one second after the ATCO has released the push-to-talk button.
Status	<in progress>
Rationale	ASR is used online, i.e. there is already an output before releasing the PTT button. Also in online mode, there is a slight delay before providing an output. There is a need to know the aircraft the ATCO is speaking to after the callsign is said. Sufficient response time has to be kept under all conditions even in case of long ATCO transmission. For the other 0.1% percent a reaction time of less than 3 seconds or a rejection with “NO_CONCEPT” is required.
Category	<Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.2
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-106_Automatic Speech Recognition supported by AI and ML algorithms for aerodrome tower operations
<ALLOCATED_TO>	<Functional block>	Automatic Speech Recognition (PJ.05-W2-97.2)
<ALLOCATED_TO>	<Function>	Concept Extraction (TWR)
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-202-203-204] Recognized commands through ASR

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[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.2
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-106_Automatic Speech Recognition supported by AI and ML algorithms for aerodrome tower operations
<ALLOCATED_TO>	<Functional block>	Automatic Speech Recognition (PJ.05-W2-97.2)
<ALLOCATED_TO>	<Function>	Command Prediction (TWR)
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-201] Highlighting recognized callsign [NSV-4][UC-202-203-204] Recognized commands through ASR

[REQ]

Identifier	REQ-05-W2-97.2-TS- ReTi.0003
Title	System reaction time
Requirement	The use of ASR SHALL have no influence on the reaction time of the different systems/functional blocks used in the controller HMI.
Status	<in progress>
Rationale	The ASR is only an add-on intended to support the controller and reduce the workload, with the goal to speed up operation. If any other system is slowed down by the usage of ASR due to e.g. system requirements, that goal is no longer given.
Category	<Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.2
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-106_Automatic Speech Recognition supported by AI and ML algorithms for aerodrome tower operations
<ALLOCATED_TO>	<Functional block>	Automatic Speech Recognition (PJ.05-W2-97.2)

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<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-202-203-204] Recognized commands through ASR [NSV-4][UC-201] Highlighting recognized callsign

[REQ]

Identifier	REQ-05-W2-97.2-TS- ReTi.0004
Title	System recognition time
Requirement	The ASR shall start with the recognition of the utterance directly after the first word has been spoken.
Status	<in progress>
Rationale	To not lose time especially in case of longer utterances it would be beneficial if the system can already start with the recognition during the spoken commands. Sometimes ASR system starts recognition when controller releases push-to-talk button. This behaviour should be avoided by this requirement.
Category	<Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.2
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-106_Automatic Speech Recognition supported by AI and ML algorithms for aerodrome tower operations
<ALLOCATED_TO>	<Functional block>	Automatic Speech Recognition (PJ.05-W2-97.2)
<ALLOCATED_TO>	<Function>	Concept Extraction (TWR)
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-201] Highlighting recognized callsign [NSV-4][UC-202-203-204] Recognized commands through ASR

[REQ]

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Identifier	REQ-05-W2-97.2-TS-Perf.0001
Title	Command Recognition Error Rate
Requirement	The ASR Command Recognition Error Rate SHOULD be less than 2.5%.
Status	<in progress>
Rationale	The Command Error Rate is the most important indicator from the operational perspective as it influences the trust of the ATCO in ASR (Command Error Rate and Command Rejection Rate have to be distinguished).
Category	<Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.2
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-106_Automatic Speech Recognition supported by AI and ML algorithms for aerodrome tower operations
<ALLOCATED_TO>	<Functional block>	Automatic Speech Recognition (PJ.05-W2-97.2)
<ALLOCATED_TO>	<Function>	Concept Extraction (TWR)
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-202-203-204] Recognized commands through ASR [NSV-4][UC-201] Highlighting recognized callsign

[REQ]

Identifier	REQ-05-W2-97.2-TS-Perf.0002
Title	Command Prediction Error Rate
Requirement	The ASR Command Prediction Error Rate SHOULD not be higher than 10% and also not be higher than 50% of the opposite command recognition rate (i.e. 100% minus the command recognition rate), without using the checker.
Status	<in progress>

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Rationale	If we have a command recognition rate of 84%, the command prediction error rate should not be higher than 0.5*(100%-84%) = 8%. The speech recognizer relies on the input of the predicted commands. Commands, which are not predicted (normally), cannot be recognized. So if command prediction accuracy is worse than recognition accuracy itself, the command prediction functionality might have no benefits for the recognition engine any more.
Category	<Performance>

[REQ]

Identifier	REQ-05-W2-97.2-TS-Perf.0005
Title	Command Recognition Rate
Requirement	The ASR Command Recognition Rate SHOULD be higher than 85%.
Status	<in progress>
Rationale	There is a clear operational need to have high recognition rate (of at least 85%) so that controllers are not distracted from work by manual corrections and they are able to keep the situational awareness and good mental picture of the situation.
Category	<Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.2
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-106_Automatic Speech Recognition supported by AI and ML algorithms for aerodrome tower operations
<ALLOCATED_TO>	<Functional block>	Automatic Speech Recognition (PJ.05-W2-97.2)
<ALLOCATED_TO>	<Function>	Concept Extraction (TWR)
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-201] Highlighting recognized callsign

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		[NSV-4][UC-202-203-204] Recognized commands through ASR

[REQ]

Identifier	REQ-05-W2-97.2-TS-Perf.0006
Title	Erroneous identification rate
Requirement	The frequency of erroneous identification of aircraft by ASR system shall be lower than 1E-04 [per ops hour].
Status	<in progress>
Rationale	To ensure the acceptable performance of the system. (requirement created within TS/IRS Part II - SAR framework)
Category	<Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.2
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-106_Automatic Speech Recognition supported by AI and ML algorithms for aerodrome tower operations
<ALLOCATED_TO>	<Functional block>	Automatic Speech Recognition (PJ.05-W2-97.2)
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-201] Highlighting recognized callsign

[REQ]

Identifier	REQ-05-W2-97.2-TS-Perf.0007
Title	Incorrect command recognition rate
Requirement	The frequency of erroneous information entered into the ATC system due to the incorrect command recognition by ASR system shall not by higher than 1.2e-05 [per ops hour].
Status	<in progress>

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Rationale	To ensure the acceptable performance of the system. (requirement created within TS/IRS Part II - SAR framework)
Category	<Performance>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.2
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-106_Automatic Speech Recognition supported by AI and ML algorithms for aerodrome tower operations
<ALLOCATED_TO>	<Functional block>	Automatic Speech Recognition (PJ.05-W2-97.2)
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-202-203-204] Recognized commands through ASR

[REQ]

Identifier	REQ-05-W2-97.2-TS-Perf.0008
Title	Impact on CWP
Requirement	ASR shall be integrated in current CWP system without affecting what already available.
Status	<in progress>
Rationale	The ASR must not introduce changes to already available systems. (requirement created within TS/IRS Part II - SAR framework)
Category	<Performance> <Interface>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.2
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-106_Automatic Speech Recognition supported by AI and ML algorithms for aerodrome tower operations

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<ALLOCATED_TO>	<Functional block>	Automatic Speech Recognition (PJ.05-W2-97.2) Controller Human Machine Interaction Management Aerodrome ATC (PJ.05-W2-97.2)

4.2.2.2.2 Safety Requirements

The following set of requirements has been created within the TS/IRS Part II – Safety Assessment Report.

[REQ]

Identifier	REQ-05-W2-97.2-TS-Safe.0001
Title	ASR and Safety Nets
Requirement	ASR shall be interoperable with other safety nets available.
Status	<in progress>
Rationale	To achieve the fully integration of ASR into the system, specially with the safety nets deployed that are related with the clearance uttered, such as conflicting clearance monitoring. (requirement created within TS/IRS Part II - SAR framework)
Category	<Safety> , <Interoperability>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.2
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-106_Automatic Speech Recognition supported by AI and ML algorithms for aerodrome tower operations
<ALLOCATED_TO>	<Functional block>	Automatic Speech Recognition (PJ.05-W2-97.2)

[REQ]

Identifier	REQ-05-W2-97.2-TS-Safe.0002
Title	Failure of ASR

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Requirement	A failure of the ASR shall have no negative influence on the Tower ATC system.
Status	<in progress>
Rationale	Even when the ASR has failed, it shall not negatively influence regular work station performance and the controller has to be able to continue handling aircraft. The ASR can only be an add-on to normal operation.
Category	<Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.2
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-106_Automatic Speech Recognition supported by AI and ML algorithms for aerodrome tower operations
<ALLOCATED_TO>	<Functional block>	Automatic Speech Recognition (PJ.05-W2-97.2)
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-201] Highlighting recognized callsign [NSV-4][UC-202-203-204] Recognized commands through ASR

[REQ]

Identifier	REQ-05-W2-97.2-TS-Safe.0003
Title	Representative ontology and voice samples
Requirement	ASR shall be trained with local operations ontology sample, which is representative of the different circumstances that occur during the operations.
Status	<in progress>
Rationale	To ensure that the system training covers the various aspects that can be found in the local communications, such as languages, background, pilot/controller, male/female voices, etc. (requirement created within TS/IRS Part II - SAR framework)
Category	<Safety>

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[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.2
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-106_Automatic Speech Recognition supported by AI and ML algorithms for aerodrome tower operations
<ALLOCATED_TO>	<Functional block>	Automatic Speech Recognition (PJ.05-W2-97.2)

[REQ]

Identifier	REQ-05-W2-97.2-TS-Safe.0004
Title	Integration into the existing system
Requirement	ASR shall be fully integrated into existing operating system.
Status	<in progress>
Rationale	E.g. electronic flight strips. To ensure that all the relevant functionalities that may be related to ASR are available. (requirement created within TS/IRS Part II - SAR framework)
Category	<Interoperability>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.2
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-106_Automatic Speech Recognition supported by AI and ML algorithms for aerodrome tower operations
<ALLOCATED_TO>	<Functional block>	Automatic Speech Recognition (PJ.05-W2-97.2)

[REQ]

Identifier	REQ-05-W2-97.2-TS-Safe.0005

Title	Contingency procedures
Requirement	Contingency procedures in case of ASR failure shall be established.
Status	<in progress>
Rationale	To ensure that contingency procedures are well defined and available. (requirement created within TS/IRS Part II - SAR framework)
Category	<Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.2
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-106_Automatic Speech Recognition supported by AI and ML algorithms for aerodrome tower operations
<ALLOCATED_TO>	<Functional block>	Automatic Speech Recognition (PJ.05-W2-97.2)

4.2.2.2.3 Human Performance Requirements

The following set of requirements has been created within the TS/IRS Part IV – Human Performance Assessment Report.

[REQ]

Identifier	REQ-05-W2-97.2-TS-ASRH.0006
Title	ASR training
Requirement	ATOCs shall be extensively trained and exposed to the new system functionalities to ensure ASR benefits and adequate trust.
Status	<in progress>
Rationale	Disparities amongst ATCOs in Europe regarding familiarity with automated tools - unified training at European level needs to be developed. (requirement created within TS/IRS Part IV - HPAR framework)

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Category	<Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.2
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-106_Automatic Speech Recognition supported by AI and ML algorithms for aerodrome tower operations

[REQ]

Identifier	REQ-05-W2-97.2-TS-ASRH.0012
Title	Working without ASR
Requirement	Local procedures and training shall be put in place to maintain ATCOs skills in working without ASR support to avoid ASR overreliance.
Status	<in progress>
Rationale	There is the need to ensure recurrent training and local procedures to avoid ASR overreliance and keep ATCOs skills. (requirement created within TS/IRS Part IV - HPAR framework)
Category	<Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.2
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-106_Automatic Speech Recognition supported by AI and ML algorithms for aerodrome tower operations

4.2.2.2.4 Security Requirements

The list of Security requirements presented below has been validated via the Security Assessment Report (SAR).

[REQ]

Identifier	REQ-05-W2-97.2-TS-SEC0.0001
Title	Network components segregation
Requirement	The ASR system linked to the controllers' working positions shall operate within a segregated network
Status	<validated>
Rationale	Segregated components will make transmissions more secure as well as protect reducing the likelihood of specific attacks.
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.2
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-106_Automatic Speech Recognition supported by AI and ML algorithms for aerodrome tower operations
<ALLOCATED_TO>	<Functional block>	Automatic Speech Recognition (PJ.05-W2-97.2)

[REQ]

Identifier	REQ-05-W2-97.2-TS-SEC0.0002
Title	Backup data saving
Requirement	For data stored in ASR system linked to the controllers' working positions, there shall be a periodic backup procedure in place in order to guarantee recovery of corrupted or lost data.
Status	<validated>
Rationale	Regular backup will mitigate effectiveness of specific attacks or disasters reducing the amount of lost data. Furthermore, using backup procedures will allow to restore systems more quickly making them more resilient.
Category	<Security>

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[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.2
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-106_Automatic Speech Recognition supported by AI and ML algorithms for aerodrome tower operations
<ALLOCATED_TO>	<Functional block>	Automatic Speech Recognition (PJ.05-W2-97.2)

[REQ]

Identifier	REQ-05-W2-97.2-TS-SEC0.0003
Title	Anti-Malware
Requirement	The ASR system linked to the controllers' working positions shall be protected with appropriate Anti-Malware software or policies to avoid installation of malicious software.
Status	<validated>
Rationale	Anti-malware software or policies will reduce the likelihood of malicious software operations impacting the specified systems.
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.2
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-106_Automatic Speech Recognition supported by AI and ML algorithms for aerodrome tower operations
<ALLOCATED_TO>	<Functional block>	Automatic Speech Recognition (PJ.05-W2-97.2)

[REQ]

Identifier	REQ-05-W2-97.2-TS-SEC0.0004
Title	Data protection

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Requirement	Data stored in the ASR system linked to the controllers' working positions shall be protected through encryption procedures.
Status	<validated>
Rationale	Specific control on the data stored by the above systems will prevent unauthorized entities from obtaining, clearly understanding and modifying confidential data in a consistent and detrimental way.
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.2
<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-106_Automatic Speech Recognition supported by AI and ML algorithms for aerodrome tower operations
<ALLOCATED_TO>	<Functional block>	Automatic Speech Recognition (PJ.05-W2-97.2)

[REQ]

Identifier	REQ-05-W2-97.2-TS-SEC0.0005
Title	Communication Assurance
Requirement	Communication availability between involved actors through radio and data links shall not be impacted by ASR. This communication shall be always ensured to prevent ground conflicts.
Status	<validated>
Rationale	Implementation of specific controls to ensure communication channels availability will prevent failures or hacker attacks such as jamming, message injection or wilful disturbances.
Category	<Security>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.2

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<ALLOCATED_TO>	<Enabler>	AERODROME-ATC-106_Automatic Speech Recognition supported by AI and ML algorithms for aerodrome tower operations
<ALLOCATED_TO>	<Functional block>	Automatic Speech Recognition (PJ.05-W2-97.2)

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5 Recommendation for Implementation

5.1 Recommendation for PJ.05-W2-97.1 Implementation

V/AR applications included within PJ.05-W2-97.1 are aimed to be implemented in the Tower environment. The Airport Operating Environment is targeted by this Solution.

As stated in the PJ.05-W2-97.1 VALR [30], not every Airport category and all the circumstances have been simulated, but it has been indicated what would be necessary, in terms of further investigations, to make the concept workable in such environments.

The applicability to a certain environment will also depend on organisational decisions, e.g. use of AR for Supervisor only, for assistant controllers, for ground controller, runway controller, or even all of them. All of these implementation options have to be carefully evaluated in future studies in order to assess the impact they have on the concept of use.

Especially, certification issues have not been addressed yet in detail, which also means that system failure or degradation issues need to be checked during future maturity levels, as well as reverting to conventional operations (that should remain as backup).

As a result of the validation activities, it has been concluded that the introduction of the concept should be addressed gradually, for instance, as an add-on feature of the current controller working position, by beginning with assistants or supervisors wearing the device in smaller environments and building up progressively afterwards. Also, it has been determined that equipment such as microphone and headset could be embedded in the Head-mounted Display.

Besides, concerning the ergonomics, it is recommended that the V/AR device weights substantially less that the current off-the-shelf devices, so that it can be brought in operation.

Concerning the deployment options, a stakeholder may consider the following Enabler combinations, based on the Enablers developed within the Solution:

a) AERODROME-ATC-103 Virtual and Augmented Reality systems for Tower ATC,

b) AERODROME-ATC-103 Virtual and Augmented Reality systems for Tower ATC with AERODROME-ATC-104 Controller productivity enhancements by Air gestures for Tower ATC,

c) AERODROME-ATC-103 Virtual and Augmented Reality systems for Tower ATC with AERODROME-ATC-105 Attention Guidance in V/AR applications for aerodrome tower operations, or

d) AERODROME-ATC-103 Virtual and Augmented Reality systems for Tower ATC with both AERODROME-ATC-104 Controller productivity enhancements by Air gestures for Tower ATC and AERODROME-ATC-105 Attention Guidance in V/AR applications for aerodrome tower operations.

5.2 Recommendation for PJ.05-W2-97.2 Implementation

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Automatic Speech Recognition at the TWR CWP is available to be implemented both in a conventional and a (multiple) remote Tower. The concept is aimed to operate in airports of any category (Very Large, Large, Medium, Small and Other).

Specific training regarding voice recognition and specific ontology and logical rules should be provided to the ASR engine considering the Operating Environment where to be deployed, i.e. the Tower environment in this case. The phraseology corresponding to this environment is considered in the ontology presented in Appendix A.

Besides, the ABSR model needs to be adjusted to the target environment, so that the recognition is facilitated by knowing beforehand the elements which are original from each environment, e.g. waypoint names, runway names or frequencies.

Having separate acoustical models for ATCO and for pilots should be considered as well, as there are differences between their utterances that should be examined for the sake of speech recognition, such as dissimilitudes in pronunciation and structure of utterances and readbacks.

Although the command prediction function (ABSR) is not considered indispensable for the implementation of Automatic Speech Recognition, its availability is considered beneficial for event recognition in all situations.

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6 Assumptions

As a result of the Human Performance Assessment report activities, it has been determined that Electronic Flight Progress strip shall be available for PJ.05-W2-97.2 when implementing ASR in the TWR.

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7 References and Applicable Documents

7.1 Applicable Documents

Content Integration

[1] PJ19-W2: EATMA Guidance, ed. 01.00.00, June 2021

Content Development

[2] SESAR Concept of Operations (CONOPS), ed. 01.00.00, May 2019

System and Service Development

[3] PJ19: RSIT, ed. 00.01.00, 25 October 2019

Performance Management

[4] SESAR Performance Framework, ed. 01.00.01-2019

[5] S2020 Common Assumptions, ed. 01.00.00, 16 September 2019

Validation

[6] PJ19-W2: Validation Targets – SESAR2020 Wave 2 & Wave 3, ed. 00.01.00, 04 May 2021

[7] E-OCVM Version 3.0 Volume I, February 2010

[8] E-OCVM Version 3.0 Volume II Annexes, February 2010

[9] D2.6 – PJ19: VALS, ed. 00.01.00, 31 October 2019

System Engineering

[10] E-OCVM Version 3, February 2010

[11]SESAR 2020 Requirements and Validation Guidelines, ed. 00.02.01, 1 May 2020

Safety

[12] SESAR2020 Safety Reference Material, Ed 00.04.01, 14 Dec 18

Human Performance

[13] SESAR Human Performance Assessment Process V1 to V3 - including VLD, ed. 00.03.01 27 Aug 2020

Environment Assessment

N/A

[14] SecRAM 2.0 – Security Risk Assessment methodology for SESAR 2020, ed. 02.00.00, 25 September 2017

7.2 Reference Documents

[15]SESAR 2020 Project Handbook, (Programme Execution Guidance), Edition 02.02.00, 8th June 2020

[16] SESAR 2020 PJ05-W2_D1.1_PMP ed.00.01, 06th Jan 2020

[17] SESAR 2020 PJ05-W2_874470_Annex1-DoW-PartB ed. 1.12

[18] ED-78A GUIDELINES FOR APPROVAL OF THE PROVISION AND USE OF AIR TRAFFIC SERVICES SUPPORTED BY DATA COMMUNICATIONS[4]

[19] D3.2.0040 – SESAR 2020 PJ.16-04-03 TRL4 TVALR – Attention Guidance (AG), Ed. 02.00.00., 30th Sept 2019

[20] D3.2.0020 – SESAR 2020 PJ.16-04-02 TRL4 TVALR – Automatic Speech Recognition (ASR), v02.00.00, 30th Sept 2019

[21] D3.2.040 – SESAR 2020 PJ.16-04-01 TRL4 TVALR – Multi Touch Inputs (MTI), Ed. 02.00.00, 30th Sept 2019

[22] D3.2.010 – SESAR 2020 PJ.16-04-02 TRL4 TS/IRS – Automatic Speech Recognition (ASR), Ed. 02.00.00, 30th Sept 2019

[23] D3.2.030 – SESAR 2020 PJ.16-04-01 TRL4 TS/IRS – Multi-Touch Inputs (MTI), Ed. 02.00.00, 30th Sept 2019

[24] [D02], "P10.10.02 Available Technology Screening Document", edition, 00.01.00, 21/02/2011

[25] [D93], "P10.10.02 Innovation Analysis Report 2013", edition, 00.01.00, 29/04/2014

[26] [D96], "P10.10.02 Innovation Analysis Report 2014", edition, 00.01.01, 16/01/2015

[27] RETINA, Validation Report, Ref. Ares(2018)248264, Edition 00.00.02, 15/01/2018

[28] MALORCA Homepage: www.malorca-project.de

[4] The EUROCAE ED-78A has been used as an initial guidance material. ED-78A is useful, but is not an applicable document, because it mostly addresses the V4-V5 phases, whilst the SESAR R&D programme is focussed on development (V1-V2-V3, and because of its partial compliance with safety regulatory requirements).

[29] D32 SESAR P06.07.01 OSED for Conflicting ATC Clearances and Conformance Monitoring Alerts for Controllers V00.01.01 Dated 10/11/2016

[30] D3.1.050 - PJ.05-W2 SESAR Solution 97 TVALR, ed. 00.01.12, 19 September 2022.

References external to SESAR

[31]Bagassi, S., De Crescenzio, F., Piastra, S., The use of synthetic vision tools in the control tower environment: The retina concept, (2018) 31st Congress of the International Council of the Aeronautical Sciences, ICAS 2018, Belo Horizonte (BR).

[32]Ellejmi, M., Bagassi, S., Piastra, S., Persiani, C.A., Evaluation of augmented reality tools for the provision of tower air traffic control using an ecological interface design,(2018) 2018 Modelling and Simulation Technologies Conference, art. no. AIAA 2018-2939, 10 p., DOI: 10.2514/6.2018-2939

[33]Bagassi, S., De Crescenzio, F., Piastra, S., Persiani, C.A., Ellejmi, M., Groskreutz, A.R., Higuera, J., Human-in-the-loop evaluation of an augmented reality based interface for the airport control tower, (2020) Computers in Industry, 123, art. no. 103291, DOI: 10.1016/j.compind.2020.10329

[34] H. Helmke, J. Rataj, T. Mühlhausen, O. Ohneiser, H. Ehr, M. Kleinert, Y. Oualil, and M. Schulder, “Assistant-Based Speech Recognition for ATM Applications,” in 11th USA/ Europe Air Traffic Management Research and Development Seminar (ATM2015), Lisbon, Portugal, 2015.

[35] ISO/IEC 30122-2:2017 Information technology — User interfaces — Voice commands — Part 2: Constructing and testing. Ed. 01. February 2017.

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Appendix A Ontology Command Types

The following Excel sheet contains the ontology command types, as agreed by the Solution partners. The different command categories mentioned in REQ-05-W2-97.2-TS-ASR0.0002 in section 4.2.2.1 can be found in this file.

2021-05-18-Comma
ndTypeValues-V-1-0

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Appendix B Security tasks

The main security objective of Solutions PJ.05-W2.97.1, 97.2 and 97.3 is to define an acceptable level of residual risk for primary operational assets. Primary ATM operational assets are listed within the foreseen operational scope for all three solutions, also defining supporting assets, which are more related to IT and technical infrastructure.

Security risk assessment activities resulted in a list of recommended security controls, whose implementation and application was deemed appropriate to reduce the impact of a successful attack. With such controls in place, the level of residual risk was finally assessed. Mitigation of attacks can also take place by means of contingency measures, but the preferred course of action is through security controls, which are aimed at prevention, instead of alleviation.

In accordance with the SESAR Cyber-security Strategy and the SecRAM 2.0 methodology, Security Objectives for all SESAR Solutions have been set at Programme level, i.e., all the Primary Assets of Solutions should have a “Low” residual risk level, that is 1 on a scale of 5. The EATMA architecture was also utilized throughout security assessment, in order to make use of an enterprise view of ATM.

As per the security assessment plan, risk evaluation activities for all three Solutions 97.1 97.2 and former 97.3 were conducted, resulting in no security exceptions found.

An important assumption is to validate and fully assess the scope of each solution, not adding redundant requirements where they are simply not needed since the parent ATM system at large is taking care of them.

Controls required, where deemed necessary:

- data backup, classification, protection processes in Software development, test and deployment

- network protection/segregation policies

- secure information transfer through formal exchange policies and authentication

- extensive logging and monitoring of ATM, application and network traffic

- encryption of commands and orders, of packets on network to/from other applications

- controlled and verified change management to configuration, OS, application

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Appendix C Solution PJ.05-W2-97.3: Interacting with Tower CWP by means of touch screen (multi touch input)

This Appendix contains the content produced by PJ.05-W2-97.3 before the solution's termination, in order to keep track of the work done.

C.1 SESAR Solution Impacts on Architecture

C.1.1 Target Solution Architecture

C.1.1.1 SESAR Solution(s) Overview

This section covers the Solution 97.3, which deals with new interaction modes at the tower CWP by the use of a Multi Touch Input device.

The Multi-Touch Inputs will use a touch input device (a touchscreen) as a new interaction means with the Air Situation Display (ASD) of the CWP, e.g. replace (and/or as a first step complement, keeping both inputs) the mouse, the keyboard with a virtual keyboard, new HMI concept with touch events and gesture etc.). By using multi-touch, data inputs into the system by the controller shall be faster, more efficient and without increasing the failure rate. Furthermore, progression through development will investigate the use of a gesture language for ATM, which may lead to greater efficiency in interacting with the system with touch, for example, through swiping, pinching and multi-finger gestures.

The MTI is denominated as a Functional Block in EATMA and it has one function attached.

The Solution is an enabling solution in the S2020 framework. The following POI and Enablers conform the Solution in EATMA. The corresponding Change Requests will be endorsed in (DS21).

OI Step	OI description	Open CR
POI-0041-SDM - New interaction modes at the Tower CWP	ATCOs will be supported by introducing innovative human machine interaction such as Multi-Touch Input technology. The goal is to automatically support certain tasks of the ATCO, which are not done or done manually today in today's systems/ CWPs.	CR 04202 has been raised and endorsed in order to create POI-0041-SDM.
EN code	**EN description**	**Open CR**
AERODROME-ATC-107	Introduction of a new automated Human Machine interaction by means of Touch Inputs at the Aerodrome CWP/HMI, for improving the controller Human Performance.	CR 04207 has been raised in order to create AERODROME-ATC-107, as well as to update the EATMA elements (links to Functions)
AERODROME-ATC-50	Advanced Airport Tower CWP integrating updates on current HMI functionalities	

Table 23: SESAR Solution PJ.05-W2-97.3 POI and EN

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The following Functional Blocks are the building blocks of the Architecture and modelling in EATMA, and justify the coverage of the Enablers in the Solution through the Functions included in the diagrams summarising the Use Cases.

SESAR Solution ID and Title	Functional Blocks/Role impacted by the SESAR Solution (from EATMA)	Enabler ID (from EATMA)	Enabler Title (from EATMA)	Enabler coverage
Solution 97.3 Interacting with tower CWP by means of touch screen (multi touch input)	Multi Touch Input	AERODROME-ATC-107	Innovative HMI with input via touch screen at the Aerodrome CWP/HMI	**Fully**
	Controller Human Machine Interaction Management Aerodrome ATC	AERODROME-ATC-50	Advanced Airport Tower Controller Working Position (A-CWP)	**Use**

Table 24: SESAR Solution PJ.05-W2-97.3 scope and related Functional Blocks/roles & Enablers

C.1.1.1.1 Deviations with respect to the SESAR Solution(s) definition

No deviation.

C.1.1.1.2 Relevant Use Cases

Table 25 provides an overview on the use cases that have been identified in the context of use of the MTI concept, and that are described in detail in the sections below.

Name	Description
UC-97-TRL4-TS-301	Controller changes the route of an aircraft which may be prior to, or within, their area of responsibility *ATCOs will use the multi-touch prototype to make changes to the route of an aircraft (e.g. changing the runway exit for an arrival flight, a runway holding point for a departure) in an ergonomically and intuitive way instead of using mouse and keyboard.*
UC-97-TRL4-TS-302	Graphical route editing *ATCOs will use the multi-touch prototype to change the route of a flight using a Graphical route editing function in an ergonomic and intuitive way instead of using the mouse and keyboard.*

Name	Description
UC-97-TRL4-TS-303	Interacting with Toolbar *ATCOs will use toolbars on the multi touch input device to get access to specific tools and functions in an ergonomic and intuitive way instead of keyboard and mouse.*
UC-97-TRL4-TS-304	Managing Flight Plan Data from the MTI device *ATCOs will use the multi-touch prototype in order to create or modify Flight Plan Data instead of using mouse and keyboard.* *In this use case, the ATCO will use the virtual Keyboard and the numeric Keypad of the MTI in order to create an abbreviated Flight Plan. For that, it will insert the call-sign and the SSR Code.*
UC-97-TRL4-TS-305	Aircraft Clearances *It shall be possible for any eligible Controller to input appropriate clearances to a flight (Push-back, Taxi, Line-up, Land etc…)*
UC-97-TRL4-TS-306	Interacting with map through multiple gestures using MTI *ATCOs will use the multi-touch prototype to interact with the map through multiple gestures:* ▪ *One gesture to move the map* ▪ *One gesture to change the zoom level of the map* ▪ *One gesture to rotate the map* *This will be done in an ergonomic and intuitive way instead of using mouse and keyboard.*

Table 25: Multi Touch Input Use Cases

Technical diagrams have been created under the EATMA framework in order to summarise the Use Cases, so that the operation and how the systems interact is presented. The technical modelling is included in section C.2.1.

C.1.1.1.2.1 UC 97-TRL4-TS-301-306 Generic use case for the MTI device using gestures

Scope/Description

This use case represents a generic use of the Multi-Touch Input device.

The process starts with a multi-touch input made by an ATCO, this input is sent to the ATC system and the process ends.

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Actors

TWR Ground ATCO, TWR Runway ATCO.

Preconditions

Tower systems relevant for the ATCO are available and running with Multi Touch Input functionalities equipped.

Post conditions

Multi Touch input is recorded into the system.

Trigger

Multi-touch input made by an ATCO on the MTI device.

Nominal Flow

1. Input is recorded into the system
2. The system performs the action triggered by the controller input

Failure Flow 1- Gesture not recognized

3. The system is unable to classify the input as a gesture and no action will be performed

Failure Flow 2- Wrong gesture recognized

4. The system classifies the input as a different gesture and performs wrong action

C.1.1.1.3 Applicable standards and regulations

ISO standard on "Ergonomics of Human System Interaction": Part 11: Usability: Definitions and concepts

https://en.wikipedia.org/wiki/ISO_9241#ISO_9241-10 see ISO 9241-110

- standard is applicable for MTI technical solution
- no need identified for new standards and/or regulations or the update of any of the existing ones

C.1.1.2 Capability Configurations required for the SESAR Solution

The following table list the Capability Configurations (CCs) required by the SESAR Solution, the relevant (sub)-Operating Environments where the CCs operate, and the links between CCs and Capabilities, Nodes and Stakeholders:

SESAR Solution ID and Title	Capability Configurations (CCs) (from EATMA)	Sub-Operating Environment(s) where the CCs operate	Capabilities (from EATMA)	Nodes (from EATMA)	Stakeholders (from EATMA)

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PJ.05-W2-97.3: Interacting with tower CWP by means of touch screen (multi touch input)	TWR	Airport	Controller Machine Interface Design	Aerodrome ATS	Civil ATS Aerodrome Service Provider

Table 26: List of Capability Configuration required for the SESAR Solution PJ.05-W2-97.3

C.1.2 Changes imposed by the SESAR Solution on the baseline Architecture

This section describes which system changes are needed compared to the baseline architecture in EATMA to deliver the Capabilities improvements (using the EATMA architecture elements such as Technical Systems, Functional Blocks, Functions and Roles).

The baseline EATMA architecture is modified in order to reflect the improvements brought in operation by the Solution.

The information is provided by enablers, listing the changes applied to their definition or the EATMA elements related to them, e.g. new Functions introduced and allocated to a Functional Block in order to support the development of a system Enabler.

Enabler ID (from EATMA)	Enabler Title (from EATMA)	Changes
AERODROME-ATC-107	Innovative HMI with input via touch screen at the Aerodrome CWP/HMI	Introduction of a new automated function for Multi-Touch Inputs at the Tower CWP for improving the controller productivity.
AERODROME-ATC-50	Advanced Airport Tower Controller Working Position (A-CWP)	Advanced Airport Tower CWP integrating updates on current HMI functionalities

Table 27: List of changes due to the SESAR Solution

C.2 Technical Specifications

C.2.1 Functional architecture overview (general introduction for all solutions)

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The Multi Touch Solution impacts the ATM environment by the introduction of the Multi Touch Input Functional Block, which has been created inside the TWR Technical System, as this activity is developed within the Aerodrome environment. The Solution also impacts the Controller Human Machine Interaction Management Aerodrome ATC FB by adding new Functions so that full advantage can be taken from MTI concept.

Functional Block	Description
Multi Touch Input Aerodrome ATC	The Multi-Touch Input device functional block uses a touch input device (a trackpad or touchscreen) as a new interaction means with the Air Situation Display of the CWP (e.g. replace the keyboard with a virtual keyboard, new HMI concept with touch events and gesture...). By using this Functional block, data inputs into the system by the controller shall be faster, more efficient and without increasing the failure rate.
Controller Human Machine Interaction Management Aerodrome ATC (PJ.05-W2-97.3)	This functional block provides controllers with a graphical user interface and with the means to interact with the Aerodrome ATC system. The CHMIM Functional Block collects and integrates different Human Machine Interfaces developed for the different airport systems into just one homogenous set of configurable and customisable Tower Human Machine Interfaces. Note: This Functional Block has been duplicated in order to include Functions which are result of the interaction with the Multi Touch Input FB.

Table 28. Functional Blocks introduced by PJ.05-W2-97.3

Within the Multi Touch Input Functional Block, some Functions have been defined in order to represent the functionalities that the Functional Block performs.

C.2.1.1 Resource Connectivity view (NSV-1)

N/A since the Solution is just affecting one Technical system, hence no new interactions between Capability Configurations are introduced.

C.2.1.1.1 Resource Infrastructure view (NSV-2)

N/A as it is just affecting one Technical system, hence no new interactions between Capability Configurations are introduced.

C.2.1.1.2 Resource Orchestration view (NSV-4s)

This section describes the sequence of how the resources interact. This must be consistent with the content defined at EATMA level and available in the latest applicable version in EATMA.

NSV-4 diagrams are created in order to describe the resource orchestration summarising the Use Cases from section C.1.1. These diagrams are modelled in MEGA.

C.2.1.1.2.1 [NSV-4]UC-301-302-303-304-305] Multi Touch Input using gestures

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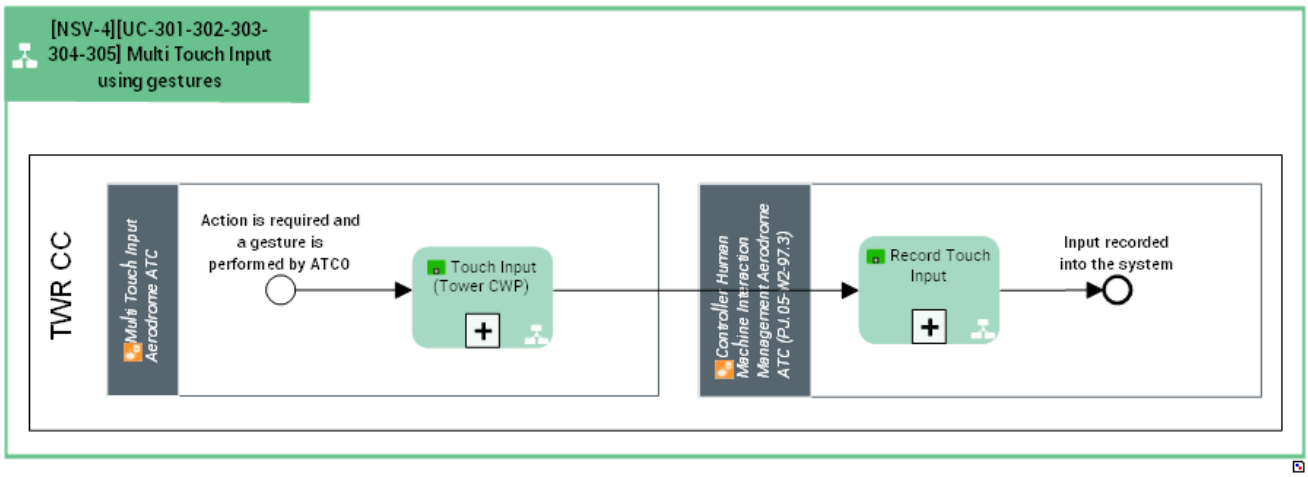

Figure 12. [NSV-4]UC-301-302-303-304-305] Multi Touch Input using gestures

The following table presents the Functions performed by the system as part of the Use Case depicted above, along with their descriptions, which are included in EATMA.

Function	Description
Touch Input (Tower CWP)	Instruction to the ATC system for the Tower environment, resulting from a gesture input by the user.
Record Touch Input	Touch Input is recorded into the system.

Table 29. [NSV-4][UC-301-302-303-304-305] Functions description

C.2.1.1.2.2 [NSV-4][UC-306] Interacting with map through MTI

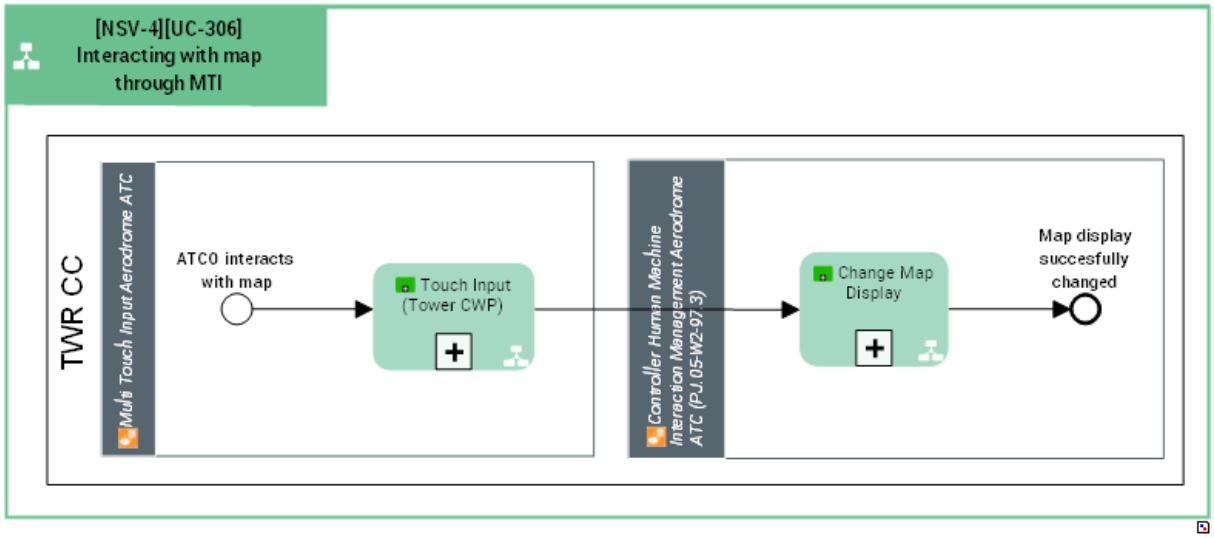

Figure 13. [NSV-4][UC-306] Interacting with map through MTI

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The following table presents the Functions performed by the system as part of the Use Case depicted above, along with their descriptions, which are included in EATMA.

Function	Description
Touch Input (Tower CWP)	Instruction to the ATC system for the Tower environment, resulting from a gesture input by the user.
Change Map Display	The map display is changed by means of touch input (e.g. move map, change level of zoom of the map, rotate map).

Table 30. [NSV-4][UC-306] Functions description

C.2.1.2 Resource Composition

A new Functional Blocks has been created in EATMA, so that the system is able to perform the new Functions introduced by the Solution. This Functional Blocks is:

e) Multi Touch Input

Multi Touch Input is included within the Aerodrome ATC Technical System. A duplication of this system has been created for PJ.05-W2-97 in order to introduce the newly created FBs.

The Solution has an impact on Controller Human Machine Interaction Management Aerodrome ATC as well, so this Functional Block has also been duplicated from the Common Libraries, so that new Functions can be allocated to it.

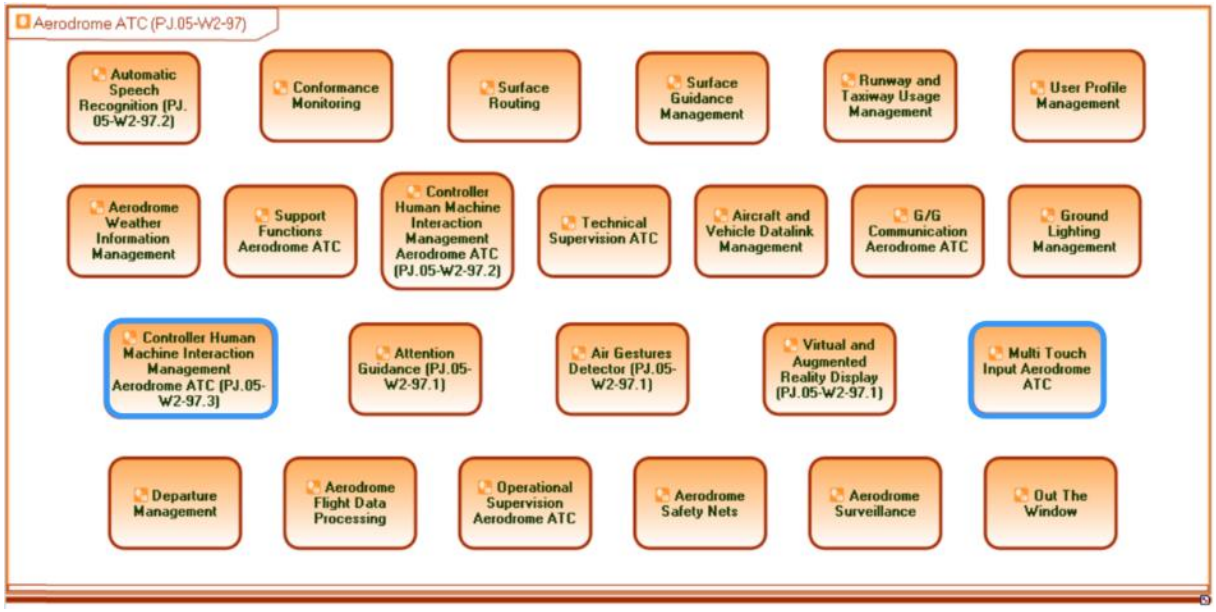

Figure 14. Aerodrome ATC (PJ.05-W2-97) Artifact Assembly Diagram

Please, be aware that the Functional Blocks created as part of other PJ.05-W2-97 Solutions framework are included as well, since all the Solutions impact the same Aerodrome ATC Technical System element, for common understanding and consolidation purposes.

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C.2.1.3 Service view

N/A as it is just affecting one Technical system.

C.2.2 Functional and non-Functional Requirements

This set of technical Requirements is subject to refinement and modification in further versions of the document.

C.2.2.1 Functional Requirements

[REQ]

Identifier	REQ-05-W2-97.3-TS-MTol.0001
Title	Map handling
Requirement	The MTI device shall offer the possibility for the ATCO to manipulate the map
Status	<in progress>
Rationale	Utilising rapid one-touch and multiple touch gestures such as pinching, swiping, rotating, etc, the multi-touch device allows faster manipulation. Then, users can manipulate the map (change the zoom, rotate, pan or tilt) in new and multiple ways which may allow them to save time as well as to drive task flow compared to the conventional input devices.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.3
<ALLOCATED_TO>	<Functional block>	Multi Touch Input Aerodrome ATC
<ALLOCATED_TO>	<Function>	Touch Input (Tower CWP)
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-306] Interacting with map through MTI

[REQ]

Identifier	REQ-05-W2-97.3-TS-MTol.0002

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Title	Input clearances
Requirement	The MTI device shall offer the possibility for the ATCO to issue clearances
Status	<in progress>
Rationale	Utilising rapid one-touch and multiple touch gestures such as pinching, swiping, rotating, etc, the multi-touch device allows faster manipulation. Then, users can input common aircraft clearances (e.g. Line-up, Take-off, etc.) in new and multiple ways which may allow them to save time as well as to drive task flow compared to the conventional input devices.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.3
<ALLOCATED_TO>	<Functional block>	Multi Touch Input Aerodrome ATC
<ALLOCATED_TO>	<Function>	Touch Input (Tower CWP)
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-301-302-303-304-305] Multi Touch Input using gestures

[REQ]

Identifier	REQ-05-W2-97.3-TS-MToI.0005
Title	Tools access
Requirement	The MTI device shall offer the possibility to access tools
Status	<in progress>
Rationale	The MTI should offer same access to the toolbar as the conventional input devices in order to have at least the same functionality.
Category	<Functional>

[REQ Trace]

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Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.3
<ALLOCATED_TO>	<Functional block>	Multi Touch Input Aerodrome ATC
<ALLOCATED_TO>	<Function>	Touch Input (Tower CWP)
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-301-302-303-304-305] Multi Touch Input using gestures

[REQ]

Identifier	REQ-05-W2-97.3-TS-MToI.0006
Title	Input Data
Requirement	The MTI device shall offer the possibility for the ATCO to insert or modify ATC system data.
Status	<in progress>
Rationale	The MTI is an input device; therefore, it needs to have the capability of inserting or modifying data.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.3
<ALLOCATED_TO>	<Functional block>	Multi Touch Input Aerodrome ATC
<ALLOCATED_TO>	<Function>	Touch Input (Tower CWP)
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-301-302-303-304-305] Multi Touch Input using gestures

[REQ]

Identifier	REQ-05-W2-97.3-TS-MToI.0007
Title	Request data from the ATC system
Requirement	The MTI device shall be able to obtain the required data from the ATC system

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Status	<in progress>
Rationale	The MTI needs to have access to the ATC system data in order to be able to display information in the MTI such as the callsign of the flights or their status.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.3
<ALLOCATED_TO>	<Functional block>	Multi Touch Input Aerodrome ATC
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-301-302-303-304-305] Multi Touch Input using gestures

[REQ]

Identifier	REQ-05-W2-97.3-TS-MToI.0008
Title	Virtual Keyboard and Virtual numeric Keypad
Requirement	The MTI device shall offer the possibility for the ATCO to use a virtual Keyboard and a numeric Keypad in the MTI screen.
Status	<in progress>
Rationale	The MTI is an input device, therefore it needs to have the capability of writing letters by the use of a virtual keyboard or numbers with a numeric keypad which is display in the MTI screen and the data is access by touching with the finger.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.3
<ALLOCATED_TO>	<Functional block>	Multi Touch Input Aerodrome ATC
<ALLOCATED_TO>	<Function>	Touch Input (Tower CWP)

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<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-301-302-303-304-305] Multi Touch Input using gestures

[REQ]

Identifier	REQ-05-W2-97.3-TS-MToI.0009
Title	Finger gestures
Requirement	The MTI device shall be able to support gestures using one or multiple fingers.
Status	<in progress>
Rationale	The MTI needs to be able to support multiple finger touch in order to input, access or display data by the ATCO in a faster and more efficient way. Therefore, the controllers' workload shall be reduced and therefore human performance capacity may be enhanced.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.3
<ALLOCATED_TO>	<Functional block>	Multi Touch Input Aerodrome ATC
<ALLOCATED_TO>	<Function>	Touch Input (Tower CWP)
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-301-302-303-304-305] Multi Touch Input using gestures

[REQ]

Identifier	REQ-05-W2-97.3-TS-MToI.0010
Title	Day to Day Finger gestures
Requirement	The MTI device shall implement Day to Day finger gestures for features which are the same than day to day life.
Status	<in progress>

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Rationale	To reduce the learning process, but also to be in line with habits, Day to day finger gestures have to be implemented (pinch for zoom in/ zoom out on a map for example).
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.3
<ALLOCATED_TO>	<Functional block>	Multi Touch Input Aerodrome ATC
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-301-302-303-304-305] Multi Touch Input using gestures

C.2.2.2 Non-Functional Requirements

[REQ]

Identifier	REQ-05-W2-97.3-TS-MToI.0012
Title	Preserve the same operations in case of MTI failure
Requirement	The ATC system shall be able to perform the same operations without the MTI.
Status	<in progress>
Rationale	No data input nor functionality that currently exists without MTI is taken away by the introduction of MTI such that controllers maintain their current types of data input or improve on it.
Category	<Safety>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.3
<ALLOCATED_TO>	<Functional block>	Multi Touch Input Aerodrome ATC
<ALLOCATED_TO>	<Function>	Touch Input (Tower CWP)
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-301-302-303-304-305] Multi Touch Input using gestures

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[REQ]

Identifier	REQ-05-W2-97.3-TS-MToI.0013
Title	Reliability of the MTI device
Requirement	The reliability of the MTI device shall be in accordance with the ATCO usage.
Status	<in progress>
Rationale	The reliability of the MTI device has not to be equal or better to the conventional input device as far as it is in accordance to the ATCO usage. On the other hand, the MTI device has not to be replaced very often.
Category	<Reliability>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.3
<ALLOCATED_TO>	<Functional block>	Multi Touch Input Aerodrome ATC
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-301-302-303-304-305] Multi Touch Input using gestures

[REQ]

Identifier	REQ-05-W2-97.3-TS-MToI.0014
Title	Accuracy
Requirement	The MTI device shall enable the necessary data to be entered accurately and as quickly as when using conventional input device.
Status	<in progress>
Rationale	MTI aims to bring together data inputting methods into a consolidated and centralised device, which consists in a touch screen. However, inputting methods must remain accurate and as quick as when using conventional input device to support the current operation without causing unnecessary burden to controller ergonomics.

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Category	<HMI>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.3
<ALLOCATED_TO>	<Functional block>	Multi Touch Input Aerodrome ATC
<ALLOCATED_TO>	<Function>	Touch Input (Tower CWP)
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-301-302-303-304-305] Multi Touch Input using gestures

[REQ]

Identifier	REQ-05-W2-97.3-TS-MToI.0015
Title	Adaptability
Requirement	The ATC system shall enable to add MTI device in addition of the conventional input device.
Status	<in progress>
Rationale	For the introduction of new features, both conventional input device and MTI device have to be adaptable.
Category	<Adaptability>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.3
<ALLOCATED_TO>	<Functional block>	Multi Touch Input Aerodrome ATC
<ALLOCATED_TO>	<Function>	Touch Input (Tower CWP)
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-301-302-303-304-305] Multi Touch Input using gestures

[REQ]

Identifier	REQ-05-W2-97.3-TS-MToI.0020

Title	MTI device hardware
Requirement	The MTI device should be designed with a COTS MTI device hardware.
Status	<in progress>
Rationale	It is not necessary to have dedicated MTI device hardware. The available technology off the shelf is sufficient for ATM domain.
Category	<Design>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.3
<ALLOCATED_TO>	<Functional block>	Multi Touch Input Aerodrome ATC
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-301-302-303-304-305] Multi Touch Input using gestures

[REQ]

Identifier	REQ-05-W2-97.3-TS-MTOI.0021
Title	Input surface routes
Requirement	The MTI device shall offer the possibility for the ATCO to input surface routes by drawing the routes on the map.
Status	<in progress>
Rationale	With an MTI device, input of surface routes can be done in a more intuitive way, making it easier for the ATCO to enter such information into the system.
Category	<Functional>

[REQ Trace]

Relationship	Linked Element Type	Identifier
<ALLOCATED_TO>	<SESAR Solution>	PJ.05-W2-97.3
<ALLOCATED_TO>	<Functional block>	Multi Touch Input Aerodrome ATC

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<ALLOCATED_TO>	<Function>	Touch Input (Tower CWP)
<ALLOCATED_TO>	<FunctionView>	[NSV-4][UC-301-302-303-304-305] Multi Touch Input using gestures

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Appendix D Service Description Document (SDD)

N/A, since no Services has been identified at Solution level.

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