RETINA Validation Plan (VALP)

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RETINA

Resilient Synthetic Vision for Advanced Control Tower Air Navigation Service Provision

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Executive Summary

This validation plan (VALP) describes the validation activities planned for the RETINA project.

The document provides an overview of validation activities planned within RETINA project and supplies detailed information on the plans proposed for fourteen validation exercises run at the UNIBO and CRIDA facilities.

The aim of the planned validation is to demonstrate the positive impact of the V/AR tools proposed by RETINA in the air service navigation provision in terms of human performance, efficiency and resilience, safety, with the final target of achieving V1.

For each RETINA solution identified in the Operational Concepts Description[1], namely Head Mounted Display and Spatial Display, a proof-of-concept is implemented and validated in a laboratory environment by means of human in the loop real-time simulations where the external view will be provided to the user through a high fidelity 4D model in an immersive environment that replicates the out-of-the tower view.

During the validation both subjective qualitative information and objective quantitative data will be collected and analysed to assess the RETINA concept.

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1 Introduction

1.1 Purpose of the document

This document provides the Validation plan for RETINA Project: validation approach and context, the validation objectives, scenarios and validation exercises are described in the following sections.

1.2 Intended readership

The intended audience for this document primarily consists in the RETINA consortium, in addition, the stakeholders reported in the section 2.1 are considered as intended readerships for this document.

1.3 Background

Airports are often considered as the bottleneck to increasing the capacity of the overall ATM system. While augmenting throughput in high performing airport operations, attention has rightly been placed on doing it in a safe manner. Many of the advances in airport operational safety come in the form of visualization tools for tower controllers. A-SMGCS based solutions, such as movement maps, conformance monitoring, and conflict detection are a few examples of these tools.
But there is a paradox in developing these tools to increase tower controller's situational awareness. By creating additional computer displays that show the runway and taxiway layout, aircraft and mobile position, and detect actual and foreseen conflicts, the controller's vision is pulled away out of the window view and the head-down time is increased. This reduces their situational awareness by forcing them mentally to switch repeatedly between these two ways of interpreting their working environment.
New developments in the realm of Augmented Reality (AR) may be able to address this paradox. AR differs from Virtual Reality (VR) insofar as it allows users to view the 'real' world along with superimposed or computer-generated information. This concept has become increasingly popular over the past decade and is being proficiently applied to many fields, such as entertainment, aviation, military & defence. The RETINA project takes the idea of augmented vision and investigates its application to on-the-site control towers through the use of synthetic vision.

Current use of similar technology was developed in SESAR Operational Focus Area 06.03.01 (Remote Tower) and SESAR Project 06.09.03 (Remote & virtual TWR). Visual aids have been used to highlight relevant information on the 'out of the window' view, such as the placement of the flight tags on top of the remote image. However, in the remote tower application, the information and overlays are placed on an array of monitors designed to replicate the out the window view that controllers would have if they were in a real tower.

The concept that RETINA investigates is not the reconstruction of an out of the window view, with extra information placed on top of it, but the placement of this additional information such as flight tags, runway layout, and warning detection over the actual window view, that the controller currently has.

In this framework, RETINA will pursue improved safety, resilience and maintenance of capacity in poor visibility conditions. As a pre-requisite for the V/ARTT implementation, a 4D airport model (3D +time) will be developed presenting 3D digital aircraft, vehicles and infrastructures data with a good degree of realism.

The RETINA project will draw information from both conventional and emerging sensing technologies, exploiting the SESAR SDM-0201 solutions.

1.4 Structure of the document

The document is structured as follows:

- **Chapter 1 “Introduction”**
  describes the purpose of the document, the intended readership, the background and gives an explanation of the abbreviations and acronyms used throughout the document.
- **Chapter 2 “Context of the Validation”**
  deals with the context of the validation and provides a summary of the solutions implemented for validation. A list of stakeholders with need and involvement is provided.
- **Chapter 3 “Validation Approach”**
  focuses on the validation approach, the stakeholders expectations as well as validation objectives in the main performance areas identified for the project.
- **Chapter 4 “Validation Activities”**
  details the assumptions and provide a description of the reference scenario and of the validation exercises. Each exercise is described as well as the planning and the validation platform.
- **Chapter 5 “References”**
  lists all the applicable and reference documents

1.5 Acronyms and Terminology

Term	Definition
ATFCM	Air Traffic Flow and Capacity Management
AR	Augmented Reality
A-SMGCS	Advanced-Surface guidance and control system
ATC	Air traffic Control
ATCO	Air traffic Control Officer
ATM	Air Traffic Management
CTOT	Calculated Take Off Time
EOBT	Estimated Off Block Time
FOV	Field Of View
GND	Ground
HMD	Head mounted Display
ILS	Instrumental Landing System

IMC	Instrumental Meteorological Conditions
KPA	Key Performance Area
LVP	Low Visibilities Procedures
MAPS	Minimum Aerodrome Performance Standard
MOPS	Minimum Operational Performance Standard
PSR	Primary Surveillance Radar
RTS	Real Time Simulation
RVR	Runway Visual Range
RWY	Runway
SA	Situational Awareness
SD	Spatial Display
SESAR	Single European Sky ATM Research Programme
SMR	Surveillance Movement Radar
SSR	Secondary Surveillance Radar
TWY	taxiway
TWR	Tower
VALP	Validation Plan
V/A	Virtual/Augmented
V/ART	Virtual/Augmented Reality Tools
V/ARTT	Virtual/Augmented Reality Tower Tools
WCAT	Wake Category
VMC	Visual Meteorological Condition
VR	Virtual reality

Table 1: Acronyms and terminology

2 Context of the Validation

The Validation Plan reports all the information gathered to plan the validation activities within RETINA project.

Retina solutions aim to increase the situational awareness and to reduce the ATCOs workload (especially during low visibility procedures) using V/A Reality Tools as Head mounted display (HMD) and Spatial Display (SD). The Operational Concept Description [1] identifies the basic requirements that the reference airport should satisfy for applications of V/ARTT. These requirements are related to the equipment, airport layout, traffic and ATC procedures:

- Primary Surveillance RADAR and Secondary Surveillance RADAR (PSR/SSR);
- Surface Movement RADAR (SMR);
- Low Visibility Procedures able to manage more than one aircraft at the same time;
- ILS CAT 3B;
- Moderate complexity (one runway, several taxiway, more than one apron);
- Moderate traffic: volume of 200/300 movement per day;
- Apron Management Procedures available;
- Meteorological sensing systems (winds, temperature, pressure, visibility, RVR – Runway Visual Range, cloud base).

In order to comply with these requirements, validation activities will use Bologna International Airport as reference scenario for the Real Time Simulation.

RETINA validation activities will cover the following conditions:

A. VMC scenario: visibility equal or greater than 5km and ceiling equal or greater than 1500ft (VFR flight available).

B. IMC visibility CONDITION 1: there are no condition for the visual flights (only Special VFR) but visibility condition 1 still hold. Visibility condition 1 (CONDI VIS 1) is considered whereas the visibility is sufficient for the pilot to taxi and to avoid collision with other traffic on taxiways and at intersections by visual reference, and for personnel of control units to exercise control over all traffic on the basis of visual surveillance.

C. IMC visibility CONDITION 2: Visibility condition 2 (CONDI VIS 2) is considered whereas the visibility is sufficient for the pilot to taxi and to avoid collision with other traffic on taxiways and at intersections by visual reference, but insufficient for personnel of control units to exercise control over all traffic on the basis of visual surveillance.

D. IMC visibility CONDITION 3: Visibility condition 3 (CONDI VIS 3) is considered whereas the visibility is sufficient for the pilot to taxi but insufficient for the pilot to avoid collision with other traffic on taxiways and at intersections by visual reference, and insufficient for personnel of control units to exercise control over all traffic on the basis of visual surveillance. For taxiing, this is normally taken as visibility equivalent to an RVR of less than 400 m but more than 75 m.

For the purpose of the validation, conditions A and B are grouped as “CONDI VIS 1”, condition C corresponds to “CONDI VIS 2”, and condition D relates to “CONDI VIS 3”.

2.1 Stakeholder identification, needs and involvement

In the following table the list of affected stakeholders:

Sector	Organisation	Stakeholder need	Key messages for the stakeholder	Importance for the project	Success factor
Sponsor	EC, SJU	Compliance to the proposal	Project on time, scope and budget	High	Buy in, transfer of results from SESAR ER to SESAR IR solutions (innovation pipeline)
Universities, Research centre	EUROCONTROL, UNIBO, CRIDA	Academic achievement	Research expertise	High	References in their publications Common studies
Airspace Users	IATA, Airlines	Transparent, No cost, effective	Cost efficient system, no cost for AU	Medium	n.a.
ATM providers	CANSO, National ANSPs	Efficient use of resources	Best use of resources, cost efficient system, situational awareness, workload, efficiency/resiliency, safety	High	Buy in
Association	IFATCA	Employment stability, safety first	Human centred system Safety first	High	Buy in
ATFCM services	NM	Cooperative and dynamic airspace management	Data sharing	Low	n.a.
Standardisation bodies	EUROCAE	Know the impact of RETINA on existing MAPS/MOPS		Medium	Create Tower categories (VT, AR ect)
Airport	ACI	Profitability	Punctuality Cost	High	n.a.

Public		Efficient system	Punctuality Cost	Medium	n.a
Industry		Functional architecture	Potential Market	High	n.a.

Table 2: Stakeholders involvement and expectations

2.2 RETINA Solutions

The analysis developed in the Operational Concept Description [1] selected the more efficient Augmented Reality Technologies integrating the "out of the window" real images with synthetic overlays.

The output of the integrated model has generated the following technology ranking: Spatial Displays, Head Mounted Displays, Object-Projected Displays, Volumetric Displays and Hand Held Displays.

The selection process has been based on current average performance of the five generic class of technology usable in control tower environment, as well as on predictions on possible improvements of such devices in the near future. As an output two solutions have been identified for the RETINA project.

2.2.1 RETINA solution 1: See-through Head Mounted Display

In this solution, both Ground/Delivery and Tower controllers are provided with a HMD to be used as a personal device. The device shows ad-hoc generated images based on the controllers' role, position and gaze orientation.

The HMD shows the synthetic overlay as registered to the out-of-the tower view by means of a wearable non-invasive, non-intrusive device that provides ATCOs with the most relevant environmental information based on the current visibility condition. The information displayed on the HMD is summarized as follows:

- **ATCO information in CONDI VIS 1**
  - ✓ **Information related to Aircraft**: Identification, Altitude, Speed, Type/WCAT, CTOT, Taxi Route assigned, Distance from Touch Down (only arrival), Ready message (only departure at stand), "Animated Bounding Box" to highlight far aircraft position;
  - ✓ **Information related to Ground Vehicles**: Identification, speed, taxi route assigned;
  - ✓ **Information related to Airport static features**: RWY status (Occupied, closed), Restricted areas (Taxiway closed);
  - ✓ **Environmental Information**: Wind, Visibility, Ceiling, QNH, RWY surface condition, NAVAIDS status;
  - ✓ **Safety Net**: Warning for some RWY incursion (RWY closed, vehicle and aircraft on RWY).

- **ATCO information in CONDI VIS 2**
  - ✓ **Information related to Aircraft:** (position and attitude) for close aircraft, "Animated Bounding Box" to highlight far aircraft position, Identification, Altitude, Speed, Type/WCAT, CTOT, Taxi Route assigned, Distance from Touch Down (only arrival), Ready message (only departure at stand);
  - ✓ **Information related to Ground Vehicles:** Identification, speed taxi route assigned;

- ✓ **Information related to Airport static features:** Aerodrome layout (apron and manoeuvring area), RWY status (Occupied, closed), Restricted areas (Taxiway closed: F), stopbar;
- ✓ **Environmental Information:** Wind, Visibility (RVR), Ceiling, QNH, RWY surface condition, NAVAIDS status;
  Safety Net: Warning for some RWY incursion (RWY closed, vehicle and aircraft on RWY).

- **ATCO information in CONDI VIS 3**

  - ✓ **Information related to Aircraft:** (position and attitude), “Animated Bounding Box” to highlight far aircraft position, Identification, Altitude, Speed, Type/WCAT, CTOT, Taxi Route assigned, Distance from Touch Down (only arrival), Ready message (only departure at stand);
  - ✓ **Information related to Ground Vehicles:** Identification, speed, taxi route assigned;
  - ✓ **Information related to Airport static features:** Aerodrome layout (apron and manoeuvring area), RWY status (Occupied, closed), Restricted areas (Taxiway closed: B,C,D,E,F,G,H), stopbar (including intermediate);
  - ✓ **Environmental Information:** Wind, Visibility (RVR), Ceiling, QNH, RWY surface conditions, NAVAIDS status;
  - ✓ **Safety Net:** Warning for some RWY incursion (RWY closed, vehicle and aircraft on RWY).

When looking at far aircraft (>1,5 NM from the control tower) the HMD shows a bounding box that draws controllers’ attention toward the aircraft. Hereafter, this concept will be referred to as the “animated bounding box” concept. The animated bounding box is made visible only to the tower controller and helps him/her retrieving the aircraft position and heading.

Alphanumeric text labels are displayed near aircraft that are inside the HMD FOV. Hereafter, this concept will be referred to as the “billboard” concept. The billboards provide controllers with aircraft identification, altitude, speed, type/WCAT, CTOT/EOBT, distance from touch down (only arrival) and ready message (only departure at stand). The displayed information depends on the aircraft flight phase (departure or arrival).

At any time, the controller will be able to adjust the HMD position according to his or her preference.

2.2.2 RETINA solution 2: Spatial Display

In this solution, both Ground/Delivery and Tower controllers are provided with a simulated see-through spatial display placed between their working position and the outside view. It is important to notice that, being this technology less mature than HMD, it is not possible to integrate any physical device into the proof of concept. The SD shows ad-hoc generated imagery based on controllers’ role, eyes position and outside visibility condition.

The Ground/Delivery controller is provided with a see-through spatial display that overlaps most of the airport’s apron and taxiways. Depending on the visibility condition, overlaid static features include taxiways borderlines, parking stands, stop-bars and restricted areas. Colour-coding is used to distinguish between accessible areas and inaccessible areas (e.g. closed taxiways), alphanumeric text labels provide controllers with aircraft identification, type/WCAT, CTOT/ EOBT and ready message (only departure at stand). Assigned taxi routes are shown on the airport layout with a green colour. In CONDI VIS 2 and CONDI VIS 3 the aircraft position is shown on the ground. Keeping track of the historical position and showing it to controllers provides directional information.

2.3 Maturity levels

The aim of the planned validation is to demonstrate the positive impact of the V/AR tools proposed by RETINA in the air service navigation provision in terms of human performance, efficiency and resilience, safety, with the final target of achieving V1.

Based on the analysis reported in State of Art and Initial Concept Requirements [2] the initial maturity level for the RETINA concept is assessed as TRL 1 as the basic principles of using synthetic vision and augmented reality tools in a control tower were observed in literature but no concept was formulated yet.

The analysis of target maturity level is performed on both RETINA concept solutions (Spatial Display based and Head Mounted Display based). The technology employed to provide the augmented reality layers is driving the target maturity levels of each concept solution. Specifically, since the SD technology is not mature yet the target maturity level for the SD based concept solution is lower than the one addressed by HMD based solution. Table 3 reports initial and target maturity levels for RETINA concept solutions.

Concept solution	Initial Maturity level	Target Maturity level	Validation target	
			V0	V1
RETINA solution1: HMD	TRL1	TRL3		X
RETINA solution2: SD	TRL1	TRL2	X	

Table 3: Maturity levels table

3 Validation Approach

3.1 Validation Objectives and metrics

The objective of the validation is to assess the impact of introduction of RETINA solutions on the ATCO working methods considering three Key Performance Areas:

- ✓ human performance;
- ✓ efficiency;
- ✓ safety.

SESAR methodology for transversal area assessment is considered as reference for the validation approach [3] [4] . The RETINA Consortium assumes that the maturity level of the project (i.e. exploratory research targeting TRL 3) justifies a partial application of SESAR methodology for transversal area assessment.

Specifically, at this stage the validation aims to define the impact of RETINA concept on the high level arguments for Human Performance listed in table 4 . The analysis of these arguments for the RETINA concept will be reported in the Validation Report.

Arg. 1: The role of the human is consistent with human capabilities and limitations
Arg. 1.1 Roles and responsibilities of human actors are clear and exhaustive.
Arg. 1.2: Operating methods (procedures) are exhaustive and support human performance.
Arg. 1.3: Human actors can achieve their tasks (in normal & abnormal conditions of the operational environment and degraded modes of operation).
Arg. 2: Technical systems support the human actors in performing their tasks.
Arg. 2.1: There is an appropriate allocation of tasks between the human and machine (i.e. level of automation).
Arg. 2.2: The performance of the technical system supports the human in carrying out their task.
Arg. 2.3: The design of the human-machine interface supports the human in carrying out their tasks.
Arg. 3: Team structures and team communication support the human actors in performing their tasks.
Arg. 3.1: Effects on team composition are identified.
Arg. 3.2: The allocation of tasks between human actors supports human performance.
Arg. 4: Human Performance related transition factors are considered
Arg. 4.1: The proposed solution is acceptable to affected human actors.
Arg. 4.2: Changes in competence requirements are analysed.
Arg. 4.3: Changes in staffing requirements and staffing levels are identified.

Table 4: High level arguments for human performance assessment

Human performance includes situational awareness and the human factors; the metrics used to assess the impact of the RETINA solutions on the human performance are SA levels (subjective assessment), head down time, number of switch head down/head up, information accessibility (time needed to access a specific info while performing a task). Tables below reports the metrics used in accordance to the objective and the related success criterion.

Efficiency includes also the airport resiliency, i.e. the ability of an airport system to react to external factors that reduces its nominal characteristics (in this case the airport capacity reduction due to LVP is considered).

Safety is related to the ATCO capability to detect some typical hazardous situations as the runway incursions. Simulation data is used to measure the impact of RETINA solutions on safety.

Tables below reports, for each KPA, the objective and their main characteristics including metrics, scenario, category, traffic condition and the involved exercises, i.e. the exercises used to test such objectives (see section 4).

In order to facilitate the comprehension of tables below an overview of the validation exercises is provided in Table 5. The exercises will address three visibility conditions, namely CONDI VIS 1, CONDI VIS 2 and CONDI VIS 3, for the two solutions identified (HMD and SD). It is important to notice that, for each exercise performed on a RETINA solution, a similar exercise is conducted adopting the baseline equipment, i.e. the current equipment, in order to compare data obtained vs success criteria and validation targets identified below. Section 4 provides details for each exercise.

VISIBILITY CONDITION	GND/TWR POSITION	Baseline equipment	RETINA equipment: HMD solution	RETINA equipment: SD solution
CONDIVIS1	GND	**EXE-RETINA-VALP-RTS1** MED-HI TRAFFIC	**EXE-RETINA-VALP-RTS3** MED-HI TRAFFIC	
	TWR	**EXE-RETINA-VALP-RTS2** MED-HI TRAFFIC		**EXE-RETINA-VALP-RTS4** MED-HI TRAFFIC
CONDIVIS2	GND	**EXE-RETINA-VALP-RTS5** MED TRAFFIC	**EXE-RETINA-VALP-RTS7** MED TRAFFIC	
			EXE-RETINA-VALP-RTS10 MED-HI TRAFFIC	
	TWR	**EXE-RETINA-VALP-RTS6** MED TRAFFIC	**EXE-RETINA-VALP-RTS8** MED TRAFFIC	**EXE-RETINA-VALP-RTS9** MED TRAFFIC
CONDIVIS3	GND	**EXE-RETINA-VALP-RTS11** MED TRAFFIC STANDARD RESTRICTIONS	**EXE-RETINA-VALP-RTS 12** MED TRAFFIC STANDARD RESTRICTIONS	
			EXE-RETINA-VALP-RTS13 MED TRAFFIC LIMITED RESTRICTIONS	
	TWR			

Table 5: Validation exercises overview. It does not include EXE-RETINA-VALP-RTS14 that will address the Interface Usability and will be run separately.

3.1.1 Human Performance

Identifier	OBJ-RETINA-VALP-HP-01
Objective	To assess the impact of the HMD solution on Human Performance in normal visibility conditions.
Metrics	SA and workload levels (subjective assessment), head down time, number of switch head down/head up, information accessibility (time needed to access a specific info while performing a task)
Category	Human Performance
Scenario	CONDI VIS 1
Traffic conditions	Medium-high
Involved exercises	EXE-RETINA-VALP-RTS3 vs EXE-RETINA-VALP-RTS1

Identifier	Success Criterion
CRT-HP-01-001	Solution HMD reduces the head down time (eye tracking) in normal visibility conditions.
CRT-HP-01-002	Solution HMD increases the accessibility of the information (subjective assessment) in normal visibility conditions.
CRT-HP-01-003	Solution HMD reduces the number of switch head down/head up (eye tracking) in normal visibility conditions.
CRT-HP-01-004	Solution HMD increases the capability of achieving the following tasks in normal visibility conditions: aircraft and vehicle identification on the manoeuvring area (GND), monitor of wind and QNH changes, monitor of incursion into closed/restricted taxiway.
CRT-HP-01-005	Solution HMD reduces the workload (NASA TLX) in normal visibility conditions.

Identifier	OBJ-RETINA-VALP-HP-02
Objective	To assess the impact of the HMD solution on Human Performance in CONDI VIS 2
Metrics	SA and workload levels (subjective assessment), head down time, number of switch head down/head up, information accessibility (time needed to access a specific info while performing a task)
Category	Situational Awareness
Scenario	CONDI VIS 2
Traffic conditions	Medium
Involved exercises	EXE-RETINA-VALP-RTS8 vs EXE-RETINA-VALP-RTS6, EXE-RETINA-VALP-RTS7 VS EXE-RETINA-VALP-RTS5

Identifier	Success Criterion
CRT-HP-02-001	Solution HMD reduces the head down time in CONDI VIS 2 (eye tracking).
CRT-HP-02 -002	Solution HMD increases the accessibility of the information in CONDI VIS 2 (subjective assessment)
CRT-HP-02 -003	Solution HMD reduces the number of switch head down/head up in CONDI VIS 2 (eye tracking)
CRT-HP-02 -004	Solution HMD increases the capability of achieving the following tasks in CONDI VIS 2: runway incursion detection (TWR), aircraft and vehicle identification on the manoeuvring area (GND), monitor of wind/QNH/visibility changes, monitor of incursion into closed/restricted taxiways.
CRT-HP-02 -005	Solution HMD reduces the workload (NASA TLX) in CONDI VIS 2

Identifier	OBJ-RETINA-VALP-HP-03
Objective	To assess the impact of the HMD solution on Human Performance in CONDI VIS 3.
Metrics	SA and workload levels (subjective assessment), head down time, number of switch head down/head up, information accessibility (time needed to access a specific info while performing a task).
Category	Situational Awareness
Scenario	CONDI VIS 3
Traffic conditions	Medium
Involved exercises	EXE-RETINA-VALP-RTS12 VS EXE-RETINA-VALP-RTS11, EXE-RETINA-VALP-RTS13 VS EXE-RETINA-VALP-RTS11

Identifier	Success Criterion
CRT-HP-03 -001	Solution HMD reduces the head down time in CONDI VIS 3 (eye tracking).
CRT-HP-03	Solution HMD increases the accessibility of the information in CONDI VIS 3 (subjective assessment).
CRT-HP-03	Solution HMD reduces the number of switch head down/head up in CONDI VIS 3 (eye tracking).
CRT-HP-03	Solution HMD increases the capability of achieving the following tasks in CONDI VIS 3: rwy incursion detection (TWR), aircraft and vehicle identification on the manoeuvring area (GND), monitor of wind/QNH/visibility changes, monitor of incursion into closed/restricted taxiways.
CRT-HP-03	Solution HMD reduces the workload (NASA TLX) in CONDI VIS 3

Identifier	OBJ-RETINA-VALP-HP-04
Objective	To assess the impact of the SD solution on Human Performance in normal visibility condition
Metrics	SA and workload levels (subjective assessment), head down time, number of switch head down/head up, information accessibility (time needed to access a specific info while performing a task).
Category	Situational Awareness
Scenario	CONDI VIS 1
Traffic conditions	Medium high
Involved exercise	EXE-RETINA-VALP-RTS4 VS EXE-RETINA-VALP-RTS2

Identifier	Success Criterion
CRT-HP-04 -001	Solution SD reduces the head down time in normal visibility condition (eye tracking).
CRT-HP-04 -002	Solution SD increases the accessibility of the information in normal visibility condition (subjective assessment).
CRT-HP-04 -003	Solution SD reduces the number of switch head down/head up in normal visibility condition (eye tracking).
CRT-HP-04 -004	Solution SD increases the capability of achieving the following tasks in normal visibility conditions: rwy incursion detection (TWR), aircraft and vehicle identification on the manoeuvring area (GND), monitor of wind/QNH/visibility changes, monitor of incursion into closed/restricted taxiways.
CRT-HP-04 -005	Solution SD reduces the workload in normal visibility condition (NASA TLX).

Identifier	OBJ-RETINA-VALP-HP-05
Objective	To assess the impact of the SD solution on Human Performance in CONDI VIS 2
Metrics	SA and workload levels (subjective assessment), head down time, number of switch head down/head up, information accessibility (time needed to access a specific info while performing a task).
Category	Situational Awareness
Scenario	CONDI VIS 2
Traffic conditions	Medium
Involved exercise	EXE-RETINA-VALP-RTS9 VS EXE-RETINA-VALP-RTS6

Identifier	Success Criterion
CRT-HP-05 -001	Solution SD reduces the head down time in CONDI VIS 2 (eye tracking).
CRT-HP-05 -002	Solution SD increases the accessibility of the information in CONDI VIS 2 (subjective assessment).
CRT-HP-05 -003	Solution SD reduces the number of switch head down/head up in CONDI VIS 2 (eye tracking).
CRT-HP-05 -004	Solution SD increases the capability of achieving the following tasks in CONDI VIS 2: aircraft and vehicle identification on the manoeuvring area, rwy incursion detection (TWR) and monitor of wind/QNH/visibility changes.
CRT-HP-05 -005	Solution SD reduces the workload in CONDI VIS 2 (NASA TLX).

Identifier	OBJ-RETINA-HF-01
Objective	Assess the readability and meaningfulness of textual information displayed by the information overlays with RETINA HMD solution.
Metrics	Controller subjective assessment; questionnaires
Category	Human Factors
Scenario	RETINA HMD Overlays.
Traffic conditions	Medium High
Involved exercise	EXE-RETINA-VALP-RTS14

Identifier	Success Criterion
CRT-HF-01-01	Controllers appreciate meaning, fonts type, dimension, colour of the information displayed by the overlays.

Identifier	OBJ-RETINA-HF-02
Objective	Assess the readability and meaningfulness of graphical objects, symbols and representations in the information overlays with RETINA HMD solution
Metrics	Controller subjective assessment; questionnaires
Category	Human Factors
Scenario	RETINA HMD Overlays.
Traffic conditions	Medium High
Involved exercise	EXE-RETINA-VALP-RTS14

Identifier	Success Criterion
CRT-HF-02-01	Controllers appreciate symbols, objects and type of information displayed on the information overlays

Identifier	OBJ-RETINA-HF-03
Objective	Assess the consistency and completeness of the information displayed by the overlays with RETINA HMD solution
Metrics	Controller subjective assessment; questionnaires
Category	Human Factors
Scenario	RETINA HMD Overlays.
Traffic conditions	Medium High
Involved exercise	EXE-RETINA-VALP-RTS14

Identifier	Success Criterion
CRT-HF-03-01	Controllers confirm that the displayed information is coherent and complete to manage the traffic in a safe manner

Identifier	OBJ-RETINA-HF-04
Objective	Assess the timeliness and prioritization of the information displayed by the overlays with RETINA HMD solution
Metrics	Controller subjective assessment; questionnaires
Category	Human Factors
Scenario	RETINA HMD Overlays.
Traffic conditions	Medium High
Involved exercise	EXE-RETINA-VALP-RTS14

Identifier	Success Criterion
CRT-HF-04-01	The displayed information is timely and correctly prioritised

Identifier	OBJ-RETINA-HF-05
Objective	Assess the adequacy of information from the overlays with RETINA HMD solution
Metrics	Controller subjective assessment; questionnaires
Category	Human Factors
Scenario	RETINA HMD Overlays.
Traffic conditions	Medium High
Involved exercise	EXE-RETINA-VALP-RTS14

Identifier	Success Criterion
CRT-HF-05-01	Controllers consider the displayed information to be adequate to perform their tasks

Identifier	OBJ-RETINA-HF-06
Objective	Assess the practicability and intuitiveness of commands on HMI objects, with RETINA HMD solution
Metrics	Controller subjective assessment; questionnaires
Category	Human Factors
Scenario	RETINA HMD Overlays.
Traffic conditions	Medium High
Involved exercise	EXE-RETINA-VALP-RTS14

Identifier	Success Criterion
CRT-HF-06-01	Controllers consider information finding and sorting quick, easy, practical and intuitive

Identifier	OBJ-RETINA-HF-07
Objective	Assess the adequacy of feedbacks of commands / actions on HMI objects, with RETINA HMD solution
Metrics	Controller subjective assessment; questionnaires
Category	Human Factors
Scenario	RETINA HMD Overlays.
Traffic conditions	Medium High
Involved exercise	EXE-RETINA-VALP-RTS14

Identifier	Success Criterion
CRT-HF-07-01	HMI objects provide adequate feedbacks for each controller input

Identifier	OBJ-RETINA-HF-08
Objective	Assess the impact that the information overlays have on supporting the controller in the decision making process with RETINA HMD solution
Metrics	Controller subjective assessment; questionnaires
Category	Human Factors
Scenario	RETINA HMD Overlays.
Traffic conditions	Medium High
Involved exercise	EXE-RETINA-VALP-RTS14

Identifier	Success Criterion
CRT-HF-08-01	Controllers confirm that the outputs and triggers provided by the different tools and displayed on the HMI support them during the decision making process.

3.1.2 Efficiency

In order to assess the impact on the efficiency it is necessary to evaluate if RETINA solutions makes it possible to increase the number of aircraft safely managed by the ATCO. For this reason, in case of CONDI VIS 2, the exercise without RETINA solution (EXE-RETINA-VALP-RTS5) will be run with a Medium traffic and the exercise with RETINA solution (EXE-RETINA-VALP-RTS10) will be run with a Medium-High traffic. Since in CONDI VIS 3 it makes no sense to compare a medium traffic situation with a Medium-High traffic situation due to the Low Visibility Procedures restrictions (see dedicated section “Local Traffic Regulation in CONDI VIS 3” when maximum 4 movements per time are allowed), the exercise without RETINA solution will be run with the standard restrictions and the exercise with RETINA solution will be run only with a subset of such restrictions, called “limited restriction” (see dedicated section: Restriction Scenario).

Identifier	OBJ-RETINA-VALP-EF-01
Objective	To assess the impact that the HMD solution has on Efficiency in COND VIS 2 compared to the baseline equipment.
Metrics	Simultaneous surface movements (ground throughput), Workload (subjective assessment)
Category	Efficiency
Scenario	CONDI VIS 2
Traffic conditions	Medium (without Retina solution) VS Medium-High (with RETINA solutions)
Involved exercise	EXE-RETINA-VALP-RTS10 VS EXE-RETINA-VALP-RTS5

Identifier	Success Criterion
CRT-EF-01 -001	Solution HMD increases the number of aircraft safely managed in CONDI VIS 2
CRT-EF-01 -002	Solution HMD provides acceptable levels of workload in CONDI VIS 2

Identifier	OBJ-RETINA-VALP-EF-02
Objective	To assess the impact that the HMD solution has on Efficiency in COND VIS 3 compared to the baseline equipment.
Metrics	Throughput, Workload (subjective assessment),
Category	Efficiency
Scenario	CONDI VIS 3
Traffic conditions	Medium traffic standard restrictions (without RETINA) VS Medium traffic limited restrictions (with RETINA)
Involved exercise	EXE-RETINA-VALP-RTS13 vs EXE-RETINA-VALP-RTS11

Identifier	Success Criterion
CRT-EF-02 -001	Solution HMD increases the number of aircraft safely managed in CONDI VIS 3
CRT-EF-02-002	Solution HMD provides acceptable levels of workload in CONDI VIS 3

3.1.3 Safety

Identifier	OBJ-RETINA-VALP-SAF-01
Objective	To assess the impact that the RETINA solutions have on Safety in CONDI VIS 1
Metrics	Simulation data
Category	Safety
Scenario	CONDI VIS 1
Traffic conditions	Medium High
Involved exercise	EXE-RETINA-VALP-RTS4 vs EXE-RETINA-VALP-RTS2, EXE-RETINA-VALP-RTS3 vs EXE-RETINA-VALP-RTS1

Identifier	Success Criterion
CRT-SAF-01 -001	Solution HMD preserves/increases the capability of achieving the following tasks in CONDI VIS 1: monitoring of holding points(GND)
CRT-SAF-01 -002	Solution SD preserves/increases the capability of achieving the following tasks in CONDI VIS 1: rwy incursion detection (TWR), ATCO to monitor the separation of traffic on final.

Identifier	OBJ-RETINA-VALP-SAF-02
Objective	To assess the impact that the RETINA solutions have on Safety in CONDI VIS 2
Metrics	Simulation data
Category	Safety
Scenario	CONDI VIS 2
Traffic conditions	Medium
Involved exercise	EXE-RETINA-VALP-RTS7 vs EXE-RETINA-VALP-RTS5, EXE-RETINA-VALP-RTS8 vs EXE-RETINA-VALP-RTS6, EXE-RETINA-VALP-RTS9 vs EXE-RETINA-VALP-RTS6

Identifier	Success Criterion
CRT-SAF-02 -001	Solution HMD preserves/increases the capability of achieving the following tasks in CONDI VIS 2 : monitoring of holding point (GND).
CRT-SAF-02 -002	Solution SD preserves/increases the capability of achieving the following tasks in CONDI VIS 2: rwy incursion detection (TWR), monitor of the traffic separation on final
CRT-SAF-02 -003	Solution HMD preserves/increases the capability of achieving the following tasks in CONDI VIS 2: rwy incursion detection (TWR), monitor of the traffic separation on final

Identifier	OBJ-RETINA-VALP-SAF-03
Objective	To assess the impact that the RETINA HMD solution has on relevant safety-critical tasks in CONDI VIS 3
Metrics	Simulation data
Category	Safety
Scenario	CONDI VIS 3
Traffic conditions	Medium
Involved exercise	EXE-RETINA-VALP-RTS12 vs EXE-RETINA-VALP-RTS11

Identifier	Success Criterion
CRT-SAF-03 -001	Solution HMD preserves/increases the capability of achieving the following tasks in CONDI VIS 3: detect deviation from taxi clearance (GND)

3.2 Validation Targets

This section lists the validation targets for RETINA solutions considering the success criterion reported in the tables above.

KPA	Trend	Expectation (what/why)
HUMAN PERF. (situational awareness)	UP	RETINA solutions increases the ATCO situational awareness in normal conditions, CONDI VIS 2 and CONDI VIS 3.
HUMAN PERF. (Human Factors)	Maintain	The RETINA solution provides an HMI interface that is subjectively acceptable to the controllers.
EFFICIENCY (Workload)	Maintain or DW	RETINA solutions provides acceptable (equal or lower with respect to the current equipment) levels of workload in CONDI VIS 2 and CONDI VIS 3.
EFFICIENCY (GND throughput)	UP	Solution HMD increases the number of aircraft safely managed in CONDI VIS 2 and 3 increasing the airport resiliency to low visibility.
SAFETY	Maintain or UP	RETINA solutions preserves/increases the capability of achieving the following tasks: monitoring of holding point and monitor of runway incursions (vehicles included).

Table 6: RETINA KPAs and Expectations

4 RETINA Validation Activities

4.1 Validation Exercise description and scope

As mentioned above the scope of the validation is to assess the impact of introduction of RETINA solutions on the ATCO working methods considering three Key Performance Areas, namely human performance, efficiency and safety. There will be a total of 14 exercises performed in two locations.

The first 13 exercises will be performed at the UNIBO premises. These exercises will address three visibility conditions, namely CONDI VIS 1, CONDI VIS 2 and CONDI VIS 3, for the two solutions identified (HMD and SD). For each exercise performed on a RETINA solution, a similar exercise is conducted adopting the baseline equipment in order to compare data obtained vs success criteria and validation targets identified below.

The solutions will be validated in a laboratory environment by means of human-in-the-loop real-time simulations where the external view will be provided to the user through a high fidelity 4D model in an immersive environment that replicates the out-of-the tower view.

The final exercise will take place at the CRIDA premises. This complimentary exercise will be conducted in a laboratory environment by means of human-in-the-loop real-time simulations and will address the controller's acceptability of the HMI (the augmented reality overlaid text and graphic elements) through the collection of subjective, qualitative information.

4.2 Validation Assumptions

The validation is based on the following assumptions:

1) PSR and SSR position and identification data are always available for HMD and SD during validation.
2) SMR position and identification data are always available for HMD and SD during validation.
3) Meteo data are always available for HMD and SD during validation.
4) NAVAIDS status information is always available for HMD and SD during validation.
5) The ATCO are familiar with the airport scenario
6) The ATCO are familiar with the RETINA tool

4.3 Validation

4.3.1 Airport Scenario

Bologna airport has been choose as reference scenario for the validation (see [1]); it has a moderately complex layout (one runway, several taxiway, more than one apron) with a moderate traffic (between 200 and 300 movements per day). Bologna is a single Runway (12 and 30) airport with a main taxiway T and several taxiway and aircraft stand taxilane. The runway has orientation 12/30 with an asphalt strip of 2803x45 m. In the table below the declared distances are reported for both runways.

13 DISTANZE DICHIARATE		DECLARED DISTANCES		
Designazione RWY RWY designator	TORA (M)	TODA (M)	ASDA (M)	LDA (M)
1	2	3	4	5
12 INT TAKE-OFF B INT TAKE-OFF C INT TAKE-OFF D	2803 2400 2100 1900	2923 2520 2220 2020	2803 2400 2100 1900	2493 - - -
30 INT TAKE-OFF J INT TAKE-OFF H	2803 2630 2395	2863 2690 2455	2803 2630 2395	2442 - -

Table 7. Declared distances for both runways

In the pictures below Bologna Airport layout is reported.

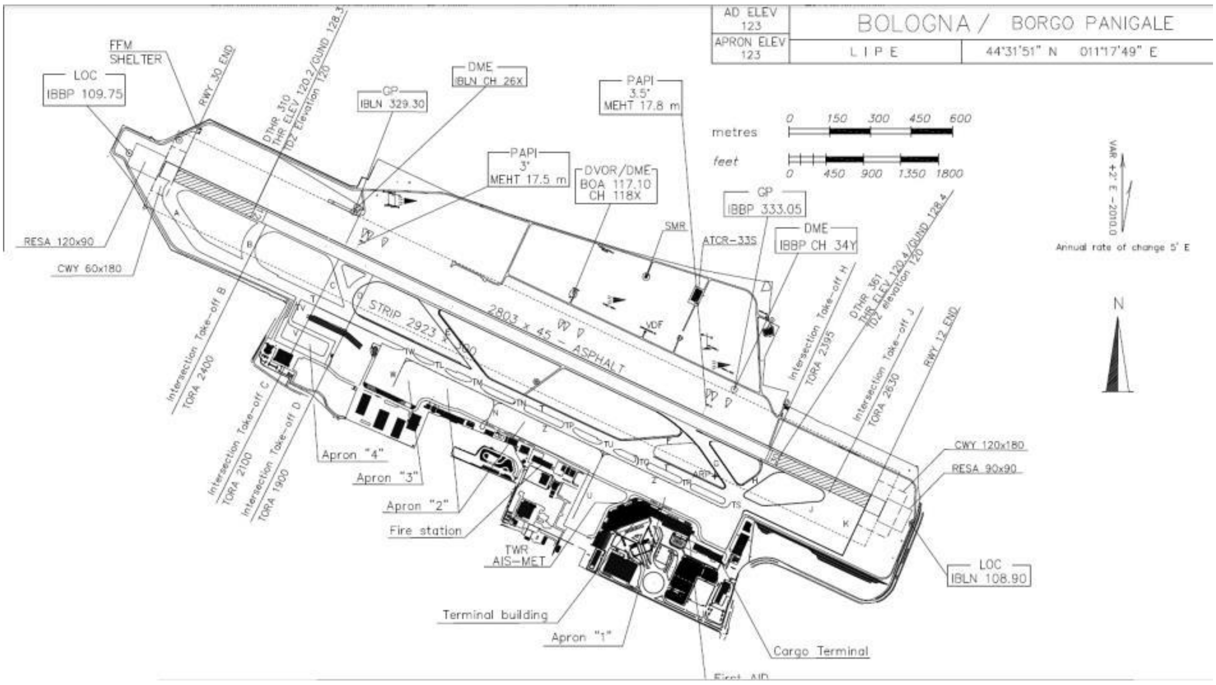


Fig 1. Bologna airport layout

The main taxiway T is parallel to the runway and it is links all the aprons with the runway. Four apron are available; Apron 1 in front of the terminal and of the Control Tower, Apron 2 on left in front of fire fighting area and hangars, Apron 3 which is the cargo area and Apron 4 for general aviation. Apron 1, 2 and 3 are linked to taxiway T with short taxiway TW, TL, TN, TM,TP, TU, TQ, TR, and TS; Apron 4 is separated from the other apron and it is linked to the main taxiway T with taxiway TV.

The Runway and the main taxiway T are linked via the taxiway A, B, C, D, E, F, G, H, J and K.

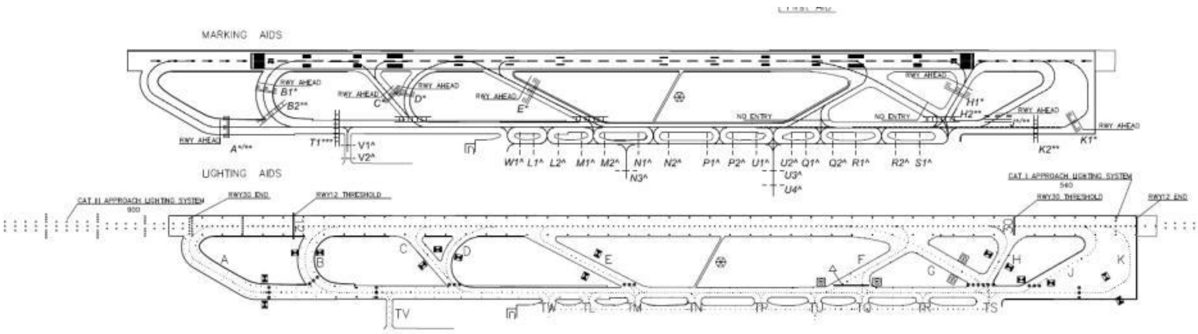


Fig 2. Bologna airport layout, runway, taxiways

The short taxiway TW, TL, TN, TM,TP, TU, TQ, TR, and TS identify specific blocks of parking stand on the Aprons. For example, the stands from 214 to 218 belong to the Block U since they are in front of TU.

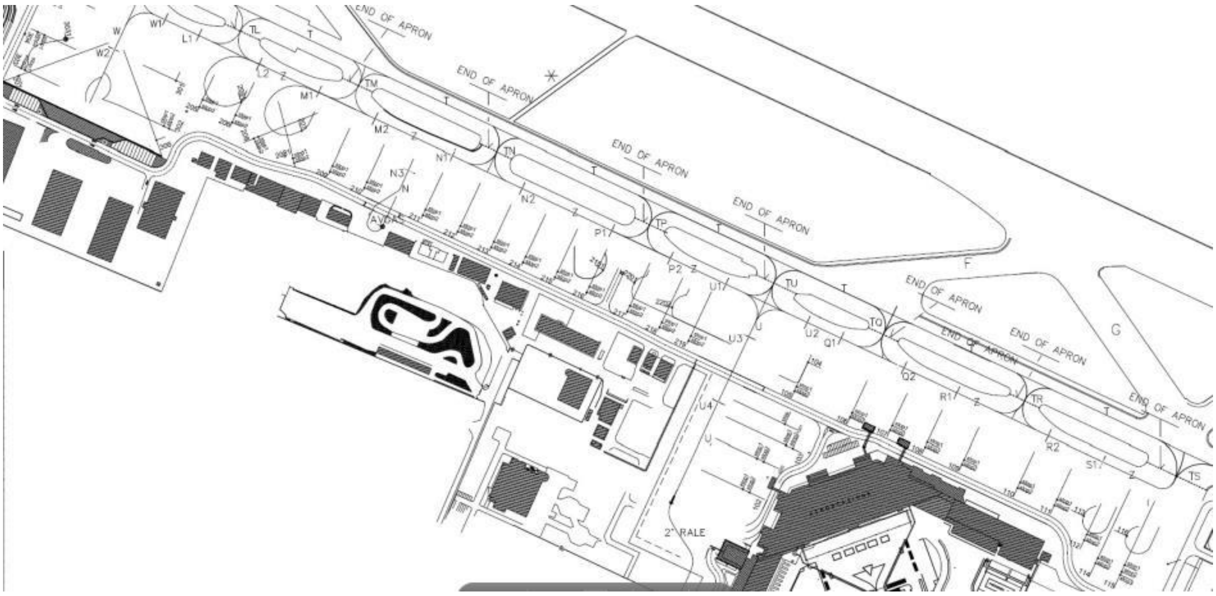


Fig 3. Bologna airport aprons chart

In Bologna airport the following ATC equipment and procedures are available:

- Primary Surveillance Radar and Secondary Surveillance Radar (PSR/SSR);
- Surface Movement Radar (SMR);
- Low Visibility Procedures able to manage more than one aircraft at the same time implemented;
- Apron Management Procedures;
- ILS CAT 3B;

4.3.1.1 Local traffic regulation in CONDI VIS 2

Runway 12 is used preferentially and it is mandatory if RVR is less than 550m. Arriving aircraft vacate runway 12 only via taxiway G,H and J and runway 30 only via B. Departing aircraft enter runway 12 only via A and runway 30 via J. The stopbar at the Runway Holding point CAT II and III are activated. Minimum spacing between arriving aircraft is 10NM if LVP are not in force, 12NM in case LVP in force, 15NM to permit departure between arrivals and LVP in force. In case of LVP, in order to ensure that the radio path of the ILS is free, the TWR controller will clear for take off a departure only if it will overfly the LOC antenna before the arriving aircraft is 4NM on final.

4.3.1.2 Local traffic regulation in CONDI VIS 3

Only runway 12 is used. Intermediate holding point (IHP) T1 on main taxiway is activated, the follow-me is positioned on the taxiway T abeam TS on TWR request in case of arrival. Departing aircraft taxi to IHP T1 initially and then to RHP A. Further departures start taxi only once the previous one is between T1 and RHP A. Arriving aircraft vacate the runway only via J and follow the follow-me until the parking. Simultaneous push back operations are allowed only from stands belonging to not contiguous blocks (for examples, simultaneous pushback are possible from stands in Q and S blocks but not from stands in Q and R blocks). Minimum spacing between arriving aircraft is 15NM in case of no departure and 16NM in case of departure. In order to ensure that the radio path of the ILS is free, the TWR controller will clear for take off a departure only if it will overfly the LOC antenna before the arriving aircraft is 4NM on final. Such restrictions are integrated with a full capacity in LVP restriction in terms of maximum movements that the ATCO can manage together: 2 departures and 2 arrivals, i.e. maximum of 4 movements together.

4.3.2 Reference traffic scenarios

The baseline traffic scenario is derived from real air traffic data from Bologna airport recorded during July 2017 and adapted to the exercise needs. As reference a 40 minutes traffic sample from 11:20 to 12:00 UTC is considered: it consists of 7 departures and 4 arrivals meaning an average of more than one operation (take-off or landing) every 3 minutes. Traffic peaks are also reported in the sample. Considering the characteristics of Bologna airport, this will be used as “medium-high traffic” sample in the validation exercises. A “medium traffic” sample to be used in the exercises is derived from the medium-high sample simply removing 1 arrival and 2 departures, i.e. it consists of 5 departures and 3 arrivals.

In order to test also ground vehicles operations, one runway inspection will be also simulated in both samples. The runway inspection will be randomly requested by the Pseudo Pilot and approved by the ATCO in accordance with the traffic. The duration of the inspection will be coordinated by the ATCO and by the pseudopilot and its duration will be between 2 and 5 minutes.

Finally, safety related events will be also randomly generated by the pseudo pilot in order to evaluate the ATCO detection capability using V/ART. Such events could be runway incursions and/or taxi deviations. During the sample, the pseudopilots will perform a runway incursion using a vehicle or an aircraft with no coordination with the ATCO.

4.3.3 Restriction scenarios

In case of low visibility conditions (i.e. CONDI VIS 2 and 3), the ATCO are not able to partially or totally monitor the traffic on the manoeuvring area using the sight. Nevertheless this is not the only reasons to the above mentioned restrictions: pilot factors and aerodrome physical limitations have also to be considered. Since RETINA solutions makes it possible to augment the ATCO sight using V/ART, two restriction scenario are considered:

- ✓ Standard restrictions: the ATCO manage the traffic applying the current regulations (note that no restrictions apply in CONDI VIS 1);
- ✓ Limited restrictions: restrictions depending on ATCO are removed during simulation;

The basic idea of the second scenario is to remove only constraints not related to pilot or to airport physical limitation. For example, the increased spacing between arrivals is determined also by “pilot factors”: in low visibility conditions the speed on final and the taxi speed are reduced (also with AMM) due to company and physical limitations. This results in removing some constraints only on departing traffic. Considering CONDI VIS 3, in the “Limited restrictions” scenario the local regulation are modified as follows:

- ✓ The use of Intermediate holding points is removed;
- ✓ The use of J exit taxiway is confirmed;
- ✓ The minimum spacing between aircraft on final is confirmed;
- ✓ The capacity constraints on the number of departures managed together (i.e. 2) is removed;
- ✓ The constraints on simultaneous pushback from contiguous blocks is removed.

The tables below reports the reference traffic scenario with the related restriction for each exercise planned.

The traffic samples are used in the exercises applying different visibility conditions: in other words the ATCO has to manage the traffic sample in the visibility conditions required by the exercise (as reported in the following tables). For examples, in the EXE-RETINA-VALP-RTS1, the ATCO has to manage a medium high traffic sample in CONDI VIS 1 with the standard restriction, i.e. with no restrictions. In the same way, in the EXE-RETINA-VALP-RTS11, the ATCO has to manage a medium traffic sample in CONDI VIS 3 with standard restrictions, i.e. maximum of 4 movements together resulting in a full capacity situation with related delay.

4.3.4 Validation Exercises

Identifier	EXE-RETINA-VALP-RTS1
Title	Base Line medium-high traffic in CONDI VIS 1 GND position
Description	Considering a medium-high traffic situation in GND position in normal weather conditions, the aim of the exercise will be: • To assess the situational awareness (detection of RWY incursion included) of the ATCO; • To measure the head down time of the ATCO; • To measure the number of switches head up/head down of the ATCO; • To measure the time needed to access a specific information (info accessibility).
Expected Achievements	Contribution to validation targets OBJ-RETINA-VALP-HP-01 and OBJ-RETINA-VALP-SAF-01
Traffic and restrictions	medium-high traffic
Validation Technique	Real Time Simulation
KPA/TA Addressed	Human Performance and Safety
Validation Dates	End October 2017
Validation Coordinator	ENAV-UNIBO
Validation Platform	UNIBO CAVE V-LAB
Validation Scenario	Bologna airport simulated environment

Identifier	EXE-RETINA-VALP-RTS2
Title	Base Line medium-high traffic in CONDI VIS 1 TWR position
Description	Considering a medium-high traffic situation in TWR position in normal weather conditions, the aim of the exercise will be: • To assess the situational awareness (detection of RWY incursion included) of the ATCO; • To measure the head down time of the ATCO; • To measure the number of switches head up/head down of the ATCO; • To measure the time needed to access a specific information (info accessibility).
Expected Achievements	contribution to validation targets OBJ-RETINA-VALP-HP-04 and OBJ-RETINA-VALP-SAF-01
Traffic and restrictions	medium-high traffic standard restrictions
Validation Technique	Real Time Simulation
KPA/TA Addressed	Human Performance and Safety
Validation Dates	End October 2017
Validation Coordinator	ENAV-UNIBO
Validation Platform	UNIBO CAVE V-LAB
Validation Scenario	Bologna airport simulated environment

Identifier	EXE-RETINA-VALP-RTS3
Title	Retina HMD medium-high traffic in CONDI VIS 1 GND position
Description	Considering a medium-high traffic situation in GND position in normal weather conditions with Retina HMD, the aim of the exercise will be: • To assess the situational awareness (detection of RWY incursion included) of the ATCO; • To measure the head down time of the ATCO; • To measure the number of switches head up/head down of the ATCO; • To measure the time needed to access a specific information (info accessibility).
Expected Achievements	Contribution to validation targets OBJ-RETINA-VALP-HP-01 and OBJ-RETINA-VALP-SAF-01
Traffic and restrictions	medium-high traffic standard restrictions
Validation Technique	Real Time Simulation
KPA/TA Addressed	Human Performance and Safety
Validation Dates	End October 2017
Validation Coordinator	ENAV-UNIBO
Validation Platform	UNIBO CAVE V-LAB
Validation Scenario	Bologna airport simulated environment

Identifier	EXE-RETINA-VALP-RTS4
Title	Retina SD medium-high traffic in CONDI VIS 1 TWR position
Description	Considering a medium-high traffic situation in TWR position in normal weather conditions with Retina SD, the aim of the exercise will be: • To assess the situational awareness (detection of RWY incursion included) of the ATCO; • To measure the head down time of the ATCO; • To measure the number of switches head up/head down of the ATCO; • To measure the time needed to access a specific information (info accessibility).
Expected Achievements	Contribution to validation targets OBJ-RETINA-VALP-HP-04 and OBJ-RETINA-VALP-SAF-01
Traffic and restrictions	medium-high traffic standard restrictions
Validation Technique	Real Time Simulation
KPA/TA Addressed	Human Performance and Safety
Validation Dates	End October 2017
Validation Coordinator	ENAV-UNIBO
Validation Platform	UNIBO CAVE V-LAB
Validation Scenario	Bologna airport simulated environment

Identifier	EXE-RETINA-VALP-RTS5
Title	Base Line medium traffic in CONDI VIS 2 GND position
Description	Considering a medium traffic situation in GND position in CONDI VIS 2, the aim of the exercise will be: • To assess the situational awareness of the ATCO. • To measure the head down time of the ATCO. • To measure the number of switches head up/head down. • To measure the time needed to access a specific information (info accessibility). • To assess the throughput
Expected Achievements	contribution to validation targets OBJ-RETINA-VALP-HP-02, OBJ-RETINA-VALP-EF-01 and OBJ-RETINA-VALP-SAF-02
Traffic and restrictions	medium traffic standard restrictions
Validation Technique	Real Time Simulation
KPA/TA Addressed	Human Performance, Efficiency, Safety
Validation Dates	End October 2017
Validation Coordinator	ENAV-UNIBO
Validation Platform	UNIBO CAVE V-LAB
Validation Scenario	Bologna airport simulated environment

Identifier	EXE-RETINA-VALP-RTS6
Title	Base Line medium traffic in CONDI VIS 2 TWR position
Description	Considering a medium traffic situation in TWR position in CONDI VIS 2, the aim of the exercise will be: • To assess the situational awareness of the ATCO. • To measure the head down time of the ATCO. • To measure the number of switches head up/head down. • To measure the time needed to access a specific information (info accessibility). • To assess the throughput
Expected Achievements	Contribution to validation targets OBJ-RETINA-VALP-HP-02, OBJ-RETINA-VALP-HP-05 and OBJ-RETINA-VALP-SAF-02
Traffic and restrictions	medium traffic standard restrictions
Validation Technique	Real Time Simulation
KPA/TA Addressed	Human Performance, Efficiency, Safety
Validation Dates	End October 2017
Validation Coordinator	ENAV-UNIBO
Validation Platform	UNIBO CAVE V-LAB
Validation Scenario	Bologna airport simulated environment

Identifier	EXE-RETINA-VALP-RTS7
Title	Retina HMD medium traffic in CONDI VIS 2 GND position
Description	Considering a medium traffic situation in GND position in CONDI VIS 2 with Retina HMD, the aim of the exercise will be: • To assess the situational awareness of the ATCO. • To measure the head down time of the ATCO. • To measure the number of switches head up/head down. • To measure the time needed to access a specific information (info accessibility). • To assess the throughput
Expected Achievements	Contribution to validation targets OBJ-RETINA-VALP-HP-02 and OBJ-RETINA-VALP-SAF-02
Traffic and restrictions	medium traffic standard restrictions
Validation Technique	Real Time Simulation
KPA/TA Addressed	Human Performance and Safety
Validation Dates	End October 2017
Validation Coordinator	ENAV-UNIBO
Validation Platform	UNIBO CAVE V-LAB
Validation Scenario	Bologna airport simulated environment

Identifier	EXE-RETINA-VALP-RTS8
Title	Retina HMD medium traffic in CONDI VIS 2 TWR position
Description	Considering a medium traffic situation in TWR position in CONDI VIS 2, the aim of the exercise will be: • To assess the situational awareness of the ATCO. • To measure the head down time of the ATCO. • To measure the number of switches head up/head down. • To measure the time needed to access a specific information (info accessibility). • To assess the throughput
Expected Achievements	Contribution to validation targets OBJ-RETINA-VALP-HP-02 and OBJ-RETINA-VALP-SAF-02
Traffic and restrictions	medium traffic standard restrictions
Validation Technique	Real Time Simulation
KPA/TA Addressed	Human Performance and Safety
Validation Dates	End October 2017
Validation Coordinator	ENAV-UNIBO
Validation Platform	UNIBO CAVE V-LAB
Validation Scenario	Bologna airport simulated environment

Identifier	EXE-RETINA-VALP-RTS9
Title	Retina SD medium traffic in CONDI VIS 2 TWR position
Description	Considering a medium traffic situation in TWR position in CONDI VIS 2, the aim of the exercise will be: • To assess the situational awareness of the ATCO. • To measure the head down time of the ATCO. • To measure the number of switches head up/head down. • To measure the time needed to access a specific information (info accessibility). • To assess the throughput
Expected Achievements	Contribution to validation targets OBJ-RETINA-VALP-HP-05 and OBJ-RETINA-VALP-SAF-02
Traffic and restrictions	medium traffic standard restrictions
Validation Technique	Real Time Simulation
KPA/TA Addressed	Human Performance and Safety
Validation Dates	End October 2017
Validation Coordinator	ENAV-UNIBO
Validation Platform	UNIBO CAVE V-LAB
Validation Scenario	Bologna airport simulated environment

Identifier	EXE-RETINA-VALP-RTS10
Title	Retina HMD medium-high traffic in CONDI VIS 2 GND position
Description	Considering a medium-high traffic situation in GND position in CONDI VIS 2, the aim of the exercise will be: • To assess the situational awareness of the ATCO. • To measure the head down time of the ATCO. • To measure the number of switches head up/head down. • To measure the time needed to access a specific information (info accessibility). • To assess the throughput
Expected Achievements	contribution to validation target OBJ-RETINA-VALP-EF-01
Traffic and restrictions	Medium-high traffic standard restrictions
Validation Technique	Real Time Simulation
KPA/TA Addressed	Efficiency
Validation Dates	End October 2017
Validation Coordinator	ENAV-UNIBO
Validation Platform	UNIBO CAVE V-LAB
Validation Scenario	Bologna airport simulated environment

Identifier	EXE-RETINA-VALP-RTS11
Title	Base Line in CONDI VIS 3 GND position with standard restrictions.
Description	Considering a medium traffic situation with standard restrictions in GND position in CONDI VIS 3, the aim of the exercise will be: • To assess the situational awareness of the ATCO. • To measure the head down time of the ATCO. • To measure the number of switches head up/head down. • To measure the time needed to access a specific information (info accessibility).
Expected Achievements	Contribution to validation targets OBJ-RETINA-VALP-HP-03, OBJ-RETINA-VALP-EF-02 and OBJ-RETINA-VALP-SAF-03
Traffic and restrictions	Medium traffic standard restrictions
Validation Technique	Real Time Simulation
KPA/TA Addressed	Human Performance, Efficiency, Safety
Validation Dates	End October 2017
Validation Coordinator	ENAV-UNIBO
Validation Platform	UNIBO CAVE V-LAB
Validation Scenario	Bologna airport simulated environment

Identifier	EXE-RETINA-VALP-RTS12
Title	Retina HMD in CONDI VIS 3 GND position with standard restrictions.
Description	Considering a medium traffic situation with standard restrictions in GND position in CONDI VIS 3 with Retina HMD, the aim of the exercise will be: • To assess the situational awareness of the ATCO. • To measure the head down time of the ATCO. • To measure the number of switches head up/head down. • To measure the time needed to access a specific information (info accessibility).
Expected Achievements	Contribution to validation targets OBJ-RETINA-VALP-HP-03 and OBJ-RETINA-VALP-SAF-03
Traffic and restrictions	Medium traffic standard restrictions
Validation Technique	Real Time Simulation
KPA/TA Addressed	Human Performance and Safety
Validation Dates	End October 2017
Validation Coordinator	ENAV-UNIBO
Validation Platform	UNIBO CAVE V-LAB
Validation Scenario	Bologna airport simulated environment

Identifier	EXE-RETINA-VALP-RTS13
Title	Retina HMD in CONDI VIS 3 GND position with limited restrictions.
Description	Considering a medium traffic situation with limited restrictions in GND position in CONDI VIS 3, the aim of the exercise will be: • To assess the situational awareness of the ATCO. • To measure the head down time of the ATCO. • To measure the number of switches head up/head down. • To measure the time needed to access a specific information (info accessibility). • To assess the throughput
Expected Achievements	contribution to validation targets OBJ-RETINA-VALP-HP-03 and OBJ-RETINA-VALP-EF-02
Traffic and restrictions	Medium traffic limited restrictions
Validation Technique	Real Time Simulation
KPA/TA Addressed	Human Performance and Efficiency
Validation Dates	End October 2017
Validation Coordinator	ENAV-UNIBO
Validation Platform	UNIBO CAVE V-LAB
Validation Scenario	Bologna airport simulated environment

Identifier	EXE-RETINA-VALP-RTS14
Title	RETINA HMD Overlays.
Description	Considering a medium high traffic situation in both GND and TWR positions in normal weather conditions, the aim of the exercise will be: • Assess the readability and meaningfulness of textual and graphical objects, symbols and representations in the information overlays • Assess the usability and adequacy of the overlays • Assess the practicability and intuitiveness of commands on HMI objects • Assess the timeliness and prioritization of the information displayed by the overlays • Assess the consistency and completeness of the information displayed by the overlays • Assess the impact that the information overlays have on supporting the controller in the decision making process
Expected Achievements	Increase Human Performance capabilities
Traffic and restrictions	Medium-high traffic
Validation Technique	Real Time Simulation
KPA/TA Addressed	Human Performance
Validation Dates	Start of November 2017
Validation Coordinator	CRIDA
Validation Platform	CRIDA HMD
Validation Scenario	Bologna airport simulated environment
Validation Location	CRIDA Headquarters, Madrid

4.4 Validation Exercise Procedures, Planning and Management

For this validation campaign at least three ATCOs will be recruited on a voluntary basis to perform tasks related to the ATC activity in a control tower simulated environment [5]. One more subject will be recruited to work as pseudo-pilot during the whole validation.

The validation exercises EXE-RETINA-VALP-RTS01 through EXE-RETINA-VALP-RTS13 will be conducted at the University of Bologna Virtual Reality Laboratory and it will last two weeks starting mid October 2017. Each ATCO will undergo a 45 minutes familiarization session before executing the first batch of exercises.

EXE-RETINA-VALP-RTS14 will be conducted at CRIDA Headquarters in Madrid, and will last for two days starting the first week of November 2017.

The following paragraph describes the activities, how they are planned and how they will be managed.

4.4.1 Activities

Preparatory phase:

A1. Recruitment

The recruitment process will be based on a public call for volunteers issued by the project Coordinator. The study will be clearly described as providing no direct benefit for those that participate in it. Partners involved in this phase are UNIBO ENAV, and CRIDA. [5]

A2. Preparation of exercises:

Exercises EXE-RETINA-VALP-RTS01 through EXE-RETINA-VALP-RTS13 will be prepared and tested at the University of Bologna Virtual Reality Laboratory before the starting date of the validation campaign. Partners involved in this phase are UNIBO, LUCIAD and ENAV.

Exercise EXE-RETINA-VALP-RTS14 will be prepared and tested at CRIDA Headquarters in Madrid before the starting date of the validation campaign. Partners involved in this phase are CRIDA.

Execution phase:

A3. Test Execution:

Exercises will be divided in four batches according to table 8 and for each batch the following general procedure will apply.

1. Briefing
2. Informed consent
3. Calibration of systems
4. Familiarization with systems
5. Execution of exercises
6. Debriefing

Each batch of exercises will be conducted on at least three subjects.

Partners involved in this phase are UNIBO, CRIDA and ENAV.

Batch1	EXE-RETINA-VALP-RTS1	EXE-RETINA-VALP-RTS2	EXE-RETINA-VALP-RTS3	EXE-RETINA-VALP-RTS4		
Batch2	EXE-RETINA-VALP-RTS5	EXE-RETINA-VALP-RTS6	EXE-RETINA-VALP-RTS7	EXE-RETINA-VALP-RTS8	EXE-RETINA-VALP-RTS9	EXE-RETINA-VALP-RTS10
Batch3	EXE-RETINA-VALP-RTS11	EXE-RETINA-VALP-RTS12	EXE-RETINA-VALP-RTS13			
Batch 4	EXE-RETINA-VALP-RTS14					

Table 8: Exercises batch planning

Post-execution phase:

A4. Data analysis:

Data collection and analysis will be performed as reported in section 4.6. Partners involved in this phase are UNIBO, CRIDA. ECTL and ENAV.

A5. Reporting:

Partners involved in this phase are UNIBO, CRIDA, ECTL and ENAV.

4.4.2 Responsibilities in the exercise and estimated time planning

Table below reports an estimated time planning for the validation exercises, changes in the planning could be possible in accordance to the partners availabilities.

Activity	Week 2017												Resp
	W38	W39	W40	W41	W42	W43	W44	W45	W46	W47	W48	W49	
A1. Recruitment													ENAV
A2. Preparation of exercises													UNIBO
A3. Test Execution								*					ENAV; *CRIDA
A4. Data analysis													UNIBO
A5. Reporting													CRIDA

Table 9: Detailed time planning and responsibilities

4.5 Validation Exercise Platform

The exercise platform architecture is depicted in Fig. 4. It consists in five main modules, the core system is the **4D model** of the reference scenario which communicates through data exchange protocols with the following four subsystems:

- Out-of the Tower View Generator (OOT): it provides the ATCO with a consistent and photorealistic view of the out of the tower scene.
- Augmented Reality Overlay Application (AR App): it derives the relevant Augmented Reality Overlays and deploys them on the appropriate ATCO Head-Up Interface (being either Spatial Display or Head Mounted Display).
- Head Down Equipment (HDE): it consists in a simplified interface that replicates the actual head down equipment in the control tower.
- Pseudo-pilot application (PP App): it allows the pseudo-pilot to monitor and update the state of the 4D model according to the commands provided by the ATCO.

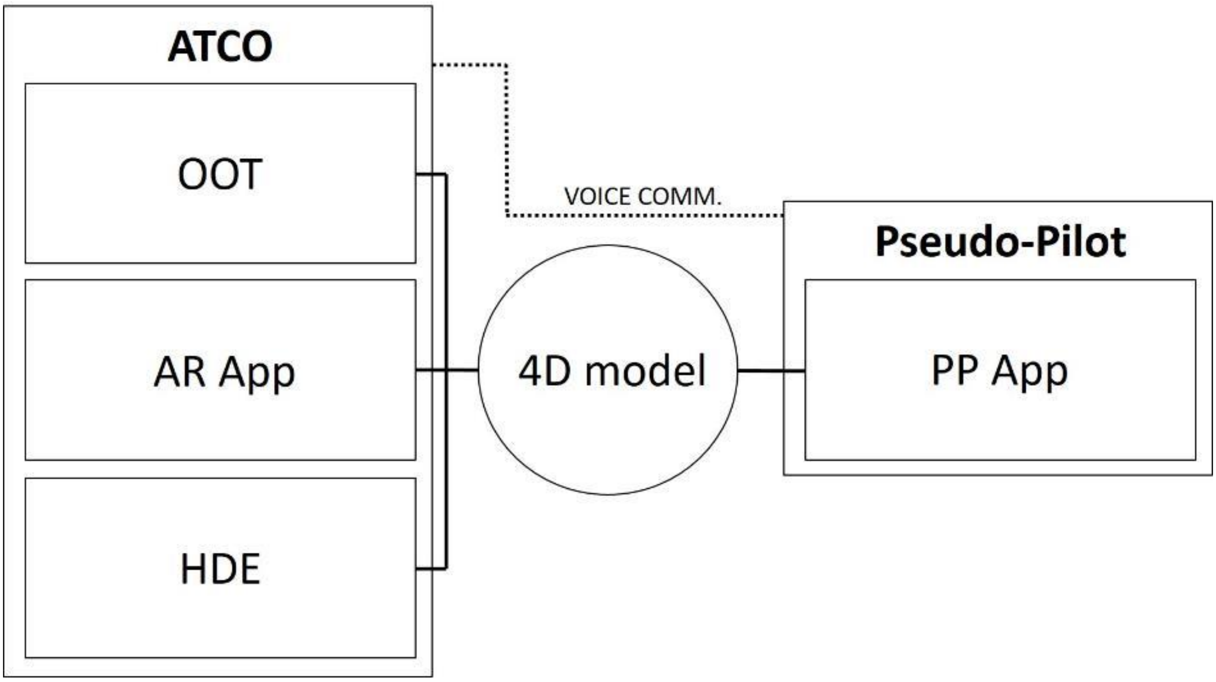


Fig. 4 Exercise Platform Architecture. The core system is the 4D model of the reference scenario which communicates through data exchange protocols with Out-of the Tower View Generator (OOT), Augmented Reality Overlay Application (AR App), Head Down Equipment (HDE) and Pseudo-pilot application (PP App).

4.5.1 4D Model

The four-dimensional digital model (3D+time) is the core system of the exercise platform. This model integrates all data sources and is able to manage events and respond to user inputs. The model was developed using Blender software [6] and it includes most of the airport static features and ground signs, a library of aircrafts and ground vehicles, a "point and click" interface for managing aircrafts and ground vehicles, assigning taxi routes ad clearing take-offs and landings.

Fig. 5 4D model of the reference scenario Bologna Airport (LIPE)

4.5.2 Out-of the Tower View Generator (OOT)

The Out-of the Tower View Generator derives a rendered view of the reference scenario from the 4D model and displays it on the RVE (Reconfigurable Virtual Environment) [7]. It provides the ATCO with a semi-immersive, consistent and photorealistic view of the out of the tower scene. The Reconfigurable Virtual Environment is a CAVE-like virtual environment designed to recreate a sense of immersion by means of three, rear-projected, flat screens. The screens can be arranged in three different configurations, closed, semi-closed and wide open. A stereoscopic 3D effect is obtained by means of active shutter glassess (NVIDIA 3D Vision) and compatible projectors. Head tracking is obtained by means of a Microsoft Kinect sensor. In the OOT a custom rendering pipeline generates images based on the viewer's position providing the user with a good immersivity.

Fig. 6 Out of the Tower view generator: screenshot (top) and deployed and the Reconfigurable Virtual Environment equipped with tracking system (bottom)

4.5.3 Augmented Reality Overlay Application (AR App)

The Augmented Reality Overlay Application derives the relevant Augmented Reality Overlays from the 4D model and deploys them on the appropriate ATCO Head-Up Interface. Depending on the equipment to be tested - being either Spatial Display or Head Mounted Display – the application deploys the AR overlay on the appropriate device.

4.5.4 Head Down Equipment (HDE)

It consists in a simplified interface that replicates the actual head down equipment in the control tower. It derives data from the 4D model and presents it to the ATCO on a 24 inches screen which embeds the eye tracking subsystem that collects head down time and number of switches between head-down and head-up view.

4.5.5 Pseudo-pilot application (PP App)

The pseudo-pilot application allows its operator to monitor and update the state of the 4D model. The 4D model and the pseudo pilot application communicate to keep the state consistent between them.

In order to have an overview of the airport and to represent the current state of the 4D model, the following data layers are available in the pseudo-pilot application:

- Background imagery (i.e. aerial picture of the airport and its surroundings)

- Schematic layout of the airport
- Visual representations of the navigation mesh (taxiways and waypoints), on which a route can be planned.
- Aircrafts and ground vehicles (matching the position in the 3D model)
- Currently planned routes

The pseudo-pilot operator can toggle the visibility of the layers above.

To execute the validation scenario the pseudo-pilot application provides the following actions.

- Load the initial state of a validation scenario.
- An aircraft or a vehicle can be selected and a taxi route can be drawn for it. A route can only be drawn from waypoint to waypoint.
- If a route is created for an aircraft or a vehicle, the pseudo pilot operator can make this aircraft/vehicle to follow the route. The aircraft/vehicle can also be ordered to stop or resume a route again (i.e. stop taxi or continue taxi).
- The pseudo pilot operator can clear an aircraft for take-off.
- The pseudo pilot operator can clear an aircraft to land.

The operator executes the actions above when prompted to do so by the ATCO. Each command will be sent to the 4D model which will update its state accordingly.

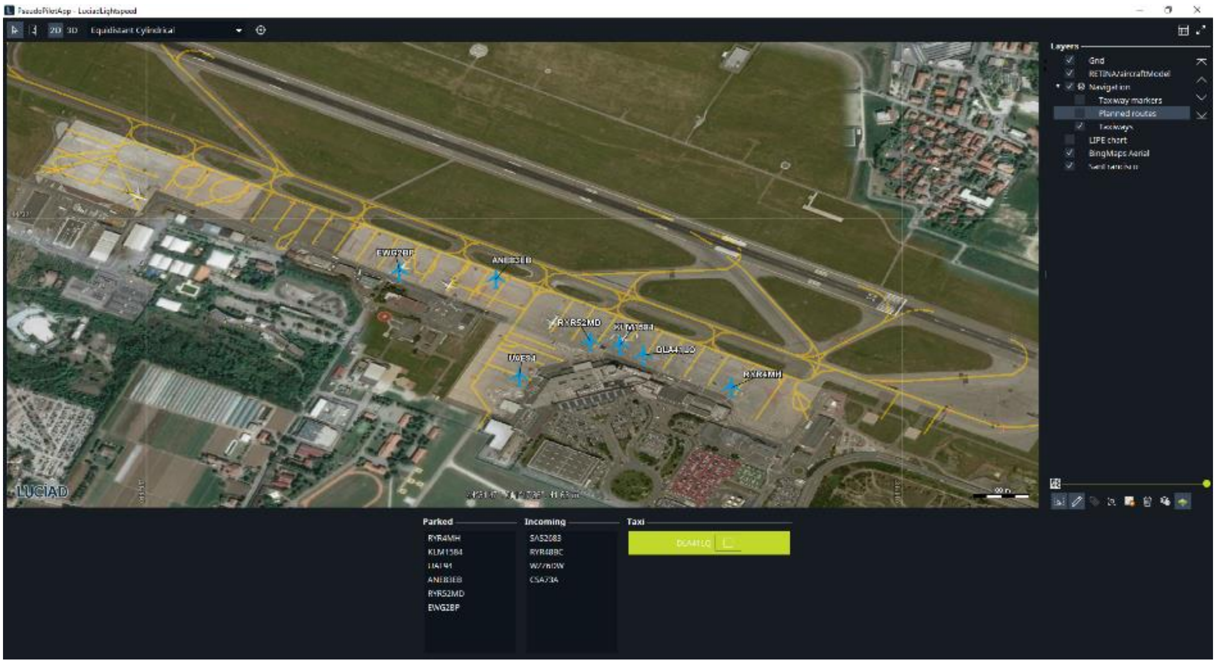


Fig. 7 Screenshot of the Pseudo-Pilot Interface

4.6 Analysis Specification

According to RETINA ethics management [5], data will be collected anonymously in the form of observations, self-assessment questionnaire and non-invasive, objective measurement techniques with no associated risk.

During the validation campaign the following data will be collected in the form of subjective qualitative assessment and objective quantitative measurement.

- Head-Down Time
- Number of Switches Head Down/Head Up
- SA levels
- Workload levels
- User Comfort
- Information Accessibility (time needed to access a specific information while performing a task)
- Throughput/Capacity

The HDE embeds eye tracking subsystem that collects head down time and the number of switches between head-down and head-up view. The eye tracking subsystem is based on the Tobii sensor which is able to remotely and non-intrusively track the user's gaze.

Fig. 8 Eye tracking subsystem is based on Tobii commercial sensor embedded in a 24'' screen

SA levels, Workload levels and User Comfort are collected by means of subjective questionnaire (see annex 1 and annex 2) and interviews during debriefing in offline conditions, while Information Accessibility and Throughput are mainly collected online during the simulation.

Collected data will be analysed, elaborated against success criteria and reported in D4.3 Validation Report.

5 References

[1] RETINA Project Deliverable D2.1 – Operational Concept Description

[2] RETINA Project Deliverable D1.1 - State of Art and Initial Concept Requirements

[3] 16.006.05 D27 SESAR Human Performance Assessment Process V1 to V3 – including VLDs

[4] D26 Safety Reference Material

[5] RETINA Project Deliverable D7.5 – H-Requirement n.5

[6] Detailed information about the software, including user manual is available at https://www.blender.org/

[7] Masotti, Nicola; Bagassi, Sara; De Crescenzio, Francesca (2016) Augmented Reality in the Control Tower: a Rendering Pipeline for Multiple Head-Tracked Head-Up Displays. Augmented Reality, Virtual Reality, and Computer Graphics - Lecture Notes in Computer Science, 9768 . pp. 321-338.

ANNEX 1

EXE-RETINA-VALP-RTS-1-to-13 Questionnaire

Document information	
Edition date	25/09/2017
Edition number	00.00.01

Run:	Date:	Hour:
ID:		

Questionnaire

First of all thank you for your participation; your opinion is very valuable for the RETINA project validation activities. We appreciate your patience and collaboration.

In this questionnaire, RETINA project seeks Air Traffic Control Operators' judgment in order to validate the different concepts developed under the project. Thus, each question has appreciation to different aspects of the developed proof of concept and the answer received will be very valuable to improve it and make it more useful in the future.

There a total of 8 questions, divided into two groups according to the objective to be checked.

Now, please complete the questionnaire.

Human Performance

Question 1.	How mentally demanding was the exercise? Very Low Fair Very High
Question 2.	How physically demanding was the exercise? Very Low Fair Very High
Question 3.	How hurried or rush was the pace of the exercise? Very Low Fair Very High
Question 4.	How successful you were in accomplishing what you were asked to do? Very Low Fair Very High
Question 5.	How hard did you have to work to accomplish your level of performance? Very Low Fair Very High
Question 6.	How insecure, discouraged, irritated, stressed and annoyed were you? Very Low Fair Very High

Information accessibility

Question 7.	How well do the proposed interface provide all the information you would expect to have? 
Question 8.	How well is the information displayed easy to find and intuitive to be used? 

Thank you for completing the questionnaire.

ANNEX 2

EXE-RETINA-VALP-RTS-14 Questionnaire

Document information	
Edition date	25/09/2017
Edition number	00.00.01

Run:	Date:	Hour:
ID:		

Questionnaire

First of all thank you for your participation; your opinion is very valuable for the RETINA project validation activities. We appreciate your patience and collaboration.

In this questionnaire, RETINA project seeks expert judgment in order to validate the different scenario developed under the project. Thus, each question has appreciation to different aspects of the prototype and the answer received will be very valuable to improve it and make it more useful in the future. Answer according to your agreement with the question acceptance.

There a total of 29 questions, divided into groups according to the objective to be checked.

Please answer the questions sincerely, and when rating below “Fair” provide shortly the reasons why it was a low rating. This will be very helpful to improve the prototype.

Now, please complete the questionnaire.

Static Information Overlays Understandability

Question 9.	How well does the font type of the static informative overlays make the information easy to read and understandable? Very Low Fair Very High If answer was below “Fair”, please give your reasons: ____ ____
Question 10.	How well do the dimensions of the static informative overlays make the information easy to read and understandable? Very Low Fair Very High If answer was below “Fair”, please give your reasons: ____ ____
Question 11.	How well does the colors of the static informative overlays make the information easy to read and understandable? Very Low Fair Very High If answer was below “Fair”, please give your reasons: ____ ____

Flight Tags Understandability

Question 12.	How well does the font type of the different flight tags make the information easy to read and understandable? Very Low Fair Very High If answer was below “Fair”, please give your reasons: ____ ____
Question 13.	How well do the dimensions of the different flight tags make the information easy to read and understandable? Very Low Fair Very High If answer was below “Fair”, please give your reasons: ____

	____
Question 14.	How well does the colors of the different flight tags make the information easy to read and understandable? Very Low Fair Very High If answer was below “Fair”, please give your reasons: ____ ____

Ground Vehicle Tags Understandability

Question 15.	How well does the font type of the ground vehicles tags make the information easy to read and understandable? Very Low Fair Very High If answer was below “Fair”, please give your reasons: ____ ____
Question 16.	How well do the dimensions of the ground vehicles tags make the information easy to read and understandable? Very Low Fair Very High If answer was below “Fair”, please give your reasons: ____ ____
Question 17.	How well does the color of the ground vehicles tags make the information easy to read and understandable? Very Low Fair Very High If answer was below “Fair”, please give your reasons: ____ ____

Graphical objects and Symbols Understandability

Question 18.	How well do the graphical representations of the different displayed objects make easy to understand what the objects and their functions?

	Very Low Fair Very High If answer was below "Fair", please give your reasons: ____ ____
Question 19.	How well do the displayed symbols make it easy to understand what their functions? Very Low Fair Very High If answer was below "Fair", please give your reasons: ____ ____

Static Information Overlays Completeness and Consistency

Question 20.	How well do the static information overlays provide all the information you would expect to have? Very Low Fair Very High If answer was below "Fair", please give your reasons: ____ ____

Flight Tags Completeness and Consistency

Question 21.	How well do the flight tags provide all the information you would expect to have? Very Low Fair Very High If answer was below "Fair", please give your reasons: ____ ____

Ground Vehicle Tags Completeness and Consistency

Question 22.	How well do the ground vehicle tags provide all the information you would expect to have?

	Very Low Fair Very High If answer was below “Fair”, please give your reasons: ____ ____

Static Information Overlays Timeliness and Prioritization

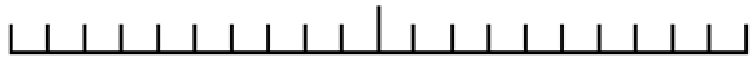
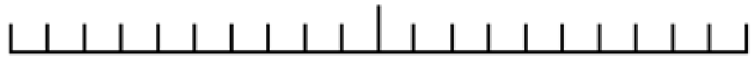
Question 23.	How well do the static information overlays provide all the information you would expect to have in the appropriate time to be used? Very Low Fair Very High If answer was below “Fair”, please give your reasons: ____ ____
Question 24.	How well is the information provided in the static information overlays correctly prioritized? Very Low Fair Very High If answer was below “Fair”, please give your reasons: ____ ____

Flight Tags Completeness and Consistency

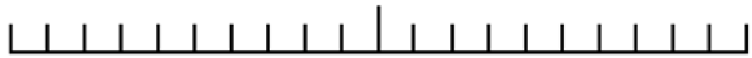
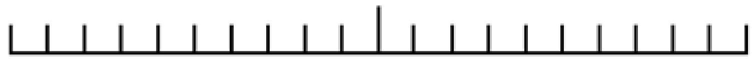
Question 25.	How well do the flight tags provide all the information you would expect to have in the appropriate time to be used? Very Low Fair Very High If answer was below “Fair”, please give your reasons: ____ ____
Question 26.	How well is the information provided in the flight tags correctly prioritized? Very Low Fair Very High If answer was below “Fair”, please give your reasons:

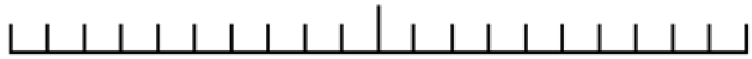
	____ ____

Ground Vehicle Tags Completeness and Consistency

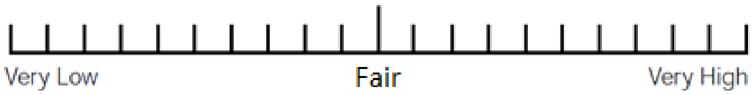
Question 27.	How well do the ground vehicle tags provide all the information you would expect to have in the appropriate time to be used?  If answer was below "Fair", please give your reasons: ____ ____
Question 28.	How well is the information provided in the ground vehicle tags correctly prioritized?  If answer was below "Fair", please give your reasons: ____ ____

Information Adequacy

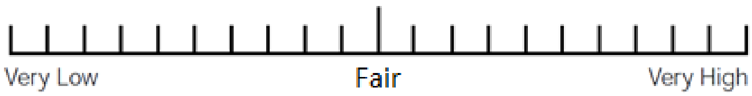
Question 29.	How well is the information displayed on the static information overlays adequate to perform your tasks?  If answer was below "Fair", please give your reasons: ____ ____
Question 30.	How well is the information displayed on the flight tags adequate to perform your tasks?  If answer was below "Fair", please give your reasons: ____ ____
Question 31.	How well is the information displayed on the ground vehicle tags adequate to perform

	your tasks?  If answer was below “Fair”, please give your reasons: ____ ____

Information Practicability and Intuitiveness

Question 32.	How well is the information displayed on the static information overlays easy to find and intuitive to be used?  If answer was below "Fair", please give your reasons: ____ ____
Question 33.	How well is the information displayed on the flight easy to find and intuitive to be used?  If answer was below "Fair", please give your reasons: ____ ____
Question 34.	How well is the information displayed on the ground vehicle easy to find and intuitive to be used?  If answer was below "Fair", please give your reasons: ____ ____

Command Feedback

Question 35.	How well do the commands inputted on the HMD provide an adequate feedback?  If answer was below "Fair", please give your reasons: ____ ____

Impact of the HMD

Question 36.	How well do the HMD outputs and feedbacks provide adequate support to perform your tasks?

	Very Low Fair Very High If answer was below "Fair", please give your reasons: ____ ____

Low Visibility Conditions

Question 29:	How well do the different overlays and tags reflect the information needed to operate under low visibility conditions? Very Low Fair Very High If answer was below "Fair", please give your reasons: ____ ____

Thank you for completing the questionnaire.