ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

enav group

Open Day Digital Technologies for Tower

PJ 05 Sol. 35 EXE 2.4 & Sol. 97.1 EXE 002



25 and 26 October 2022
Forlì, Italy

This project has received funding from the SESAR Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No 874470.

SUPPORTED BY sesar JOINT UNDERTAKING

Overview of Solution 97.1

Virtual/Augmented Reality Applications for Tower

Ramona Santarelli
Leader of Solution 97.1

UNIBO & ENAV OPEN DAY PJ05-W2 – DTT, Forlì (Italy), 25-26 October 2022

EUROPEAN PARTNERSHIP

Co-funded by the European Union

A spreading fast innovation









Forbes

ENTERPRISE TECH

The Top 10 Tech Trends In 2022 Everyone Must Be Ready For Now

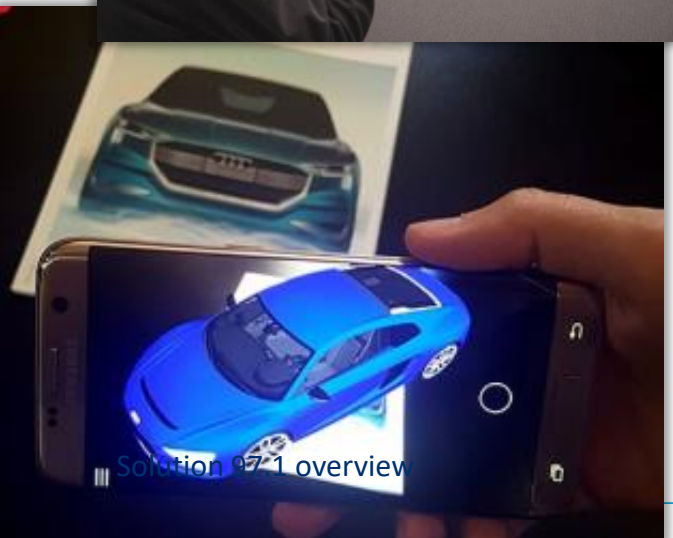
Bernard Marr Contributor

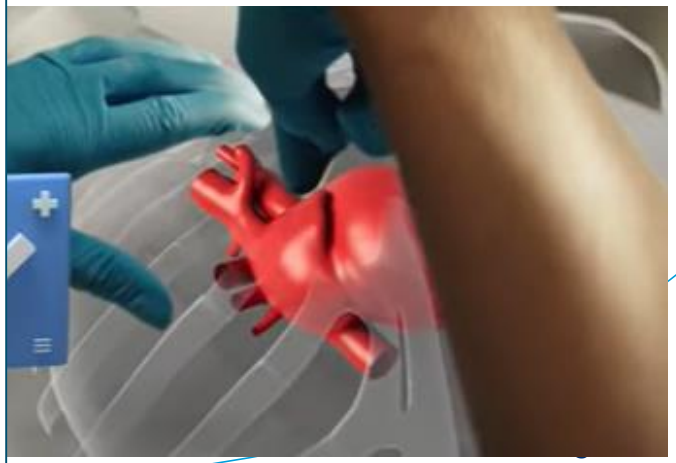
Follow

#6 Extended Reality

We now have more augmented reality (AR) capabilities on our devices (particularly our phones and tablets), and we're seeing an even bigger push toward virtual reality (VR). In 2022, we'll see new, lighter, more portable VR devices, so instead of having clunky headsets that require WiFi connections, we will have devices that are more like glasses that connect to our phones and give us superior VR experiences on the go.







New interaction experience



holograms projection

spatial un-derstanding

hand tracking

eye-sensor



Why in ATC Tower?



HEAD UP
out of tower view

HEAD DOWN
Screens
Keyboard
Strips







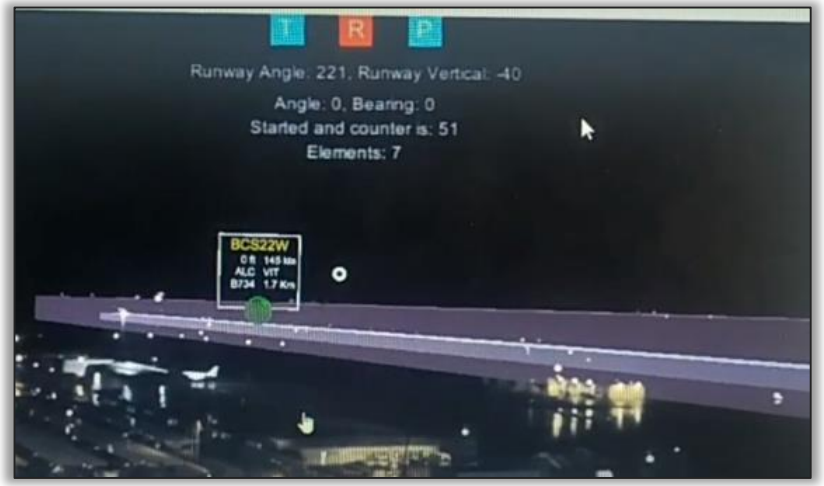
Augmented Reality

SESAR 1
•RETINA

SESAR 2020
•**Sol.97-1**

SESAR 3
•CONNECT

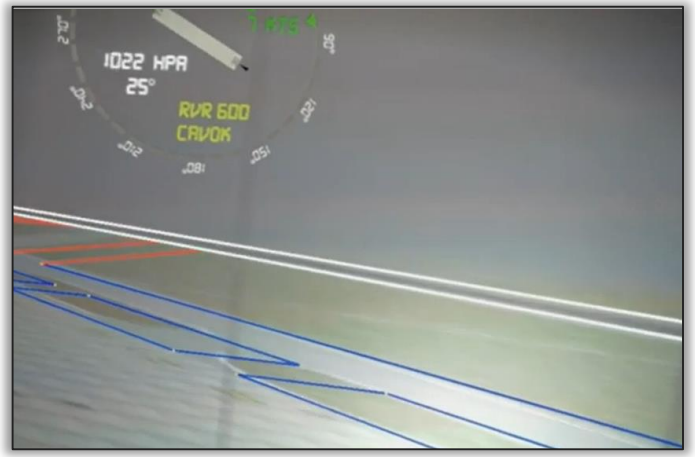
Keeping an augmented eye on the traffic



Tracking Labels



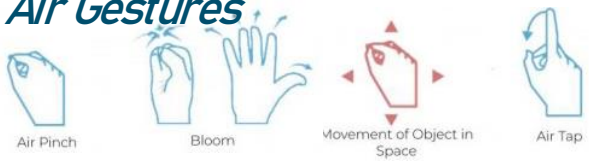
Attention Guidance – Safety cues

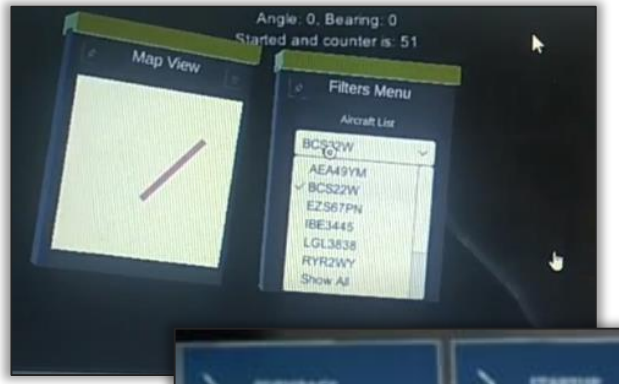


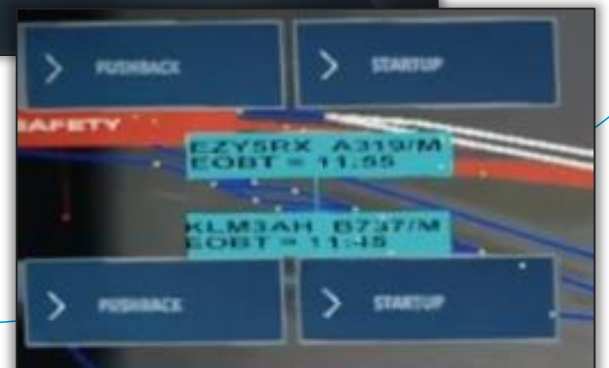
Aerodrome outlines
Meteo information



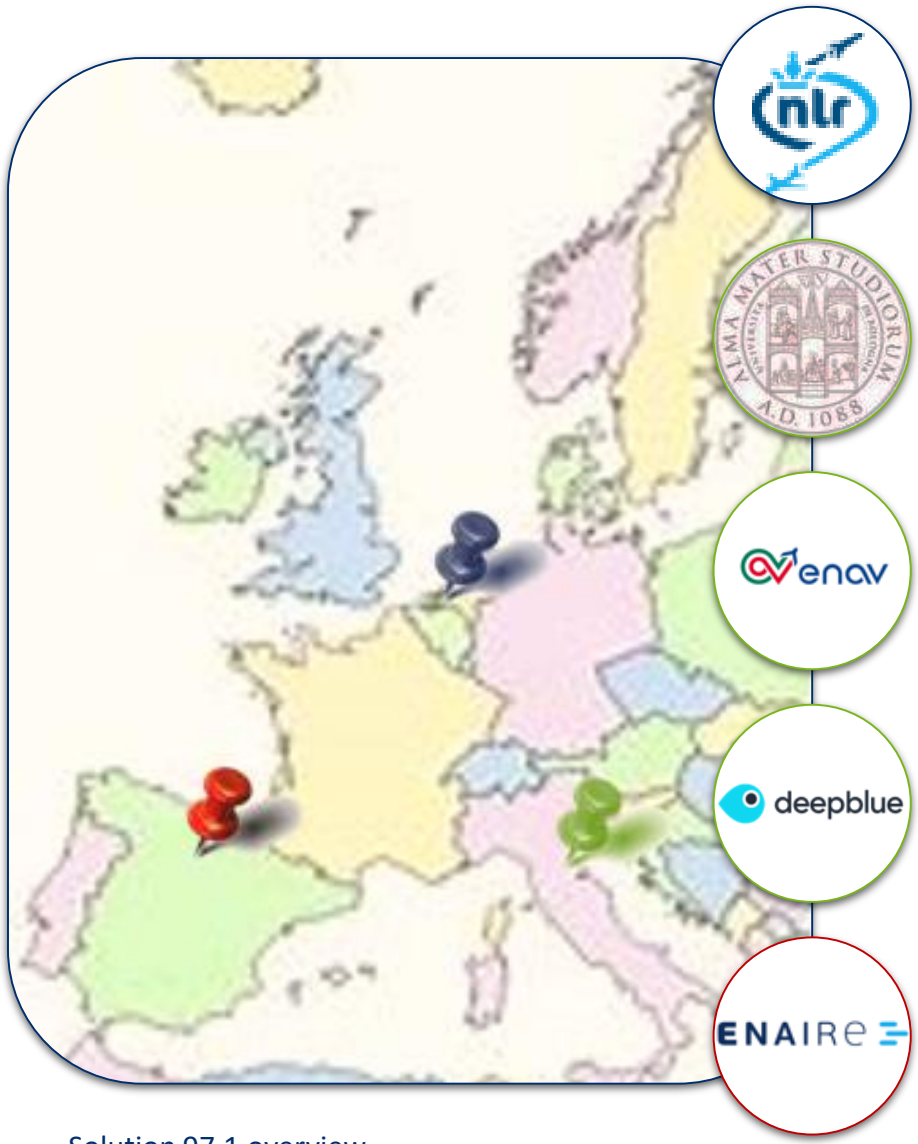
Air Gestures







Technical Validations



Solution 97.1 overview

Maturity

TRL 2 → TRL 4 → TRL 6

Maturity Gate

7 February 2023

Planning



Findings

Feasibility
Head up time
HMI Design
Usability
Workload and Situation Awareness
Safety
Alternative/additional mean

Expected benefits

	Key Performance Area	Key Performance Indicator
	CEF2 (ATCo EFFICIENCY and productivity)	Flights per ATCO hour on duty
	Safety	Indirect Safety Impacts
	Human Performance	User acceptability of the proposed solution (qualitative) Cognitive indicators
	Resilience	Loss of Airport Capacity Avoided


THANK YOU

Validation and Infrastructure Description

Virtual/Augmented Reality Applications for Tower

Sara Bagassi
Leader of EXE-002

UNIBO & ENAV OPEN DAY PJ05-W2 – DTT, Forlì (Italy), 25-26 October 2022

Augmented Reality Multimodal Control Tower Interaction EXE 002

Objective:

- to mature the results obtained in the previous RETINA validation campaign;
- including additional features that were not considered at exploratory research level, such as: adaptive HMI, working positions, multimodal interaction and safety nets visualization.

Expected achievements:

- Increase in situational awareness of the controller;
- Reduction of controller workload;
- Increased ATCO efficiency;
- Improved HMI and usability and performance of interactions;
- Increased or maintained safety.



sesar
JOINT UNDERTAKING

Technical Solution



OUTSIDE VIEW

AR OVERLAY

COMBINED VIEW



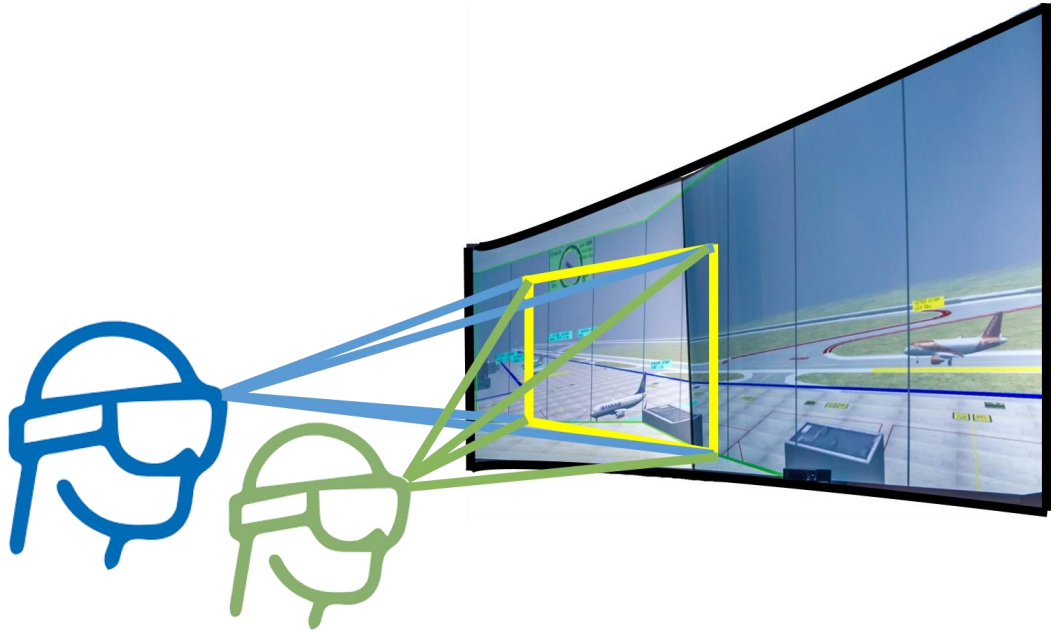




Adaptive HMI

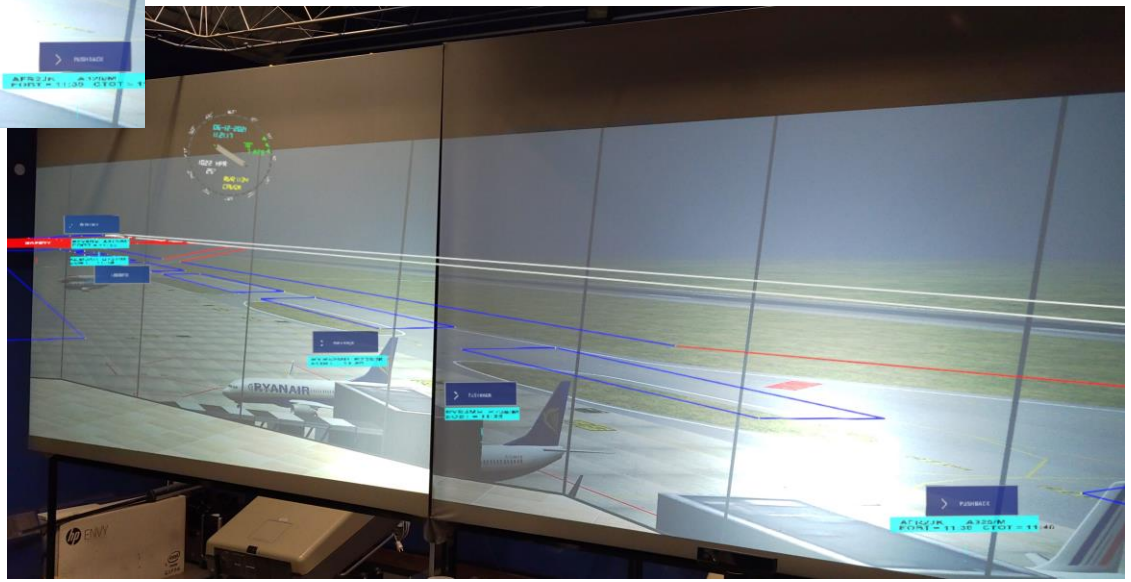
The information displayed onto the overlays depends on:

- Working position (GND/RWY)
- Phase of flight
- Visibility conditions

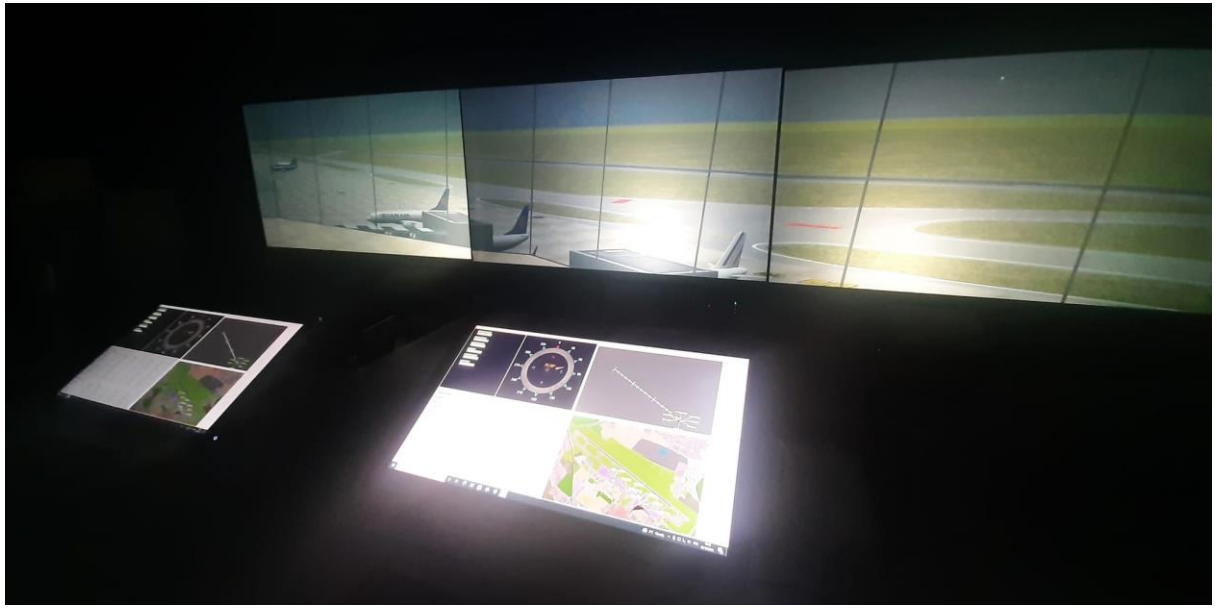


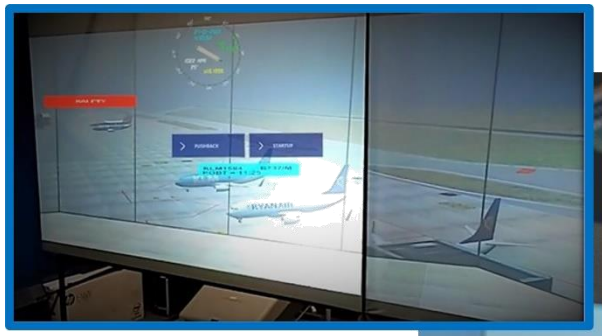
Adaptive HMI vs visibility condition



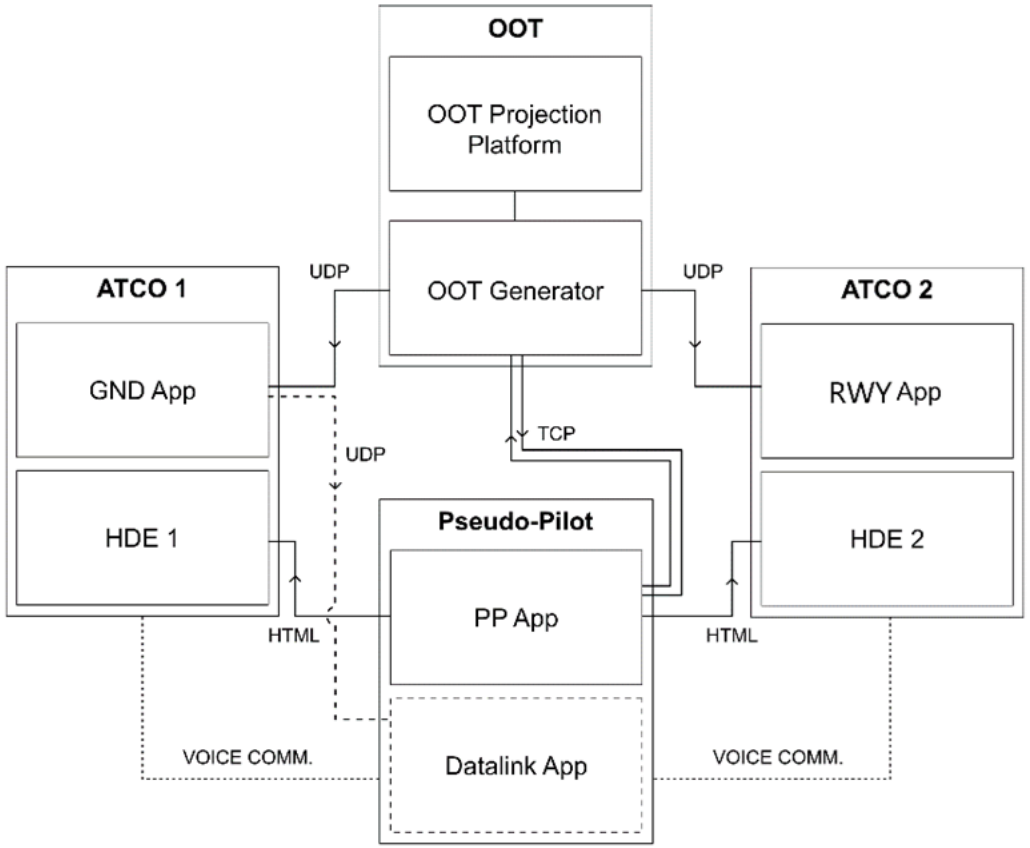


Platform Architecture



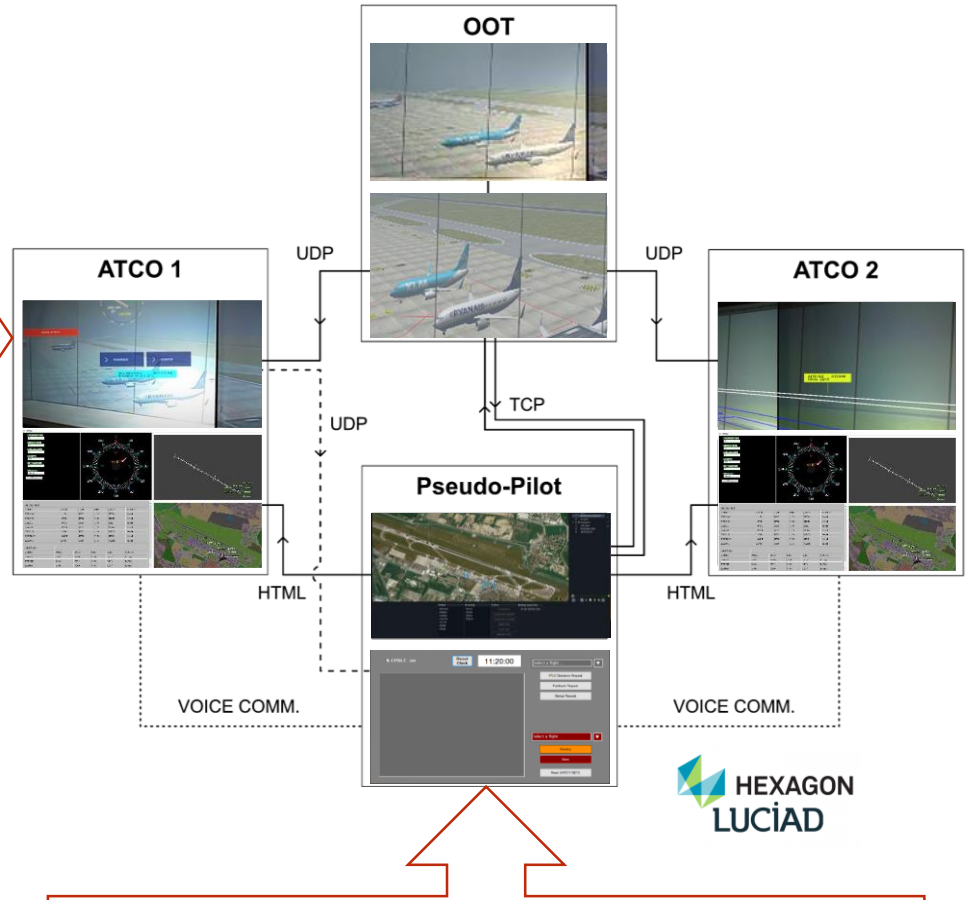






Provides the users with a **consistent scenario of the out of the tower view of Bologna** airport.

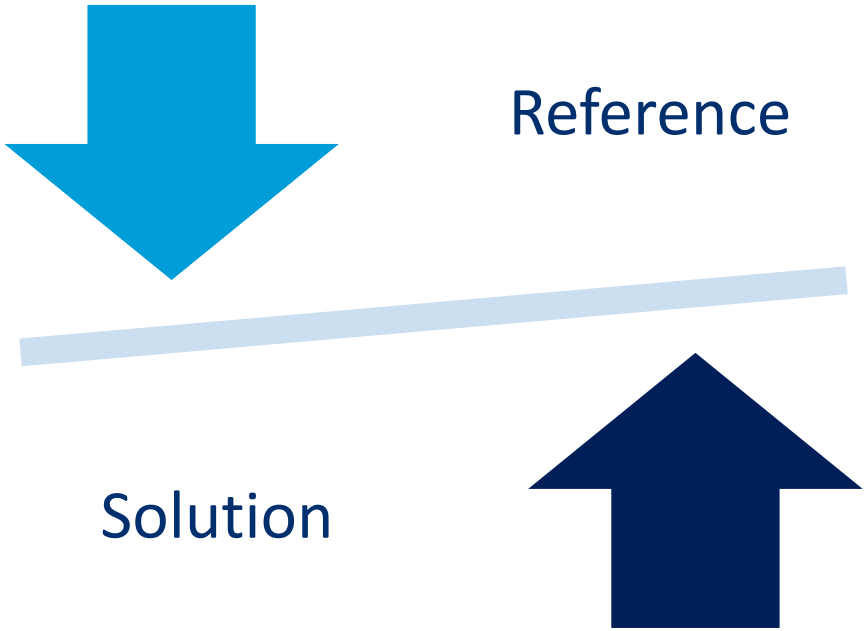
GND & **RWY App**, tailored wrt the user point of view and the specific information based on the working position, **deploy** the necessary **AR overlays** on two head mounted Microsoft **Hololens2** displays. The **ATCOs** can **simultaneously see** the **out of the tower** view and the **AR overlays.**



The **HDE** is the same for the two controller working positions (CWP) and replicates in a **simplified interface the actual HDE of the control towers**.

Enables the pseudo-pilot to **update the state of the 4D model in accordance with the ATCOs instructions**. For the scenario related to Air Gestures, a allow the user to both **send specific clearance requests and receive datalink-like messages from the ATCOs.**

Experimental Plan



	Reference	Solution
Scenario 1 (40' VISIBILITY VARIATION: 15' CONDIVIS1 10' CONDIVIS2 15' CONDIVIS3)	EXE-002-001	EXE-002-002 (VAR+TKL)
		EXE-002-003 (VAR+TKL+AG) 15' CONDIVIS1
Scenario 2 (30' CONDIVIS1 UNUSUAL)	EXE-002-004	EXE-002-005 (VAR+TKL+SN)

- 10 ATCOs
- 5 full days of simulation
- 25 run in total
- 5 repetitions of each batch of exercises
- 5 different teams of GND and RWY controllers – Average years of experience = 18.4
- No rotation of the ATCOs amongst the positions to make a good comparison between reference and solution
- GND ATCO trained on the gestures before the exercise



Virtual/Augmented Reality Applications for Tower: an operational perspective

Carlo Alfredo Persiani
Operational leader for EXE-002

UNIBO & ENAV OPEN DAY PJ05-W2 – DTT, Forlì (Italy), 25-26 October 2022

EUROPEAN PARTNERSHIP

Co-funded by the European Union

Concept

Superimposition of synthetic overlays to the real out-of-the-tower view.



Overlays

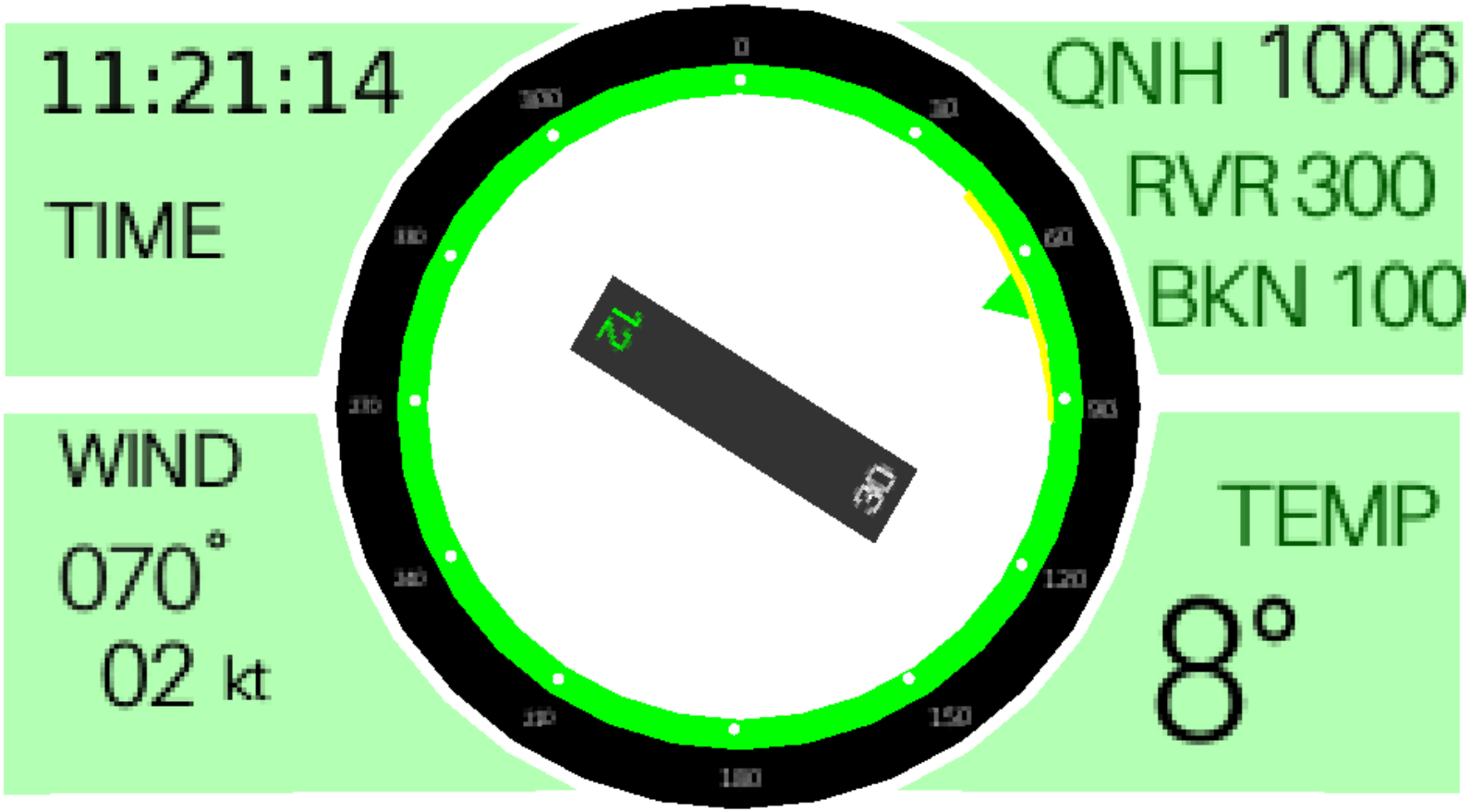
- ✓ Operational information
- ✓ Position
- ✓ Synthetic representation of the operational environment

Adaptive HMI

- ✓ Operational position
- ✓ Type of operations (departure/arrival and flight phase)
- ✓ Weather conditions



Information overlay: Meteo

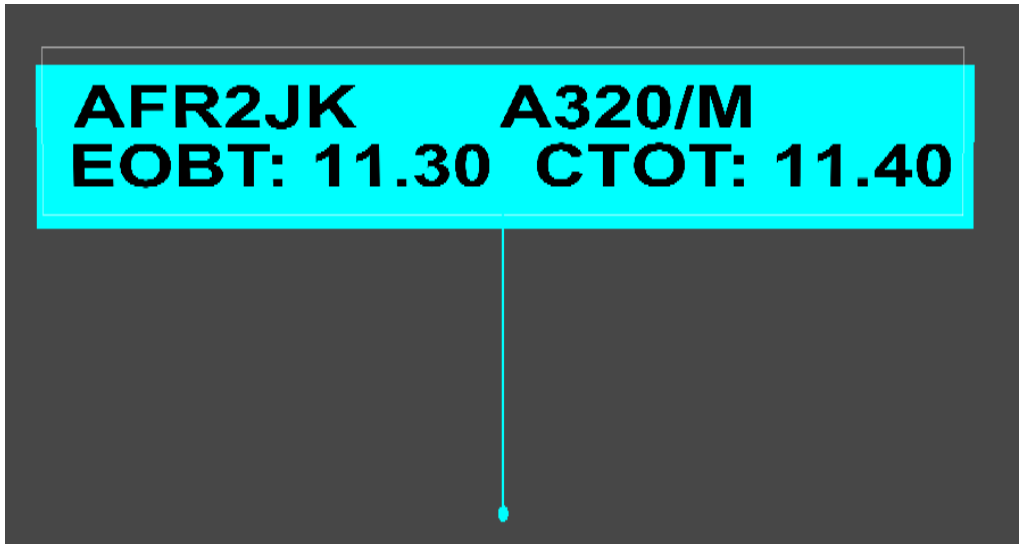


Information overlay: departure label

- The Departure label appears when the READY message is received from the handler. They contain 2 kinds of information (permanent and adaptive)

Call Sign

Afc Type/WCAT



Taxi

Push back

Hold Position

Take off

Estimated Off Block Time

Calculated Take Off Time

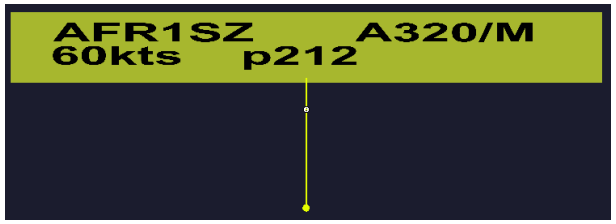
Information overlay: Arrival Label

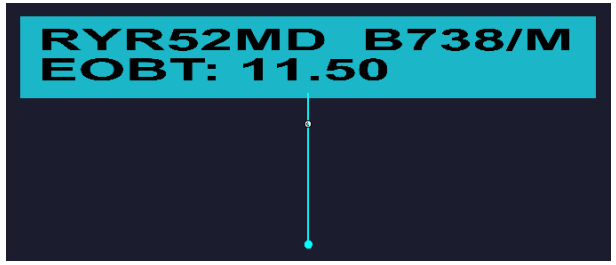
- The arrival label appears when the flight is at a specific distance on final. Also arrival labels contain two kinds of information (permanent and adaptive)

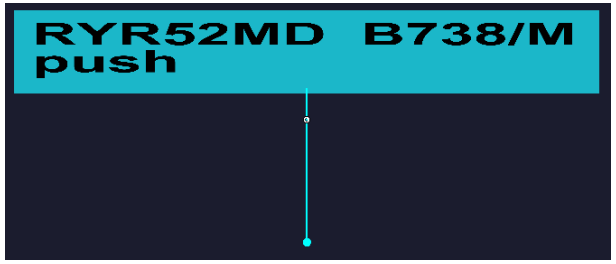


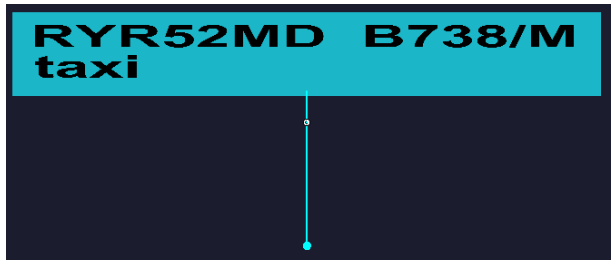
Adaptive HMI vs phase of flight

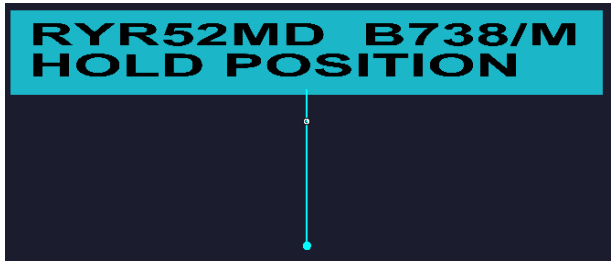


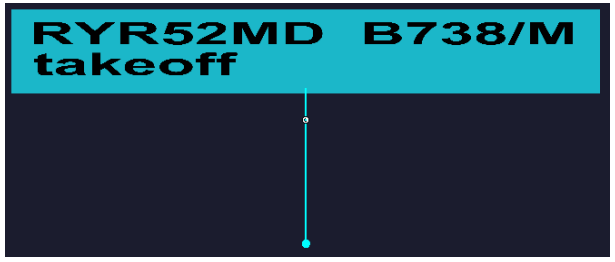








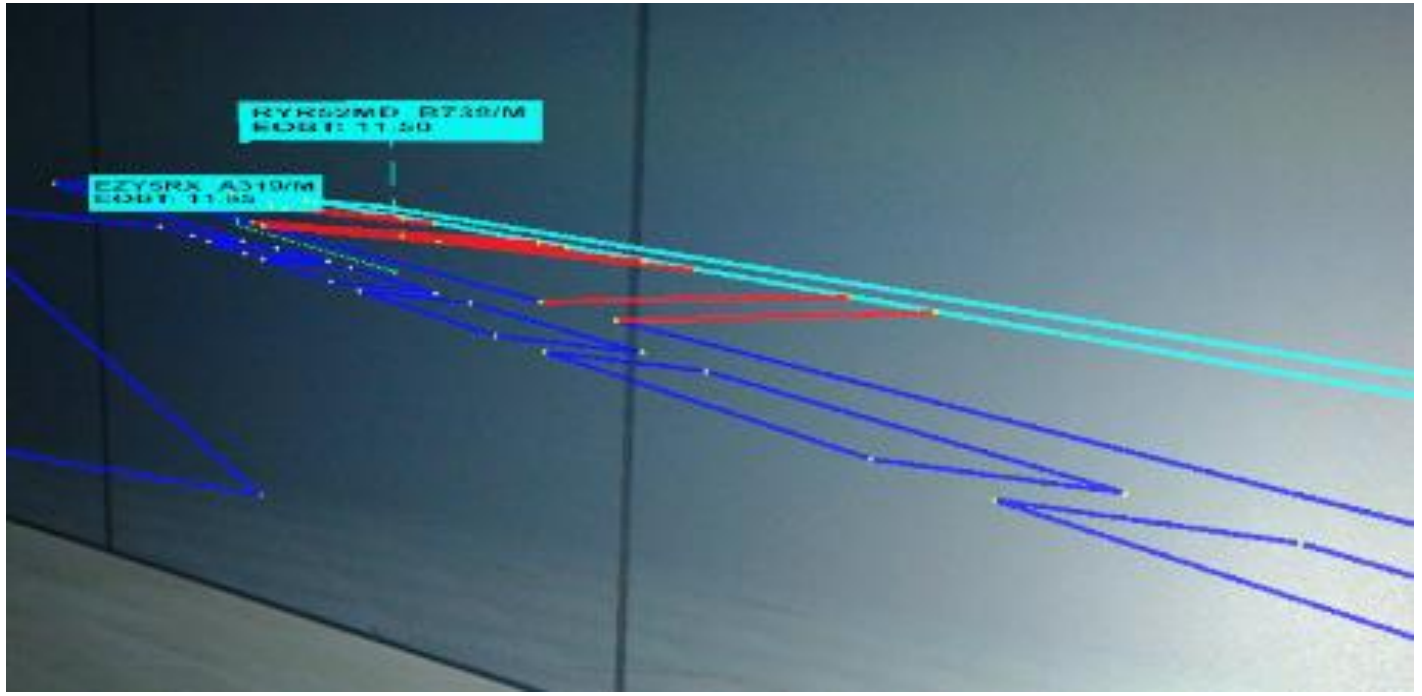




Airport layout overlay

Manoeuvering area layout

RWY status



Taxiway closed

Taxiway not available

A new operating method



Classic working method VS V/A reality working method

- ✓ Operational information is reported in the relative system (position information on radar screen, meteo info on meteo system as E-AWOS, EOBT and CTOT in data processing systems, etc.)
- ✓ The controller must search and find single information selecting the correct screen/system
- ✓ In low vis condition the out of twr view simply does not exist
- ✓ Many screens are required and they can shut the out of tower view

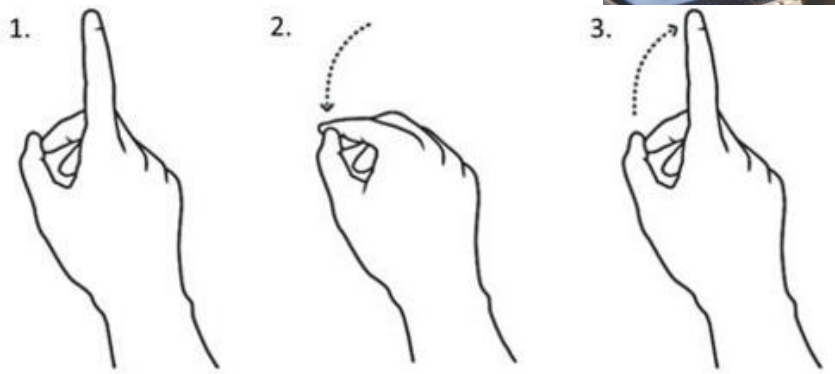
- ✓ Operational information is reported as overlays in the adaptive HMI. Focus on the traffic, less head down operations.
- ✓ The controller finds the information as overlay on his/her view. Focus on the traffic.
- ✓ In low vis condition the out of tower view becomes a synthetic representation of the reality
- ✓ Less screens less «visual pollution»

Air Gesture Interaction

Only for not-time critical tasks:

- Pushback
- Start-Up





A new operating method: air gesture

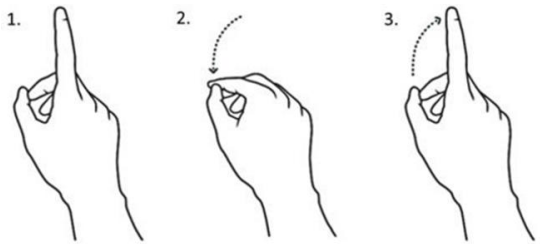
Classic working method

- ✓ The controller receives the r/t call from ready aircraft
- ✓ The controller searches on the the systems the flight data and check if all is OK (EOBT and CTOT)
- ✓ The controller selects the flight and starts DL dialogue sendig Start-up message.
- ✓ The controller sends the push-back message.

VS

V/A reality working method

- ✓ The controller receives the r/t call from ready aircraft
- ✓ The controller just looking outside the TWR is able to see and immediately check all information
- ✓ The controller with one gesture sends the start-up message.
- ✓ The controller with one gesture sends the push back message.



Safety Nets

Conflicting clearances

- ✓ The controller is provided with alert on the V/A reality label of the aircraft involved in conflicting clearances and aural warning

10 scenarios are identified:

Line-up vs line-up (LUP/LUP)

Line-up vs Enter or Cross (LUP/CRS)

Line-up vs take-off (LUP/TOF)

Line-up vs land (LUP/LND)

Cross or enter vs cross or enter (CRS/CRS)

Cross or enter vs take-off (CRS/TOF)

Cross or enter vs land (CRS/LND)

Take-off vs take-off (TOF/TOF)

Take-off vs land (TOF/LND)

Land vs land (LND/LND)

RWY Incursion

- ✓ The controller is provided with alert on the synthetic representation of the runway

A new operating method: safety net

Classic working method

- ✓ The controller provides aircraft with 2 conflicting clearences (input in electronic strips)
- ✓ The controller receives alert from electronic strips system.
- ✓ In case of rwy incursion the controller receives alert from electronic strips system or via the radar screen

VS

V/A reality working method

- ✓ The controller provides aircraft with 2 conflicting clearances (input in electronic strips or speech recognition)
- ✓ The controller receives alert via the V/A reality labels and from eletronic strips system (if available)
- ✓ In case of runway incursion, the controller receives alert also from V/A reality overlays. The synthetic representation of the runway is highlighted.

THANK YOU FOR YOUR ATTENTION

Co-funded by the European Union

Solution 97.1 EXE-002 Validation Results

LAURA MOENS
Validation Expert

UNIBO & ENAV OPEN DAY PJ05-W2 – DTT, Forlì (Italy), 25-26 October 2022

EUROPEAN PARTNERSHIP

Co-funded by the European Union

Human Performance & Safety (Post-Run)

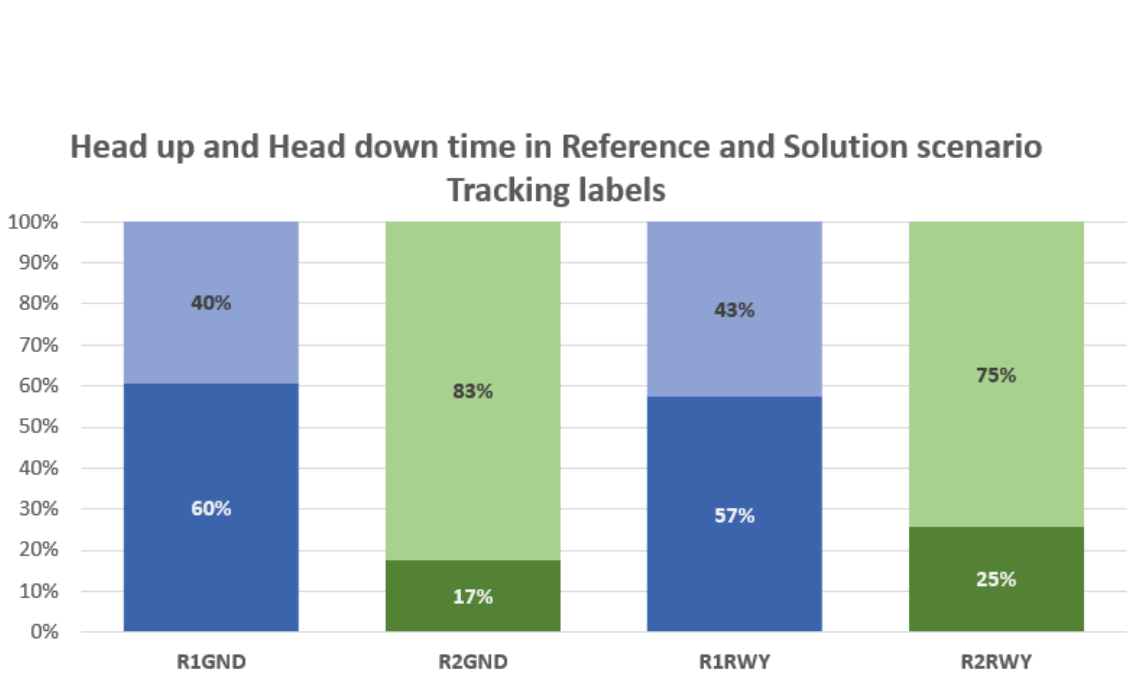
			Tracking Labels		Safety Net	
			REF	SOL	REF	SOL
HUMAN PERFORMANCE	MENTAL WORKLOAD	GND	👍	👍	👍	👍
		RWY	👍	👍	👍	👍
	ACCEPTANCE	GND	👍	👍	👍	👍
		RWY	👍	👍	👍	👍
	PHYSICAL ERGONOMICS	GND	👍	!	👍	👍
		RWY	👍	👍	👍	👍
HYBRID	SITUATION AWARENESS	GND	👍	👍	👍	👍
		RWY	👍	👍	👍	👍
SAFETY	SAFETY LEVEL	GND	👍	!	👍	!
		RWY	👍	👍	👍	👍

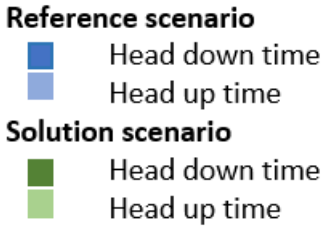
Other Human Performance indicators (Post-Exe)

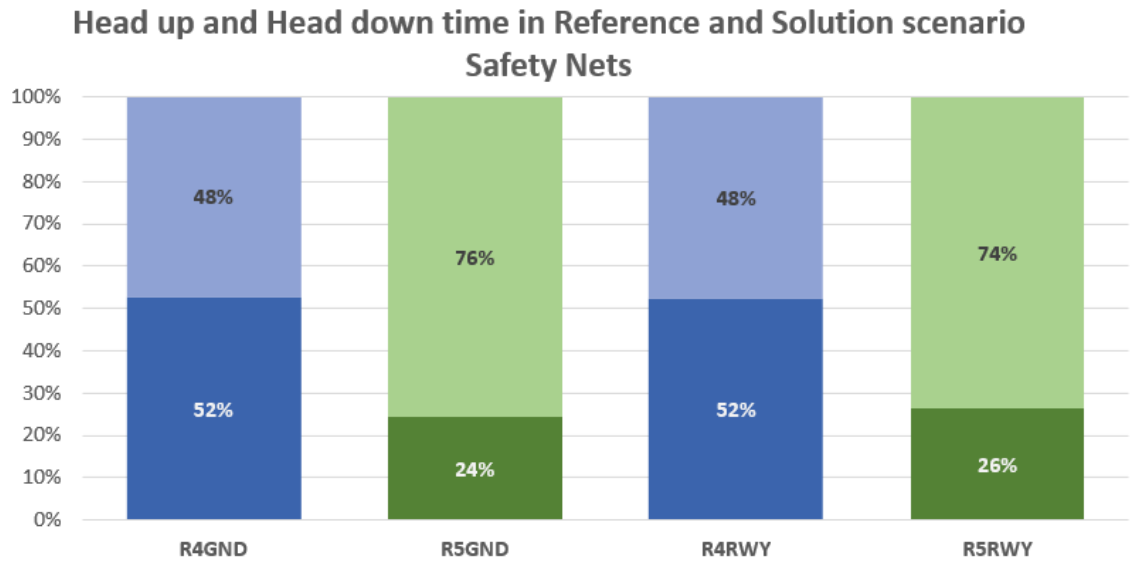
		TL	SN
Potential for Human Error	**GND**	↑	↑
	RWY	→	↑
Trust	**GND**	↑	↑
	RWY	↑	↑
Usability	**GND**	→	↑
	RWY	↓	↑
Job Satisfaction	**GND**	→	↑
	RWY	↑	↑

↑ = improved compared to REF
→ = same as in REF
↓ = negatively impacted compared to REF

Head-Up/Head-Down time

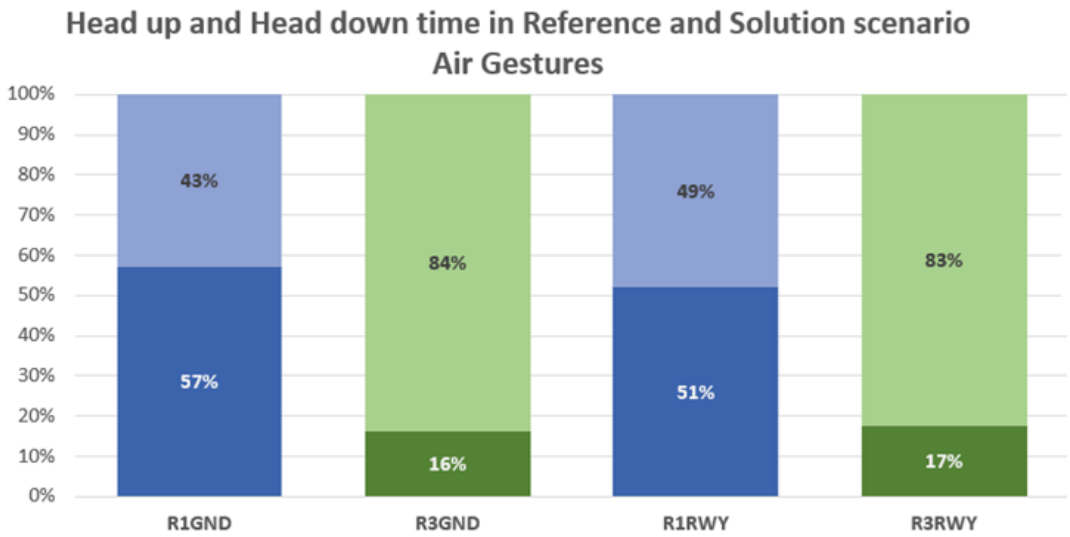






Air Gestures





Conclusion & Recommendations

Feedback from controllers showed that the prototype for V/A-R supports controllers in maintaining an acceptable level of workload, (team) situation awareness, the potential for human error, trust, acceptance, job satisfaction, and perceived safety. Moreover, time spent in head-up increased in the solution scenario with respect to the reference scenario.

The prototype for V/AR with Safety Nets improved the perceived safety performance.

- Usability can be improved by designing the tracking labels in a way that they do not overlap each other and/or cover the background.
- Air Gestures need to be refined so that ATCOs do not have difficulties using them. It should be considered to use Air Gestures only for non-critical clearances.

THANK YOU FOR YOUR ATTENTION