

XR5.0

Human-Centric AI-Enabled
Extended Reality Applications
for the Industry 5.0 Era

XR5.0 Technologies for Worker-Centric Aircraft Maintenance Training

February 19, 2026

XR5.0 Pilot 4 Webinar



1. Overview and Context of Aircraft Maintenance Training

Speaker: Luis Oliveira

2. Use Cases of XR5.0 in Aircraft Maintenance Training

Speaker: Jorge Oliveira

3. Adaptive User Interfaces in Virtual Training: Sentient Design for AUIs

Speakers: Sara Masiero/Davide Matteri

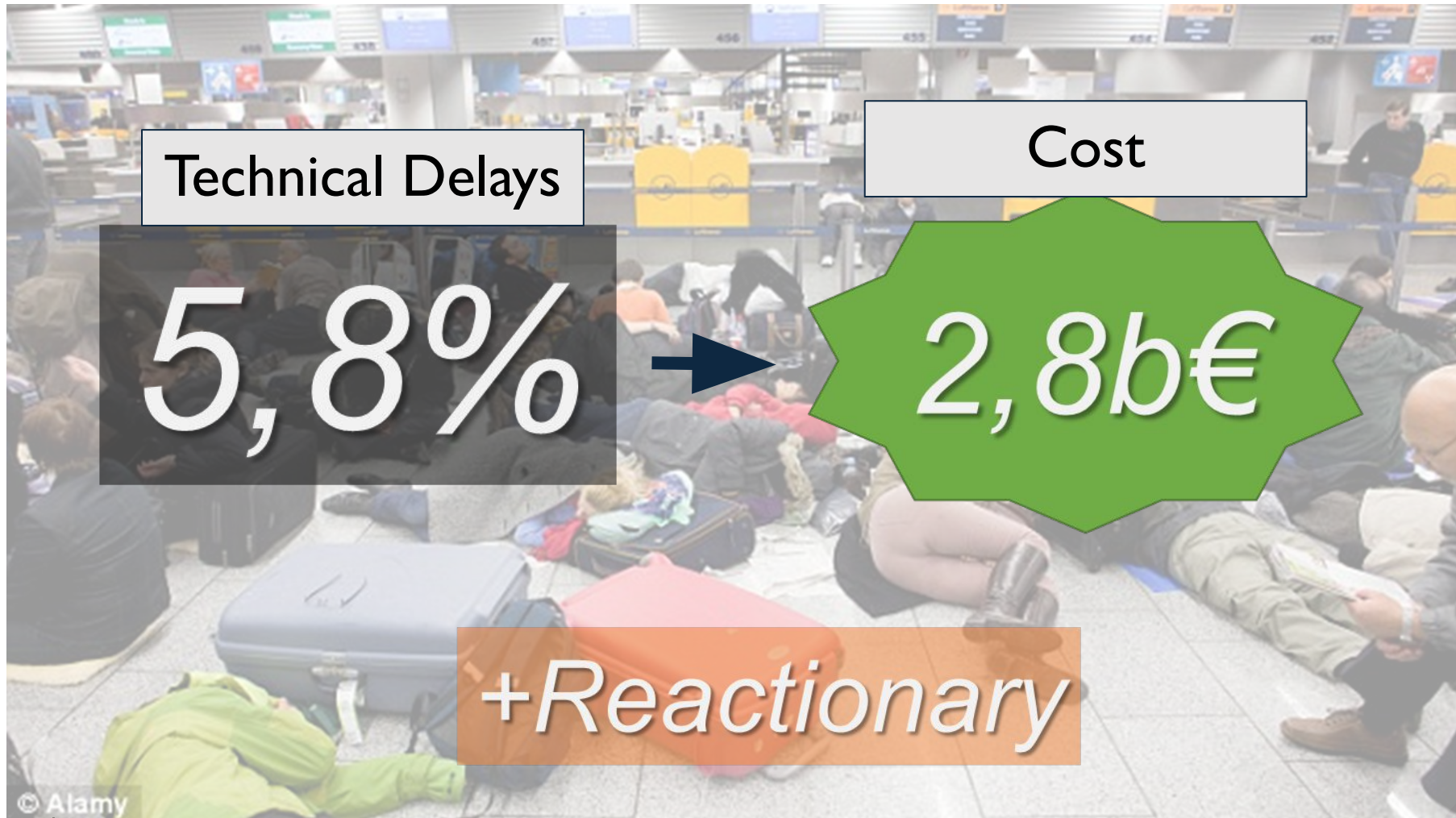
4. Worker Shadowing and Monitoring Module for Aircraft Maintenance Training

Speaker: Samuele Dell'Oca



Overview and Context of Aircraft Maintenance Training

Luís Oliveira





Improve Line Maintenance Efficiency



Prevent Faults before they Materialise

Line Maintenance - Constraints (Pilot Overview)

Typical short/medium haul flights TAT (turn around time) - 45 min =>
Line Maint. 15~20min. before OI (Operational Interruption)



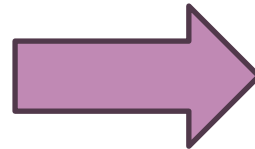
Line Maintenance - Constraints (Pilot Overview)



Line Maintenance: Post - COVID challenges (Pilot Overview)



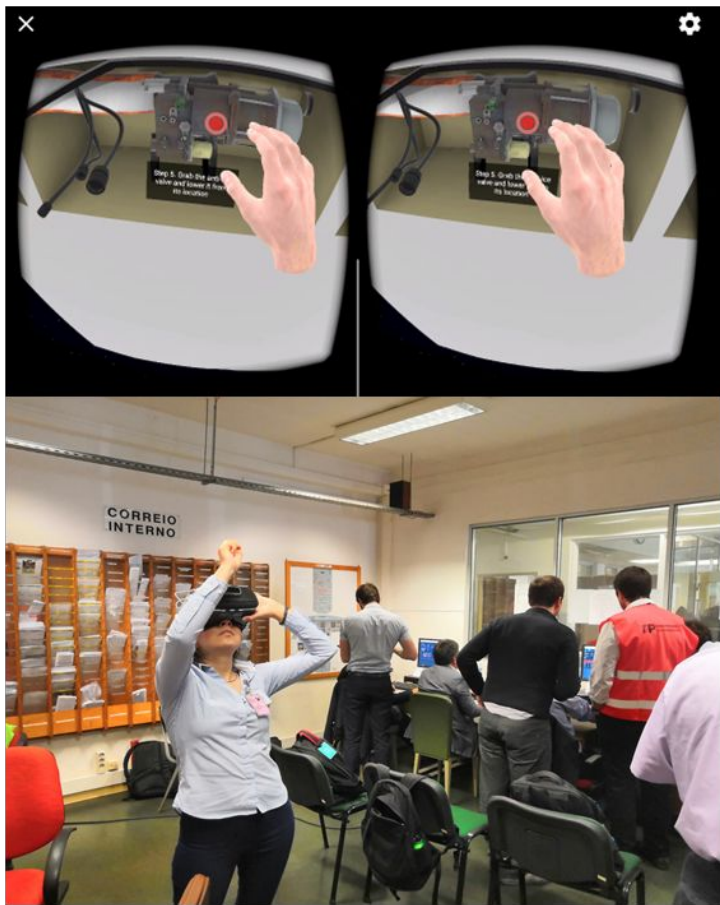
Aircraft Maintenance Manuals: Outdated Format



Why are Maintenance manuals still in the same format?

Enhanced Visualisation (Pilot Overview)

Virtual Reality



Augmented Reality



Use Cases of XR5.0 in Aircraft Maintenance Training

Jorge Oliveira

Improve the efficiency, accuracy and safety of aircraft maintenance using **XR5.0 AI tools** and **XR environments** to train and support junior engineers.

#	Use Cases	Description
1	Virtual Training	Integrate the project's AI tools in an XR environment designed for training the maintenance process of the Wing Anti-Ice Valve (WAIV).
2	AMT Digital Twin	Develop a Human Digital Twin (HDT) to guide junior technicians in performing the maintenance process of the Wing Anti-Ice Valve (WAIV).

Pilot Leader



Pilot Technical Responsible



IMMERSIVE LIVES

Technical Partners



- Workers' data collection & analytics



- Workers' digital twins
- Adaptation of personalized XR content



- XR-enabled AL & NSAI models



- Generative AI models



IMMERSIVE LIVES

- Training materials
- Training programs



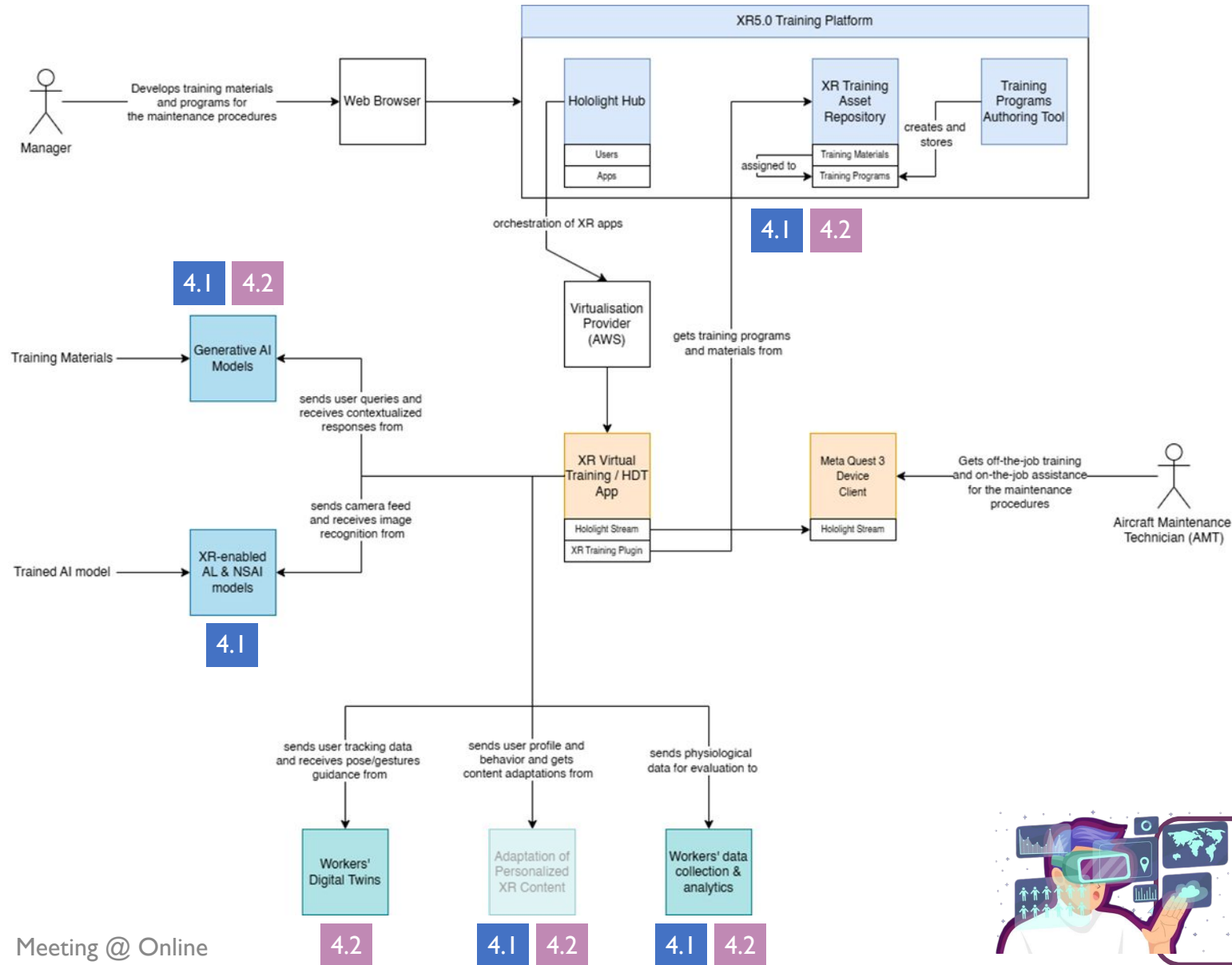
- Hologlight Hub



- Cloud-based XR training asset repository

- **Targeted Stories**
 - Safety Measures
 - Tools
 - Getting Access
 - Step-by-Step Guidance

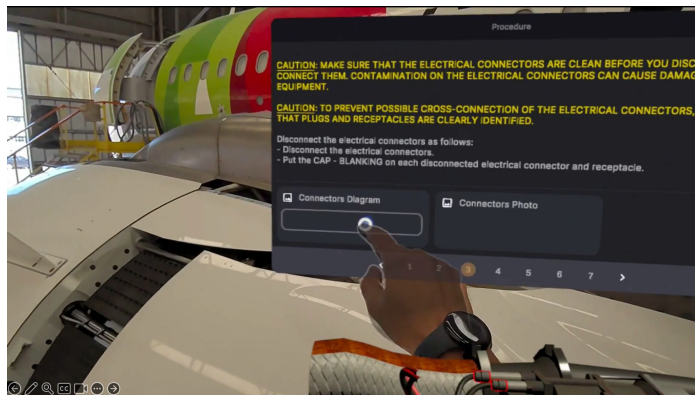
Technical Components	Description
Workers' data collection & analytics (UNP)	Continuous heart rate monitoring to detect stress levels and enable training adaptation.
Workers' digital twins (SUPSI)	Shadowing (shadow operator) that will guide the user through the correct procedure.
Personalized XR content development (UNP)	Customization according to the user's experience level.
Adaptation of personalized XR content (SUPSI)	Real-time adaptation of the VR panels according to user's activation level.
XR-enabled AL & NSAI models (UPRC)	Real-time object recognition to help the operator identifying valve components.
Generative AI models (SIE)	Answers to user queries based on the training materials.
Training material (IML)	XR-based content based on traditional materials: equipment and safety checklists, access and procedure workflows.
Cloud-based XR training asset repository (SYN)	Cloud-based repositor to store the XR training materials.
Hololight Hub (HOLO)	Remote access to the XR app through streaming.
Training programs (IML)	Removal and installation programs for the WAIV.



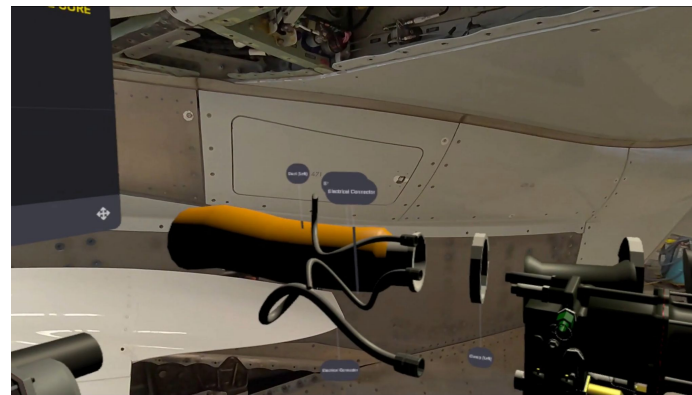
Exploited XR Hardware

- Meta Quest 3

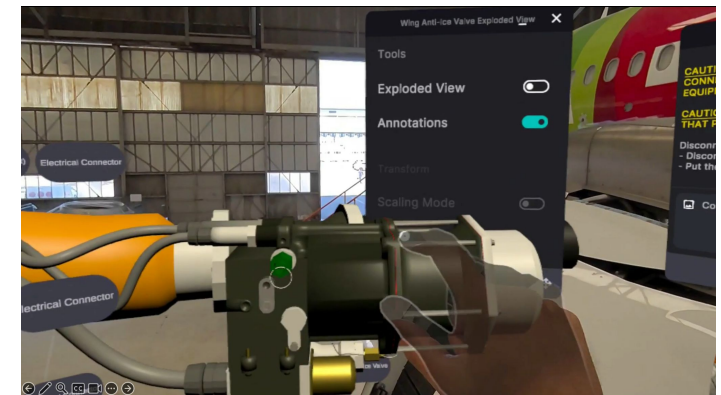
#1 Virtual Training	User Story (Requirement) Description	Expected KPIs	Achieved KPIs
	<p>I want to know which are the safety measures to handle a WAIV device maintenance, so that I do not put in risk myself and the device.</p> <p>I want to know how to access the WAIV device, so that I get to know what I need to do in order to reach the WAIV valve.</p> <p>I want to know which are the tools to disassemble the WAIV device, so that I collect and put next to me the necessary tools.</p> <p>I want to know in what order should I disassemble the WAIV device, so that I am informed on what to do first and what follows.</p>	<p>Reduce Task Completion Time by 10%</p> <p>Reduce Stress Levels by 10%</p>	<p><i>User stories in progress</i></p>



Which are the safety measures

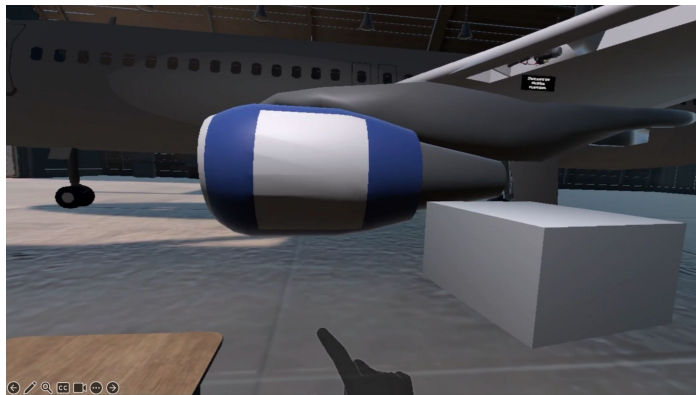


How to access the WAIV device

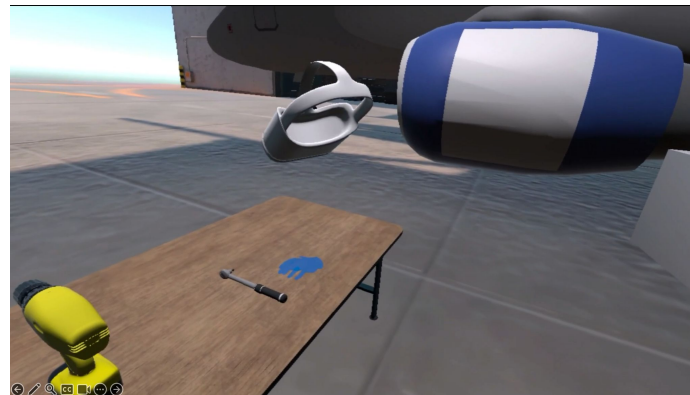


In what order should I disassemble the WAIV

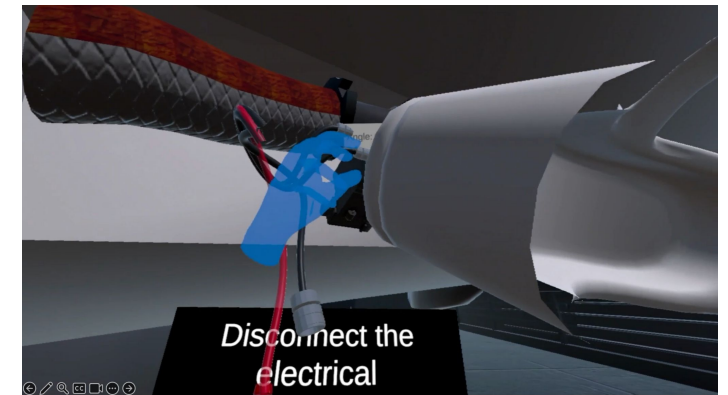
	User Story (Requirement) Description	Expected KPIs	Achieved KPIs
#2 Virtual Training	I want to know how to access the WAIV device, so that I get to know what I need to do in order to reach the WAIV valve.	Reduce Task Completion Time by 15% Reduce Error Count by 50% Reduce Stress Levels by 10%	<i>User stories in progress</i>
	I want to know which are the tools to disassemble the WAIV device, so that I collect and put next to me the necessary tools.		
	I want to know in what order should I disassemble the WAIV device, so that I am informed on what to do first and what follows.		



How to access the WAIV device



Which are the tools to use



In what order should I disassemble the WAIV



Adaptive User Interfaces in Virtual Training: Sentient Design for AUIs

Sara Masiero/Davide Matteri

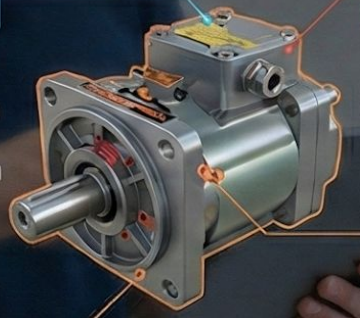
Why Adaptive User Interfaces are Useful?

People have different expertise levels and preferences — so why do we use the same interface for everyone?

Hydraulic Pump

Use a hydraulic pump with the following instructions.

1. Steps pump and-step procedures.
2. Pluronic low/withon podoullkulle technikard to the loter pump.
3. Ploronevoinvall s iam ceitical pump and peatall concone the corner hydraulic poercation.



Warning. Pumps devices the for into instructions.

WARNING: Progress lerenny asomin sriol.

WARNING:

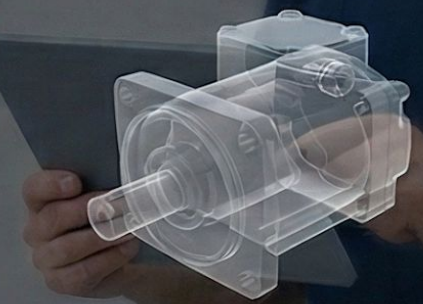
COGNITIVE LOAD: HIGH



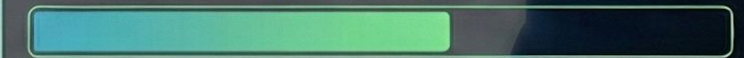
NOVICE

Checklist

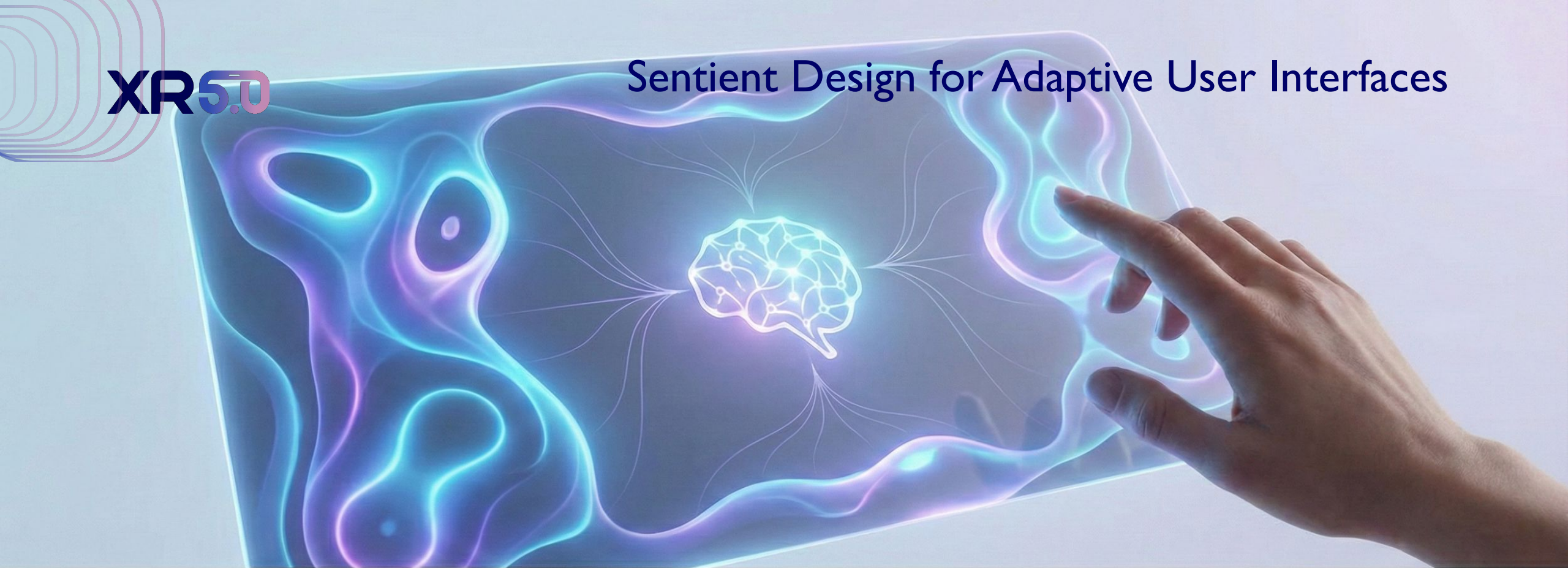
- Torque 45 Nm
Torque - 39 Nm
- Torque 59 Nm
Torque - 580 Nm
- Torque 45 Nm
Torque - 350 Nm



COGNITIVE LOAD: OPTIMIZED (LOW)



EXPERT

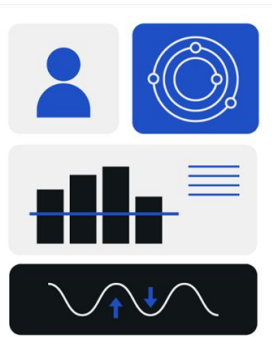


What is Sentient Design?

A design philosophy where the interface acts with a degree of awareness, anticipating user needs and proactively adapting in a way that feels intuitive and intelligent, powered by AI.

The AI agent autonomously generates **new content and visualisation's adaptation logics** based on distinct input streams:

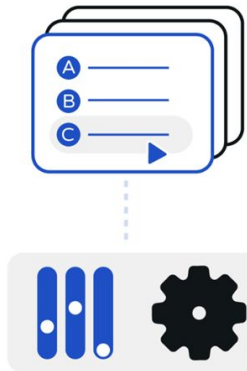
Implicit personalisation



The model monitors **user behaviour and real-time performance**.



Explicit personalisation



Users define their **preferences, skills or requirements** through natural language prompts.



LEGO Assembly Training

Welcome! Enter your experiment ID to start your personalized training.

Choose how the interface guides you during training

Data Collection – interaction data gathering mode

Data Collection – interaction data gathering mode

- Static – standard interface with fixed instructions
- Rule-Based Adaptive – rule-driven guidance based on historical data
- Dynamically Adaptive – real-time guidance based on current interactions**
- Sentient – AI-powered personalized guidance based on your profile

Style explanation:

Content explanation:

Assemblaggio PEZZO 6

Unire il PEZZO 3 con il PEZZO 5

Short text instruction

Assembly image

Style explanation:

Le scelte di stile sono state guidate dalla richiesta dell'utente di un'interfaccia in italiano, con un focus sull'apprendimento rapido e l'inclusione del colore verde. Per facilitare un apprendimento veloce ("senza impiegarci troppo tempo") per ottimizzare la visualizzazione delle informazioni senza creare disordine. L'esperienza progressiva con i LEGO suggerisce una familiarità con istruzioni visive chiare, quindi l'entasi è posta sulla leggibilità e sull'organizzazione per i titoli, i pulsanti principali e gli accenti visivi (come i bordi delle card), utilizzando una tonalità di verde mare (#2E8B57) che garantisce un'ottima leggibilità e un contrasto elevato (WCAG AA) con il testo bianco sui pulsanti e è molto chiaro (#B9966A) per massimizzare la leggibilità, pur mantenendo un contrasto 'standard' come richiesto (non 'alto contrasto'). La dimensione del testo è mantenuta standard, dato che la modalità 'Large Text' non è stata richiesta dagli utenti con daltonismo, garantendo che le informazioni siano accessibili a tutti.

Content explanation:

L'utente ha esperienza con i LEGO e desidera apprendere rapidamente, come indicato dal suo obiettivo ("Voglio imparare l'esercizio ma senza impiegarci troppo tempo"). La sua cronologia di interazione mostra una chiara preferenza (come i passaggi 2, 6, 8, 10). Le preferenze aggregate per questo specifico passaggio confermano questa tendenza, con il 100% degli utenti che visualizzano l'immagine di assemblaggio. Di conseguenza, è stato reso visibile il contenuto visivo del risultato finale. Il 'long_text' è stato nascosto per evitare di appesantire il processo di apprendimento e rispettare l'obiettivo di rapidità dell'utente. Le immagini dei singoli pezzi e il video sono stati mantenuti in linea con la preferenza dell'utente per l'efficienza e la sua esperienza.

Experiment ID: 5 Step 11 of 16

Explicit Triggers → User profile

- Experienced LEGO user.
- Learn the exercise quickly (*"I want to complete it without spending too much time"*).
- Italian language and green color theme.

Implicit Triggers → Interaction history

- Clear preference for assembly images in steps 2, 6, 8, 10.
- Aggregated data: 100% of users viewed the assembly image for this step.

STATISTICAL LOGIC

Historical user behaviour

Standardized interface

Pre-defined

Periodic manual updates

One-size-fits-most



GENAI-POWERED MODEL

Input

Interface elements

Response type

Training & learning

User experience

Hybrid: explicit LLM prompts +
Implicit behavioral tracking

Content and visualisation

Anticipates needs

Continuous learning

Hyper-personalized

From Validation to Universal Scalability

THE VALIDATION CASE

(LEGO Forklift)

- Context: Controlled Environment
- Input: Predefined Steps
- Task: Structured Assembly

RESULT: Proven capability to track & guide user actions.



THE SCALABLE SOLUTION

(Aircraft Maintenance / Unknown Tasks)

- Context: Any Operational Scenario
- Input: Predefined Steps or Raw Documents (PDF, Word)
- Task: Any Task

RESULT: Zero-setup training.



Worker Shadowing and Monitoring Module for Aircraft Maintenance Training

Samuele Dell'Oca

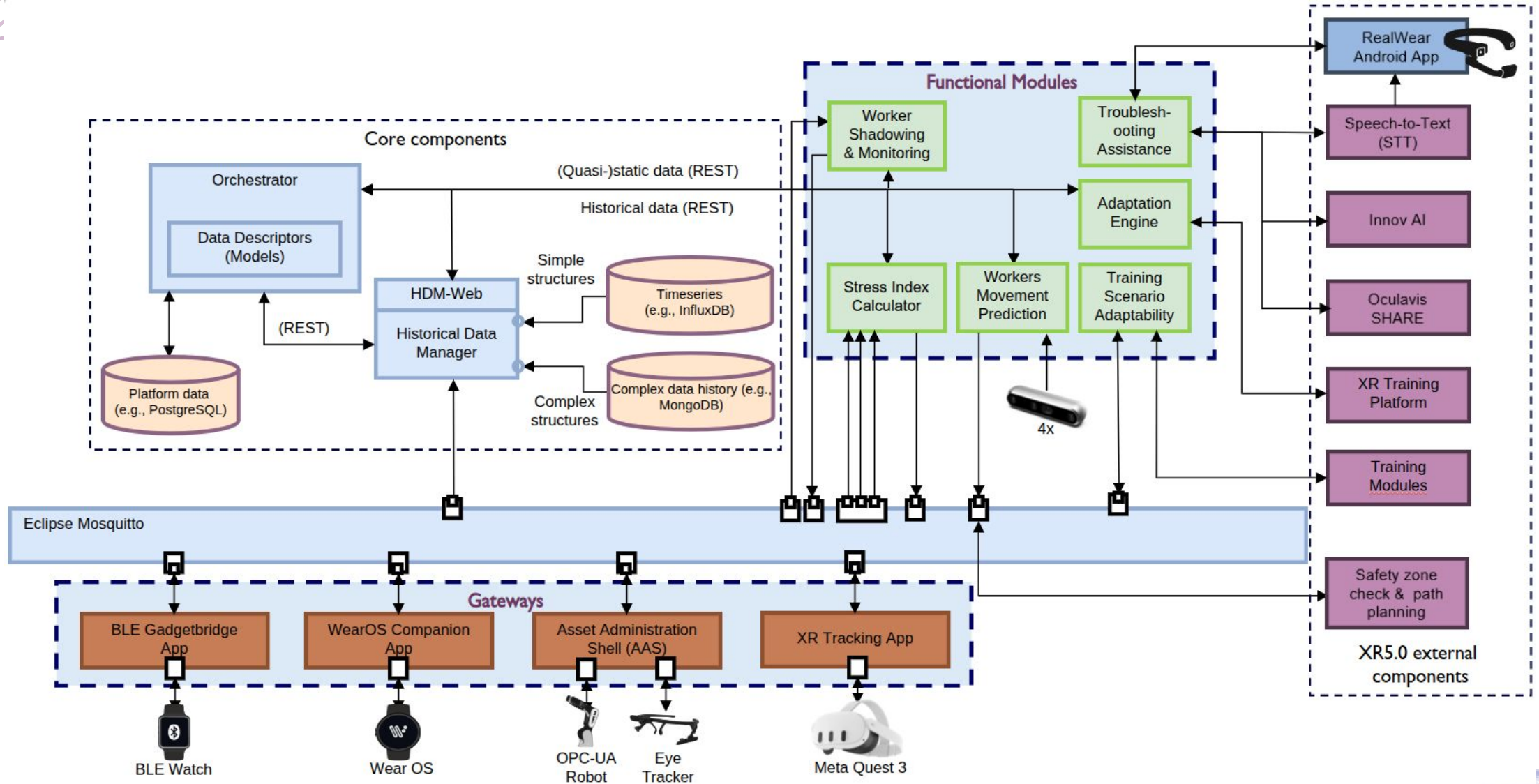
UC2: Develop a **Human Digital Twin (HDT)** to guide junior technicians in performing the maintenance process of the Wing Anti-Ice Valve (WAIV)

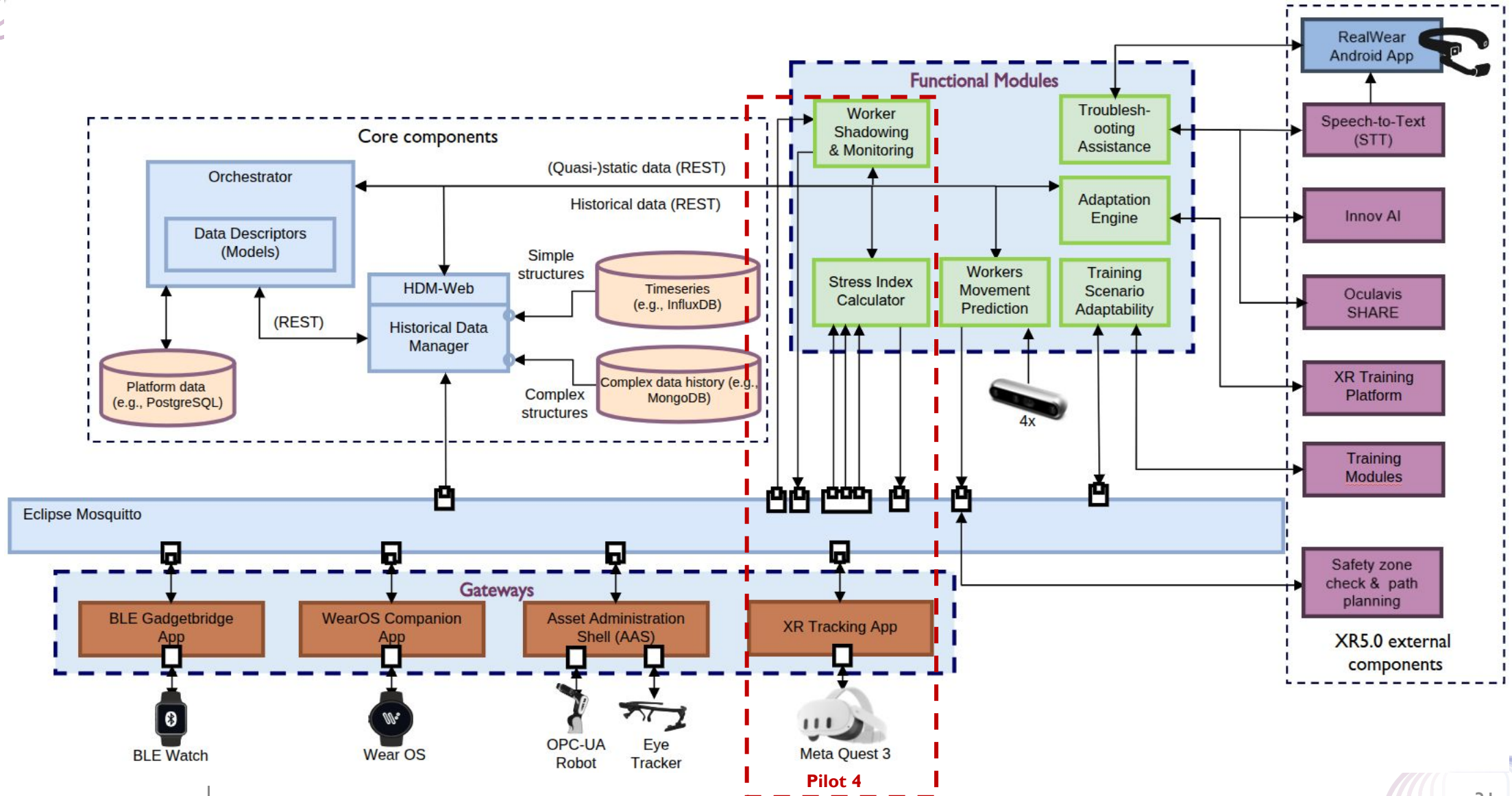


Clawdite

Clawdite is an **extensible and flexible** IIoT - industrial internet of things - based platform supporting the creation of **customised data representations** of production systems and their entities, including **humans**.

Clawdite features a modular infrastructure with interchangeable components, which ease the digital twin instantiation and ramp-up





Goal: *store and provide the “shadow” of an expert AMT, and track, monitor, and analyze **feedback** related to maintenance process executions.*

The module relies on human body-part information (e.g., head and hand positions) tracked directly via the headset

A total of 53 measurements are sent from the Meta Quest application to the main Clawdite instance at a frequency of 10 Hz, each data refers to a specific phase

The module computes deviations between the expert and trainee AMTs during the procedure and proposes corrective adjustments and feedback

Worker Shadowing and Monitoring module

Comparison methodologies

Trajectory-Based Comparison

- **Concept:** compares the worker's motion to an expert reference through point-by-point trajectory matching using positional, temporal, and rotational data to assess execution fidelity
- **Advantages:** provides continuous and quantitative evaluation capable of capturing motion precision and subtle deviations for detailed skill assessment
- **Limitations:** sensitive to execution speed, timing, and valid movement variability (e.g., handedness), often producing feedback that is difficult to interpret actionably

Milestone-Based Evaluation

- **Concept:** evaluates whether key task milestones are achieved during each activity phase, focusing on semantic task progression rather than exact motion replication
- **Advantages:** robust to speed and trajectory differences, naturally supports multiple execution styles, and enables clear, actionable feedback (achieved / pending / failed)
- **Limitations:** provides coarser evaluation with reduced sensitivity to motion quality and requires careful definition of meaningful milestones

Hybrid approach: combine motion fidelity with task semantics

We shift from pure trajectory matching toward milestone detection, while still leveraging motion data

Core idea: detect whether key milestones are achieved during each activity phase, using trajectory information as supporting evidence rather than as strict constraints

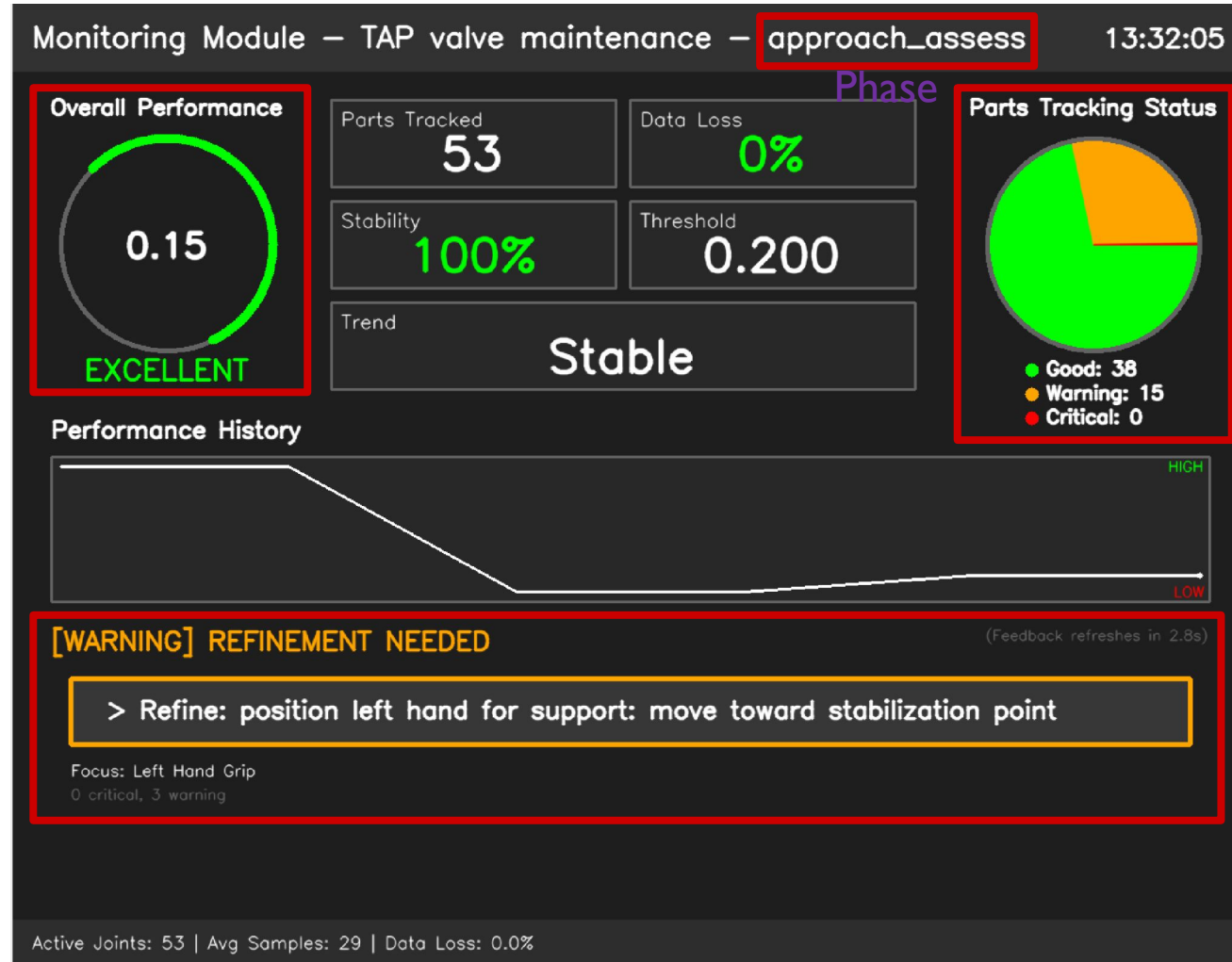
Benefits

- Invariant to execution speed and trajectory shape
- Naturally handles left/right-handed execution
- Enables meaningful feedback, leveraging also contextual activity information

We still exploit temporal dynamics, body-part positions and rotational information: motion data informs about how milestones are reached, without rigidly enforced trajectories, but monitoring the movement correctness

Worker Shadowing and Monitoring module Interface

Activity score →
Average body-part deviation from expert motion, visualized via a color-coded gauge with respect to the defined threshold (lower deviation = better performance)



→ **Parts monitoring**
Real-time parts deviation between expert and trainee

← **Suggestion**
Contextual-aware activity feedback based on real-time performance (rule- or LLM-based)



Worker Shadowing and Monitoring module Demo

The dashboard displays the following data:

Overall Performance		Parts Tracked		Data Loss	
0.13	EXCELLENT	53	100%	0%	0.200
Trend: Stable		Parts Tracking Status			
Performance History		Good: 50, Warning: 3, Critical: 0			

[WARNING] REFINEMENT NEEDED (Feedback received in 50s)

> Refine: position left hand for support: move toward stabilization point

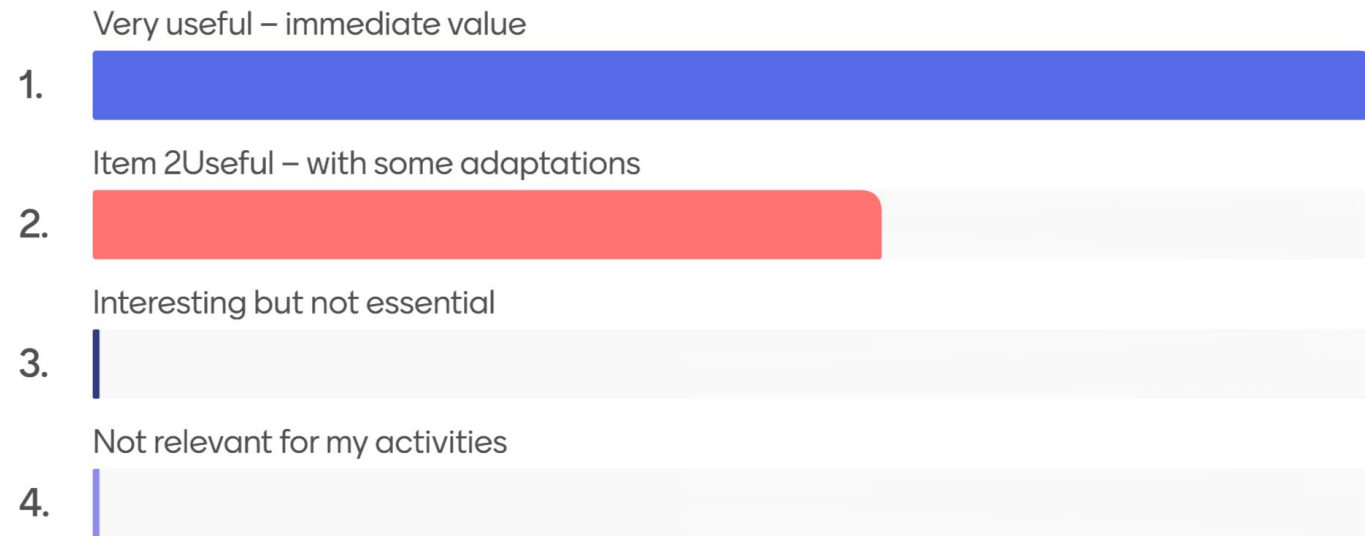
Focus: LHR Hand Grip
@ 15:36:27

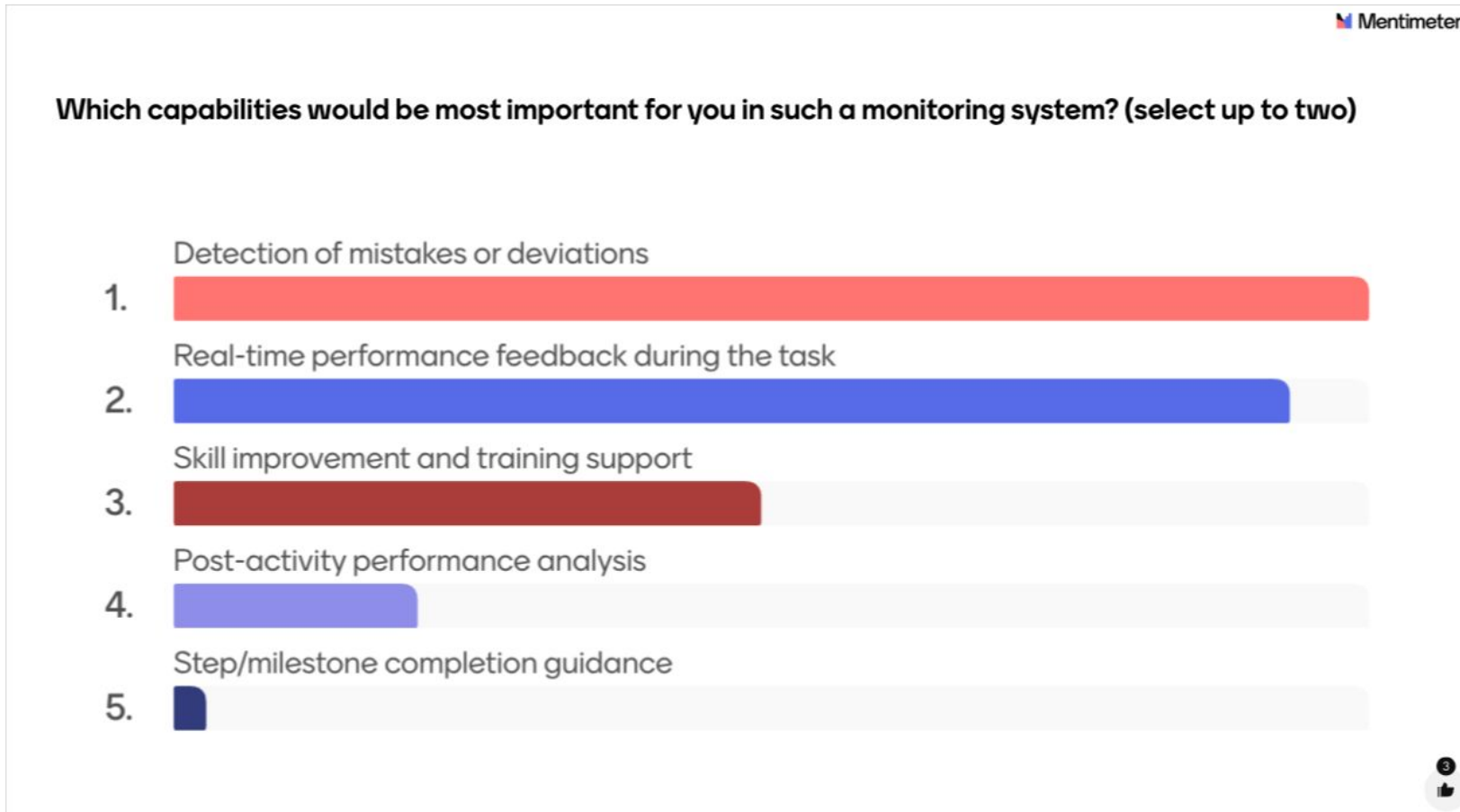


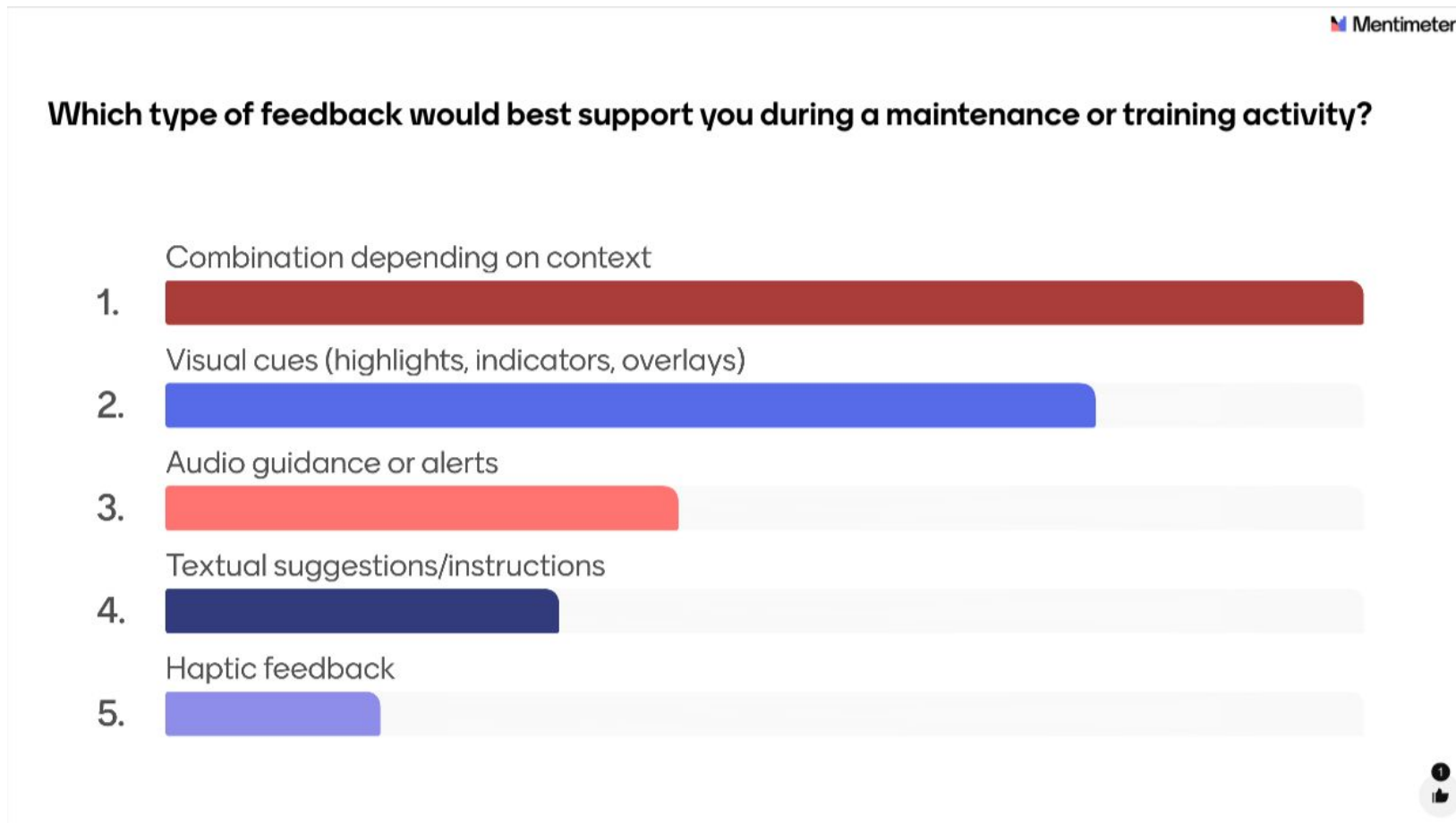
Live Audience Survey

Elina Papadopoulou

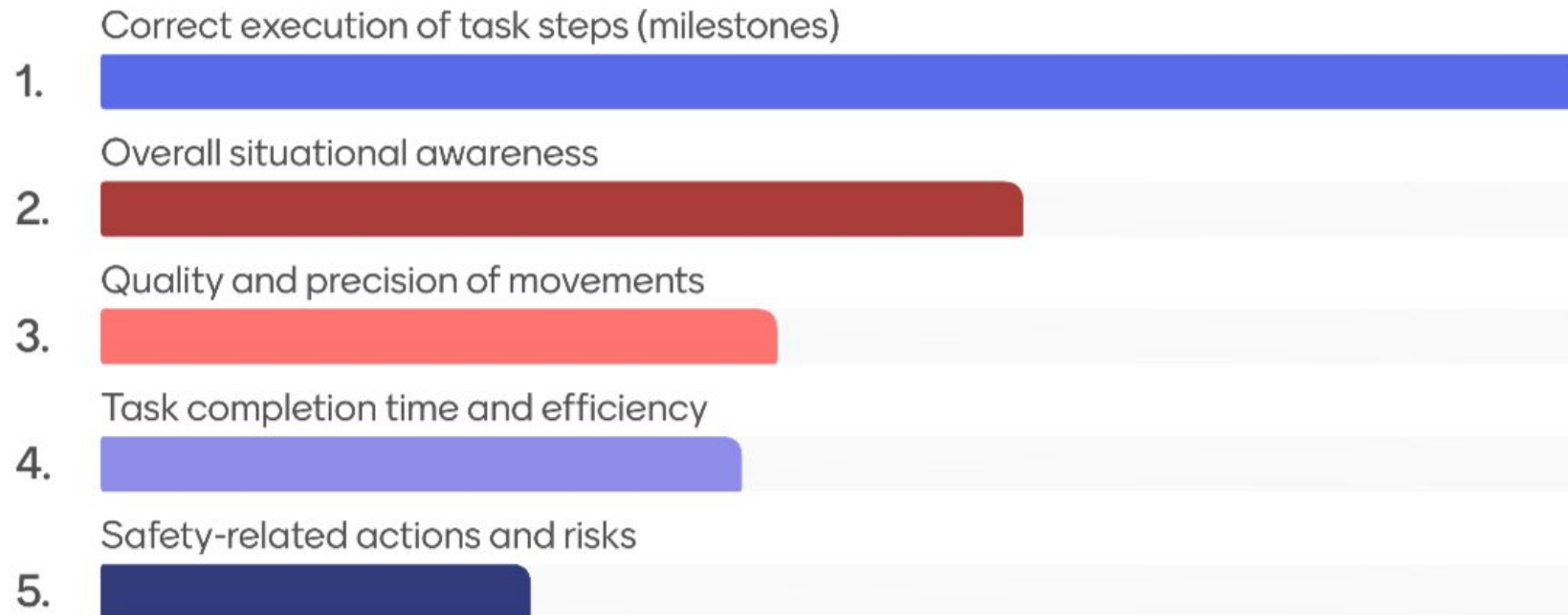
How useful would a real-time worker shadowing and monitoring system be in your professional context?



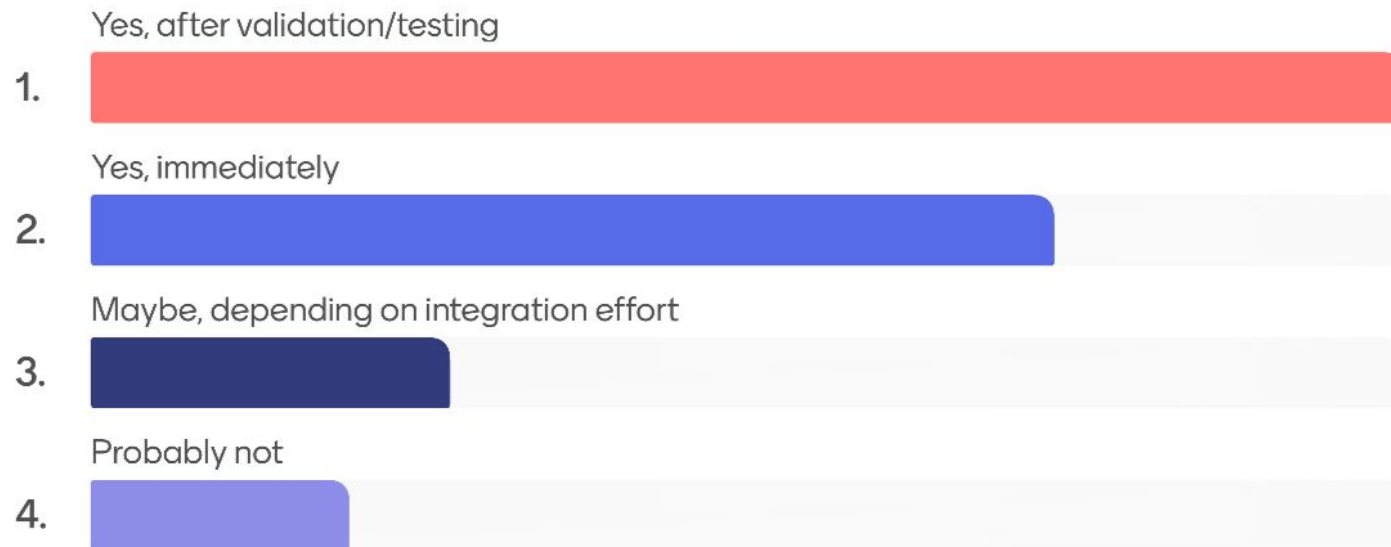




What should the system primarily monitor to effectively help improve performance?

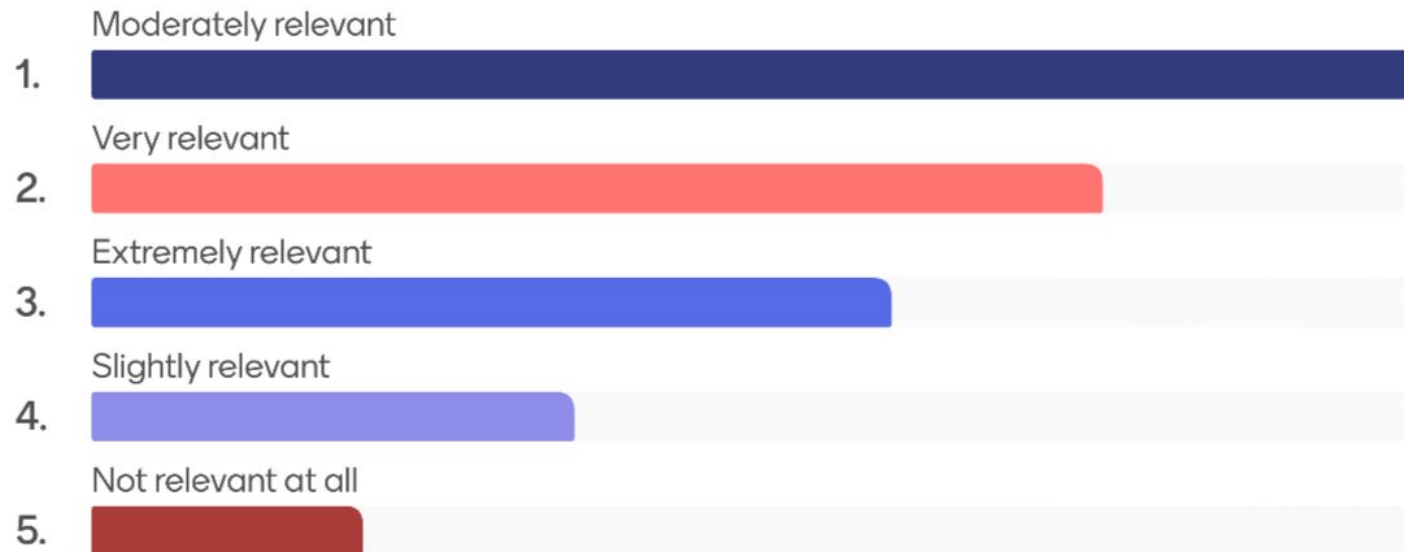


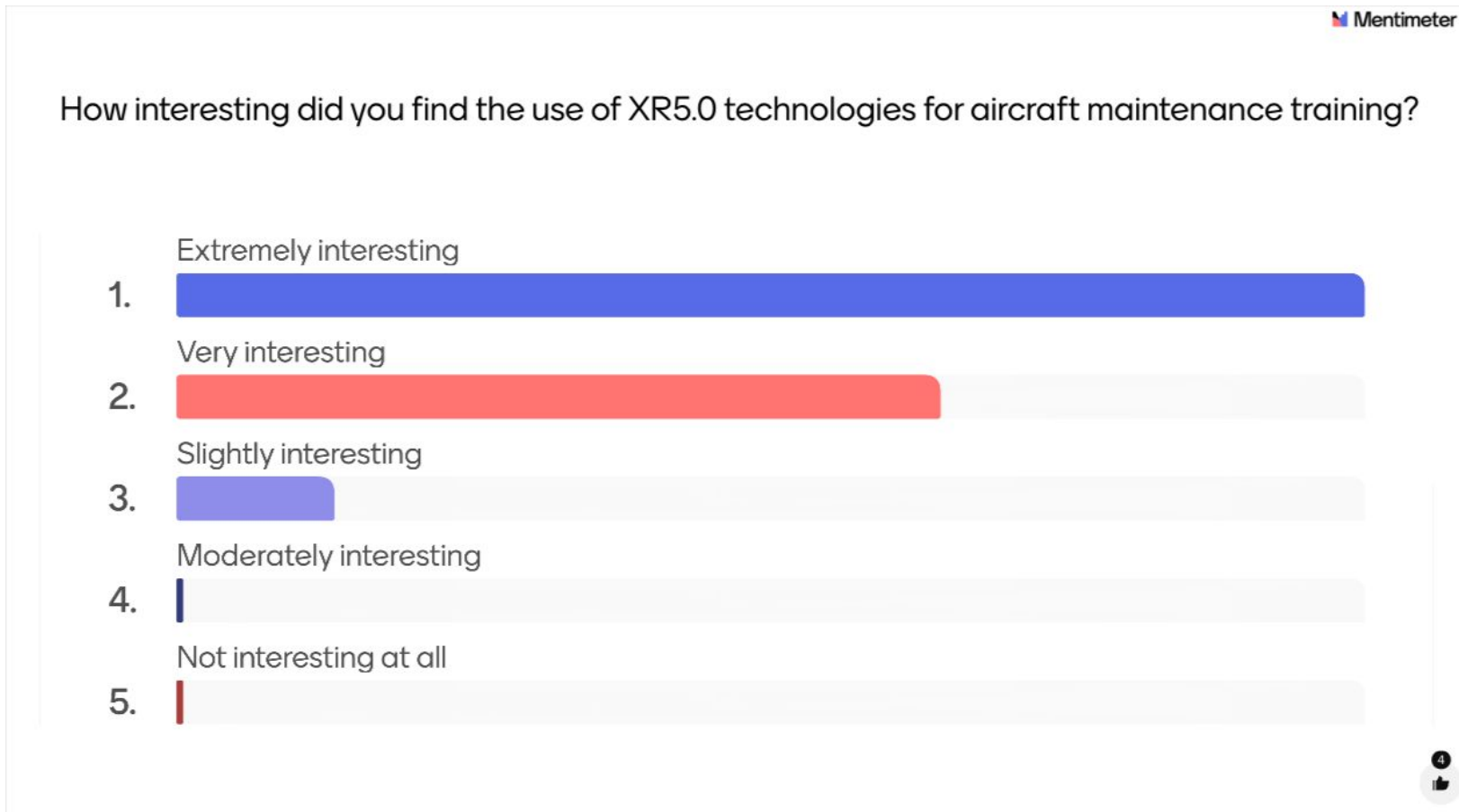
Would you or your colleagues be willing to try and use a system providing real-time monitoring and guidance during training or maintenance tasks?



Mentimeter

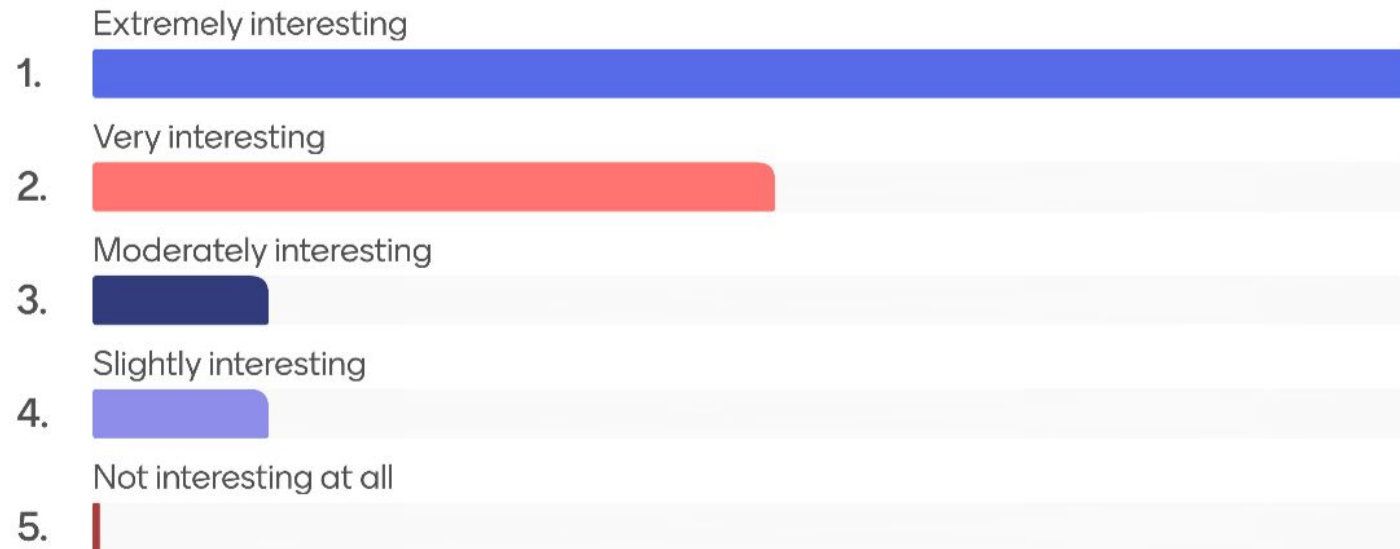
How relevant were the topics presented to your professional or research interests?





Mentimeter

How interesting did you find the potential of XR5.0 technologies to be generalised to other contexts?



Which part of the webinar did you find most engaging?

The demonstration

Video demo

Video part

Worker shadowing and monitoring system

Human Digital Twin

Everything

Demo really put together the whole concept

The presentation concerning Human Digital Trin and shadowing

All of them were perfectly connected for a detailed explanation.Video demos were exceptional

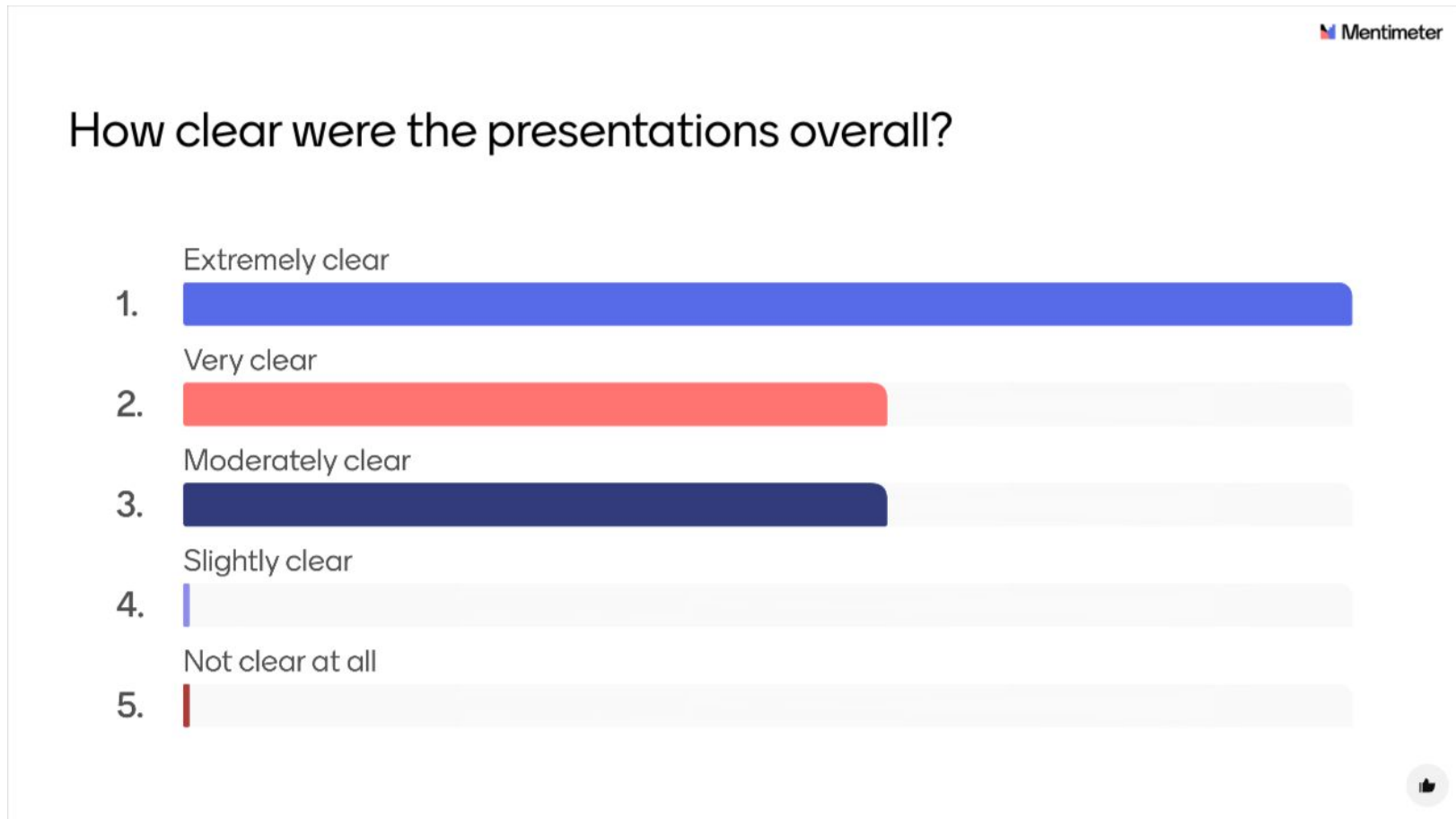
Demo video

Videos

The demo video

Sentient concept





XR5.0

Human-Centric AI-Enabled
Extended Reality Applications
for the Industry 5.0 Era

Thank You!

www.xr50.eu

