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

Funded by
the European Union

Agenda

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

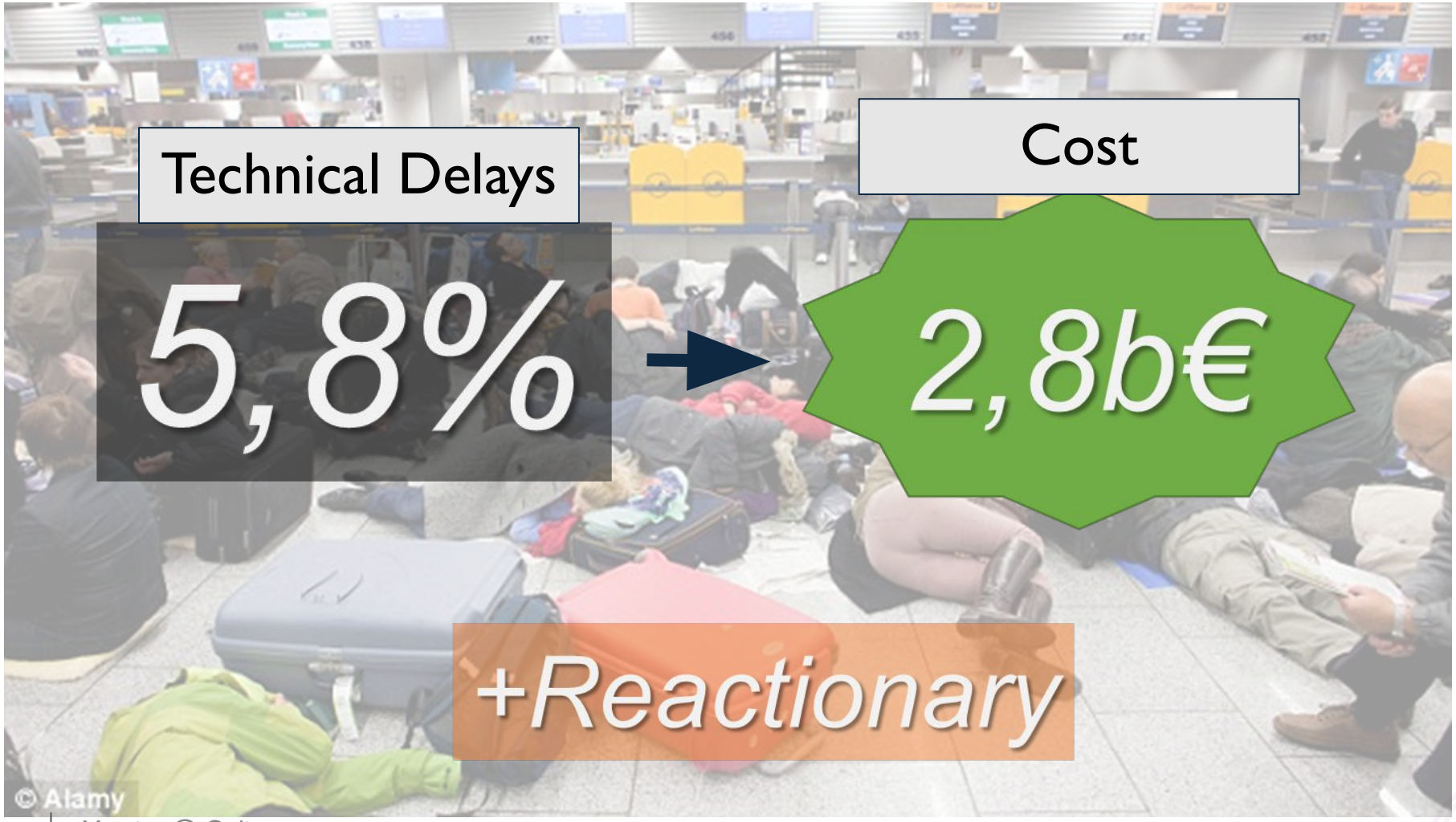
4. **Worker Shadowing and Monitoring Module for Aircraft Maintenance Training**

Speaker: Samuele Dell'Oca

Overview and Context of Aircraft Maintenance Training

Luís Oliveira

Aircraft operation (Pilot Overview)



Approach (Pilot Overview)

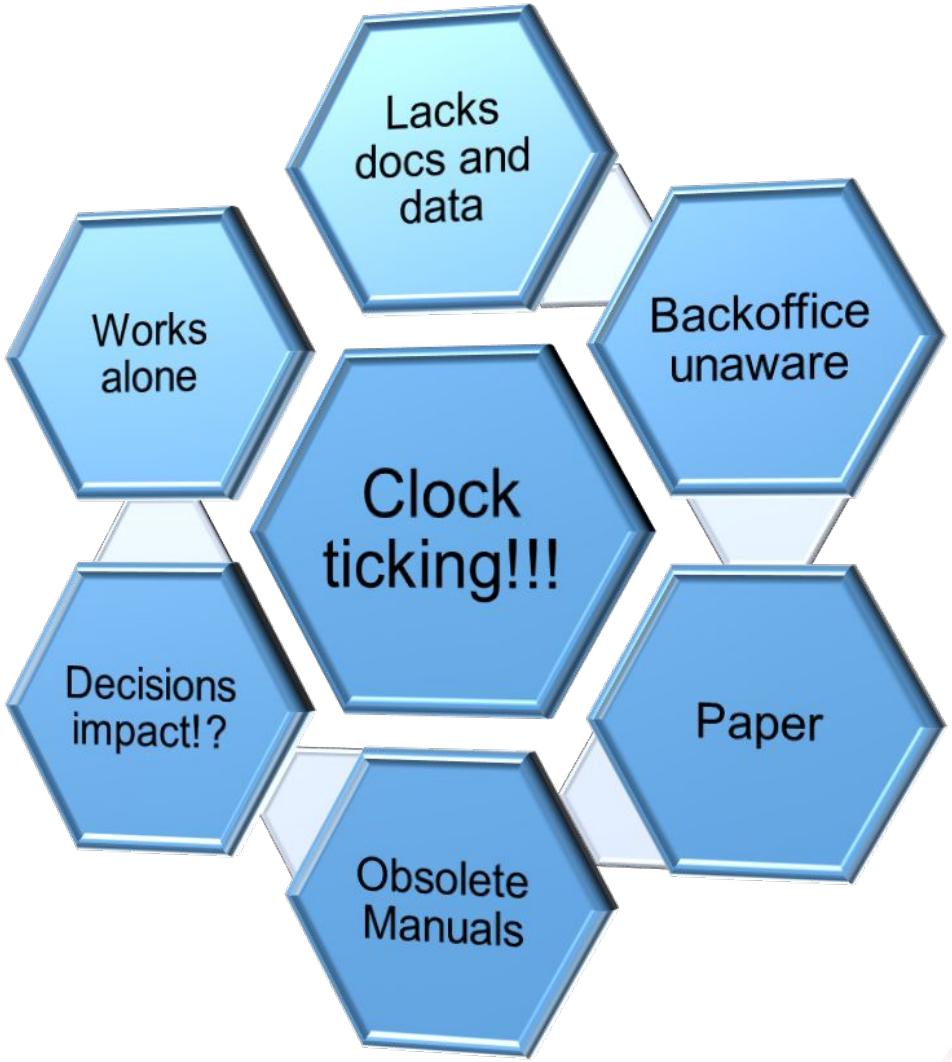
Improve Line Maintenance Efficiency

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)



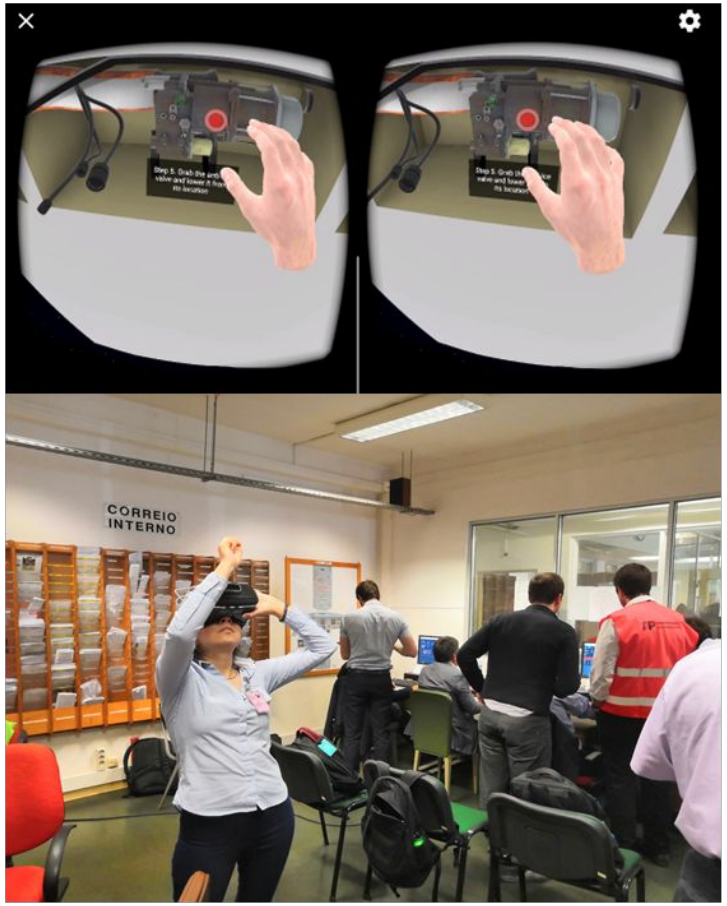
Line Maintenance: Post - COVID challenges (Pilot Overview)

Aircraft Maintenance Manuals: Outdated Format

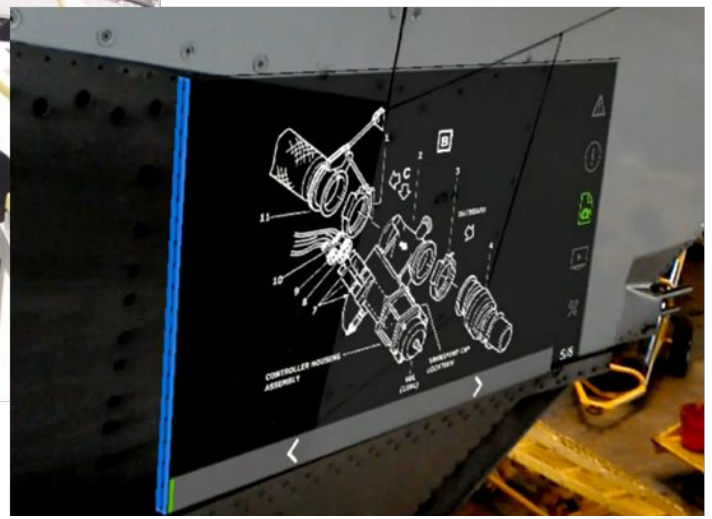
Why are Maintenance manuals still in the same format?

Enhanced Visualisation (Pilot Overview)

Virtual Reality



Augmented Reality



Use Cases of XR5.0 in Aircraft Maintenance Training

Jorge Oliveira

Use Cases in XR5.0

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).

Partners

Pilot Leader

TAP PORTUGAL

Pilot Technical Responsible

IMMERSIVE LIVES

Technical Partners

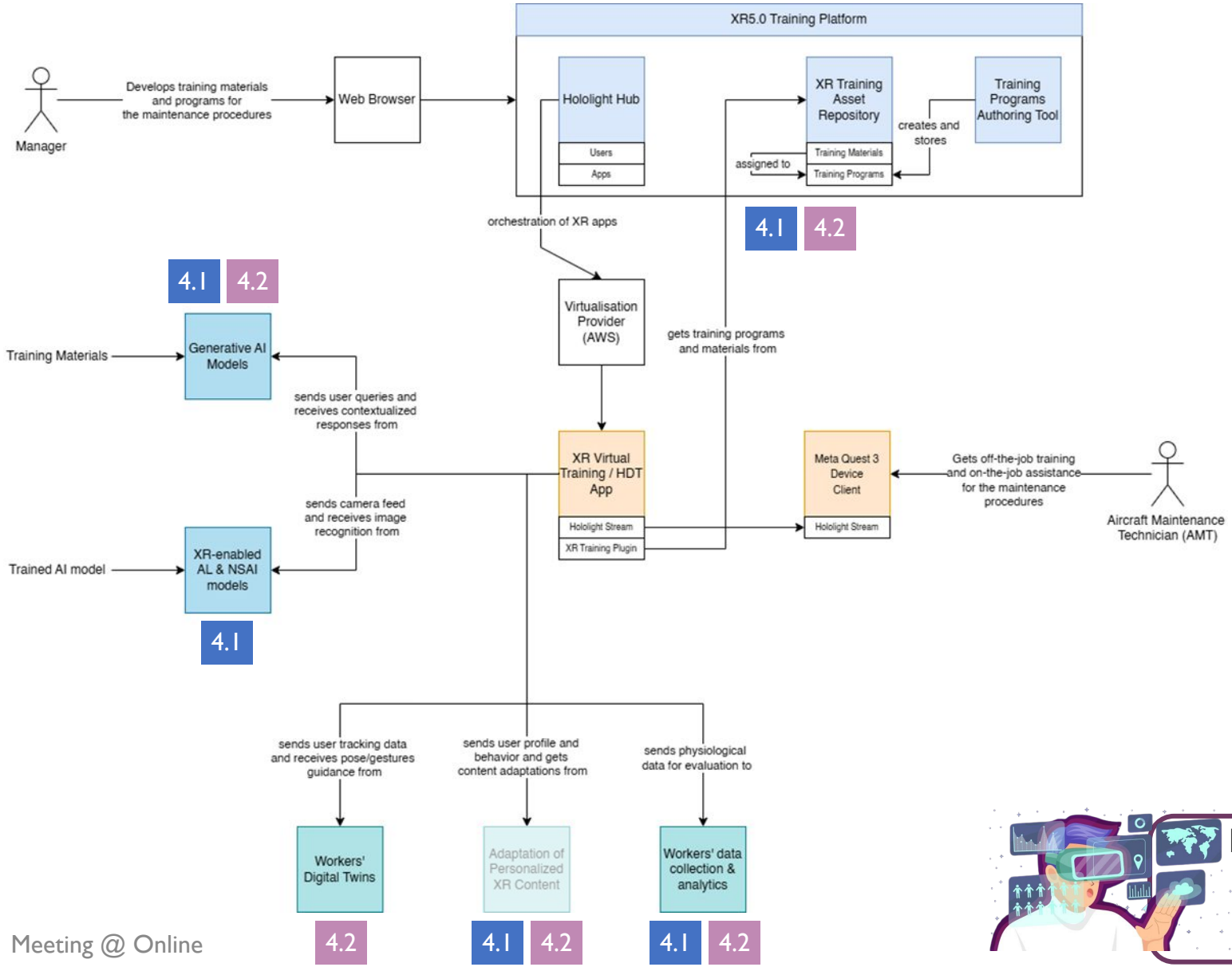
UNPARALLEL	• Workers' data collection & analytics
SUPSI	• Workers' digital twins • Adaptation of personalized XR content
UNIVERSITY OF PIRAEUS RESEARCH CENTER	• XR-enabled AL & NSAI models
SIEMENS	• Generative AI models
IMMERSIVE LIVES	• Training materials • Training programs
HOLOLIGHT	• Hololight Hub
SYNELIXIS	• Cloud-based XR training asset repository

Technical Components

- **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 adapation 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.

Architecture



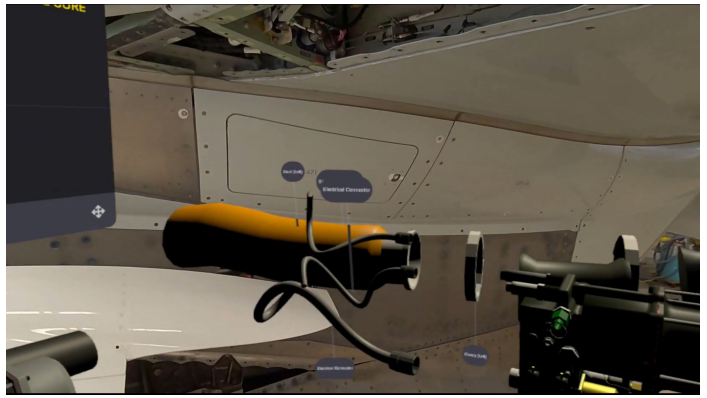
Exploited XR Hardware

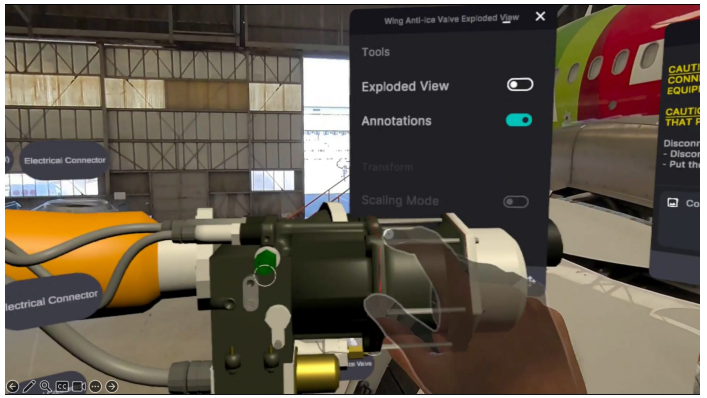
- Meta Quest 3

UC 1 - Expected results

	User Story (Requirement) Description	Expected KPIs	Achieved KPIs
#1 Virtual Training	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. 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. 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.	Reduce Task Completion Time by 10% Reduce Stress Levels by 10%	*User stories in progress*

Which are the safety measures

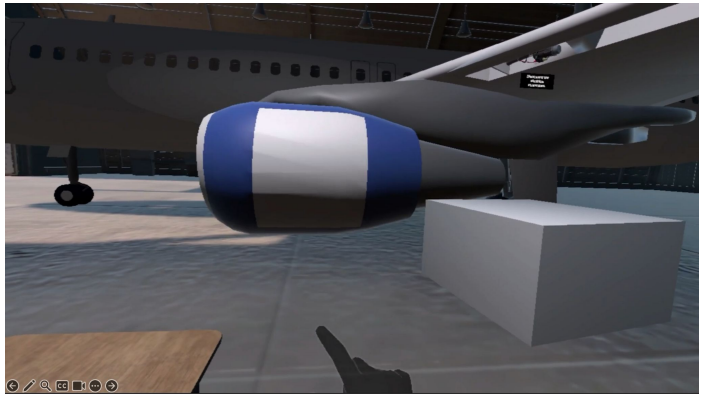

How to access the WAIV device



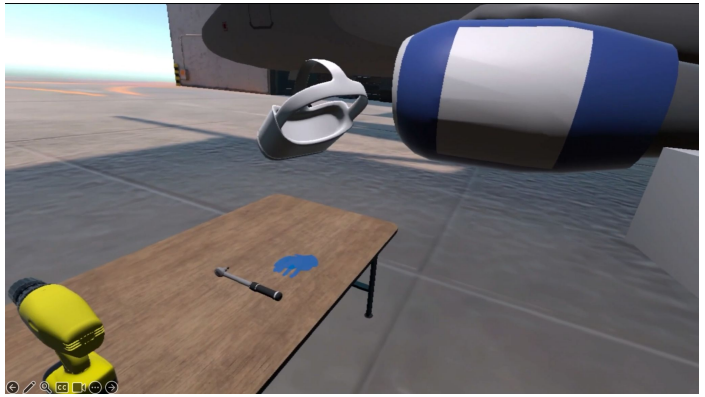
In what order should I disassemble the WAIV

UC 2 - Expected results

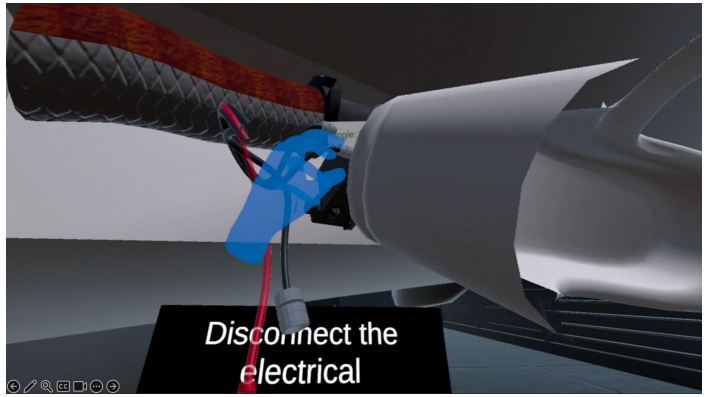
	User Story (Requirement) Description	Expected KPIs	Achieved KPIs
#2 Virtual Training	I want to know how to access the WAIV device, so that I get to know what I need to do in order to reach the WAIV valve.	Reduce Task Completion Time by 15% Reduce Error Count by 50% Reduce Stress Levels by 10%	*User stories in progress*
	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



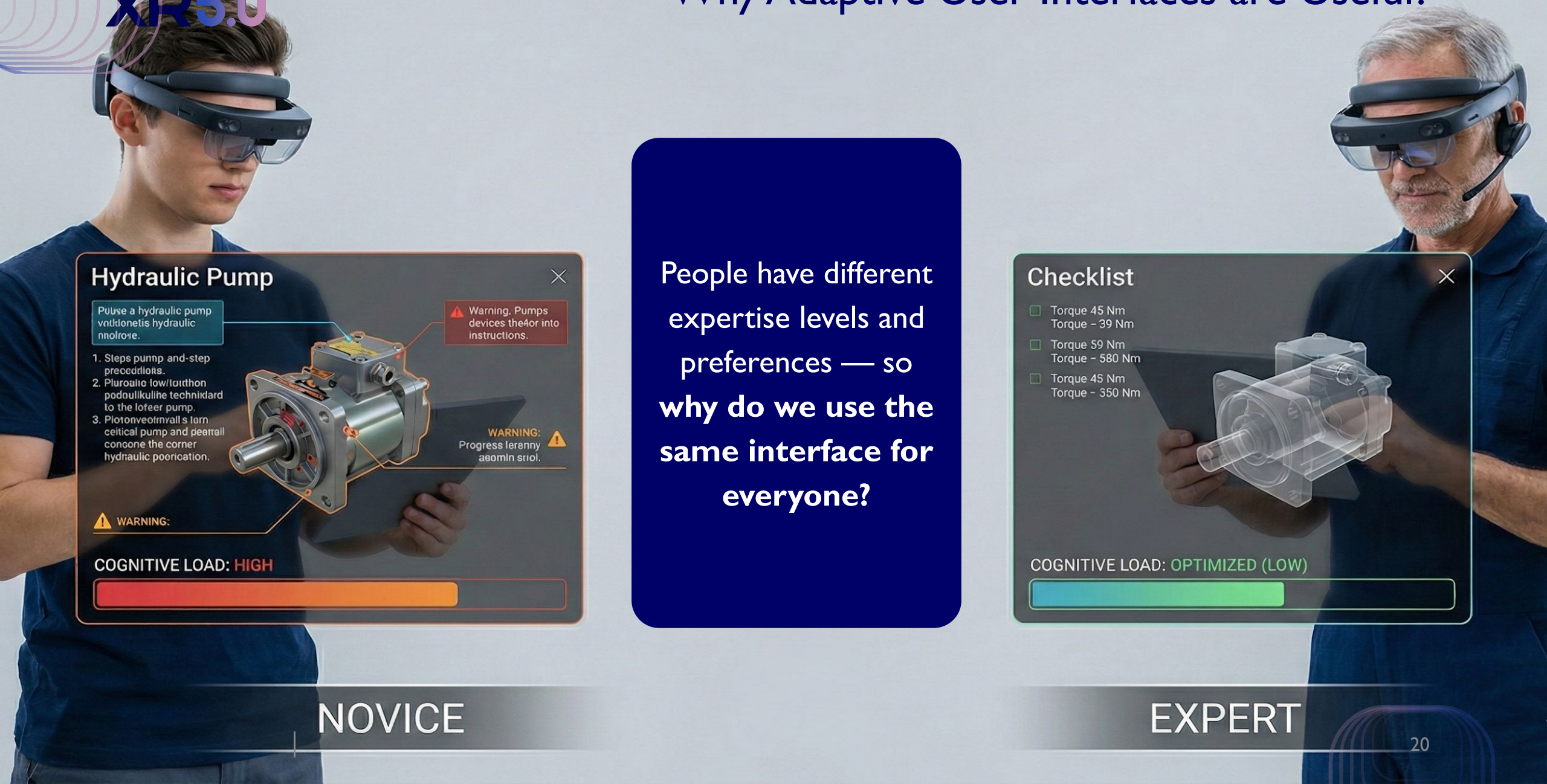
In what order should I disassemble the WAIV

Video Demo UC1 and UC2

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?**

Sentient Design for Adaptive User Interfaces

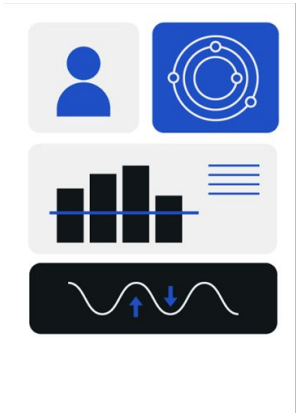
What is Sentient Design?

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.

GenAI Powered Adaptation

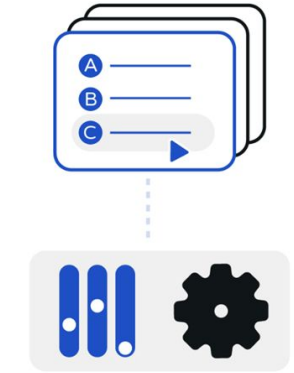
The AI agent autonomously generates **new content and visualisation's adaptation logics** based on distinct input streams:

Implicit personalisation



The model monitors user behaviour and real-time performance.

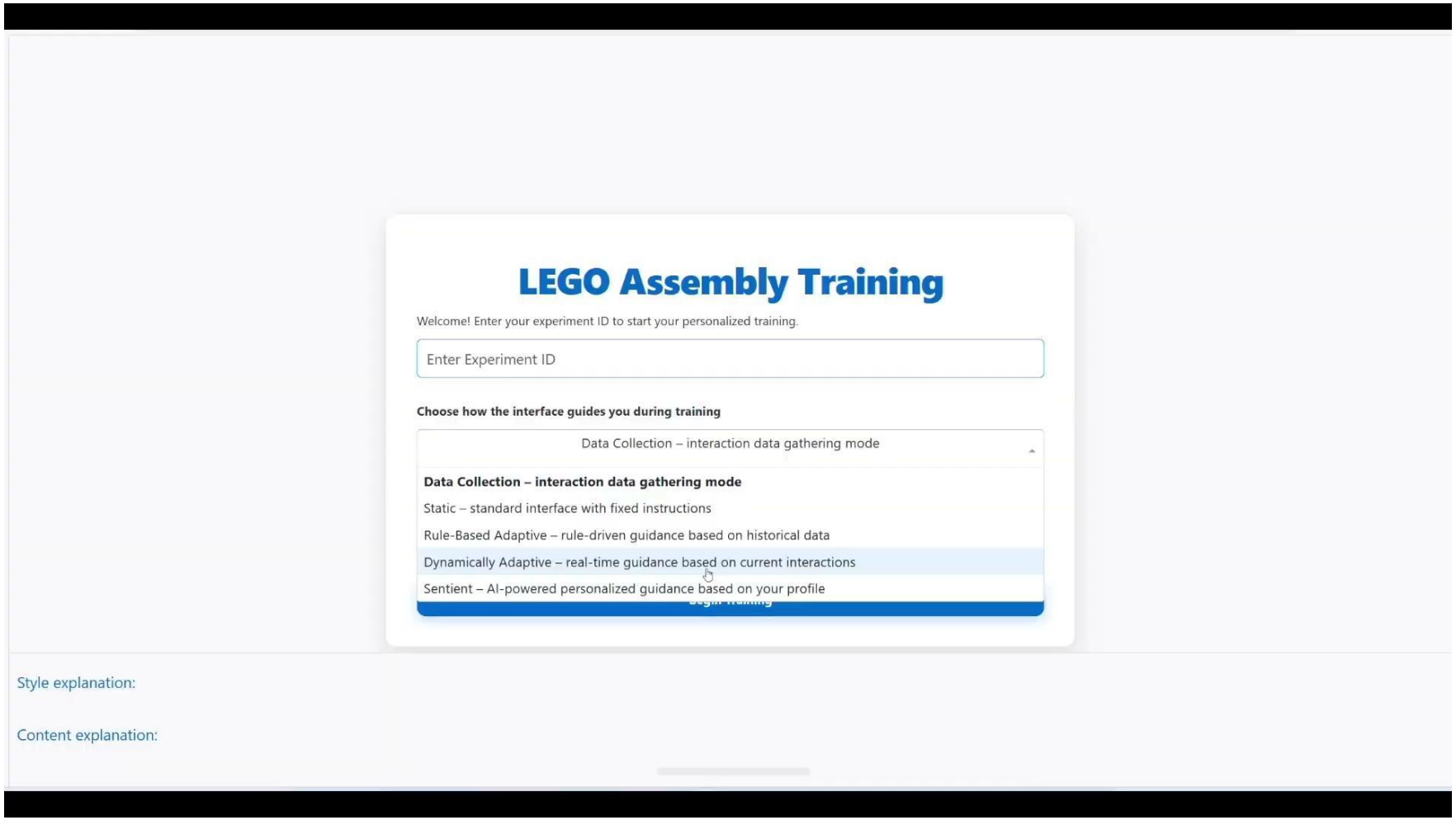
Explicit personalisation



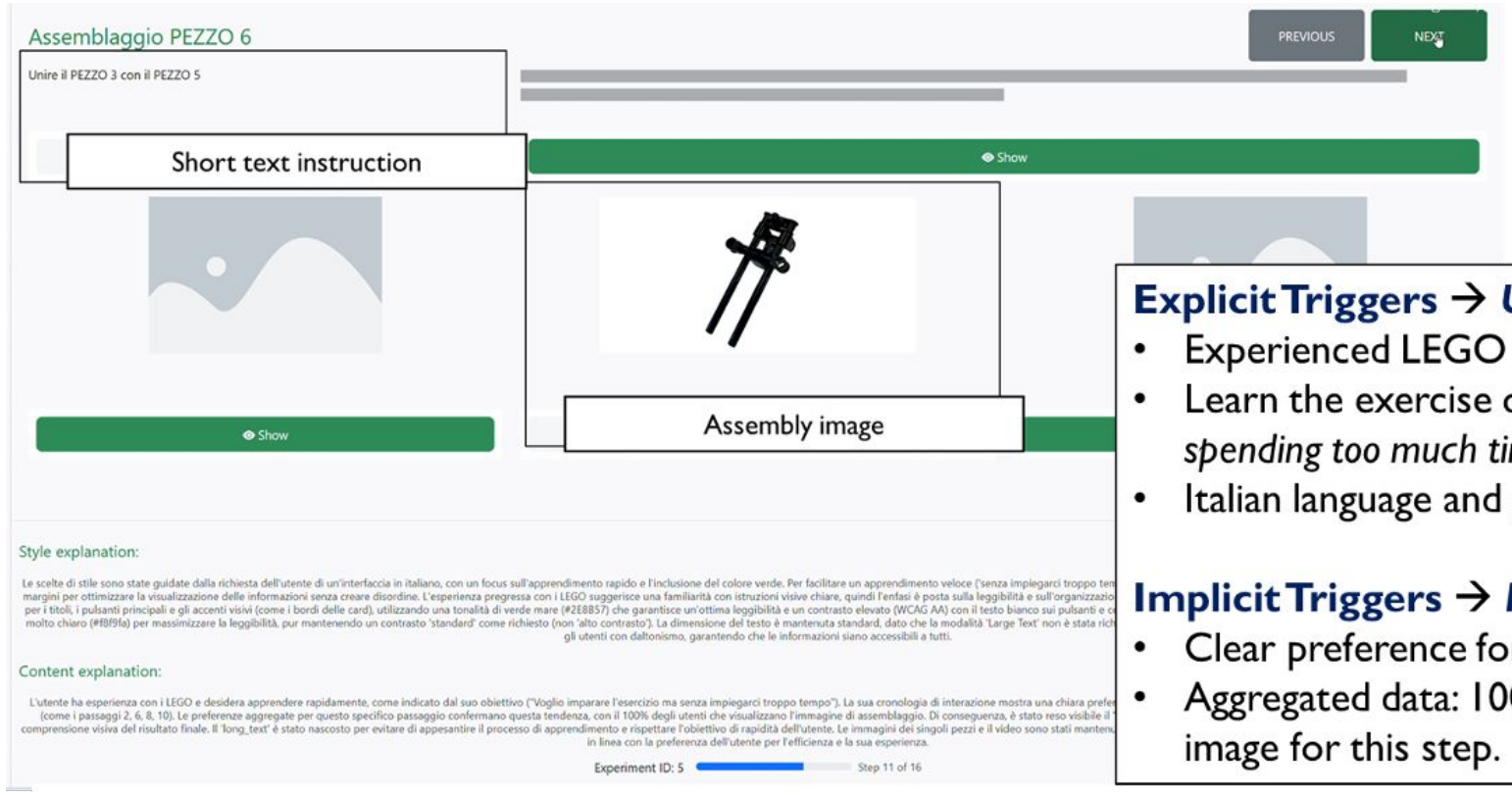
Users define their preferences, skills or requirements through natural language prompts.

Our Aircraft

A Video Demonstration



AUI Triggers



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		GENAI-POWERED MODEL
Historical user behaviour	Input	**Hybrid**: explicit LLM prompts + Implicit behavioral tracking
Standardized interface	Interface elements	**Content and visualisation**
Pre-defined	Response type	**Anticipates needs**
Periodic manual updates	Training & learning	**Continuous learning**
One-size-fits-most	User experience	**Hyper-personalized**

Statistical models categorize the operator; GenAI adapts the environment around the operator

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

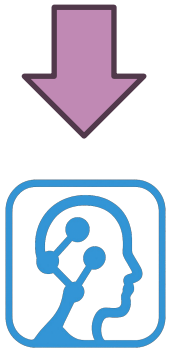
RESULT: Zero-setup training.

Worker Shadowing and Monitoring Module for Aircraft Maintenance Training

Samuele Dell'Oca

Human Digital Twin
Clawdite Platform

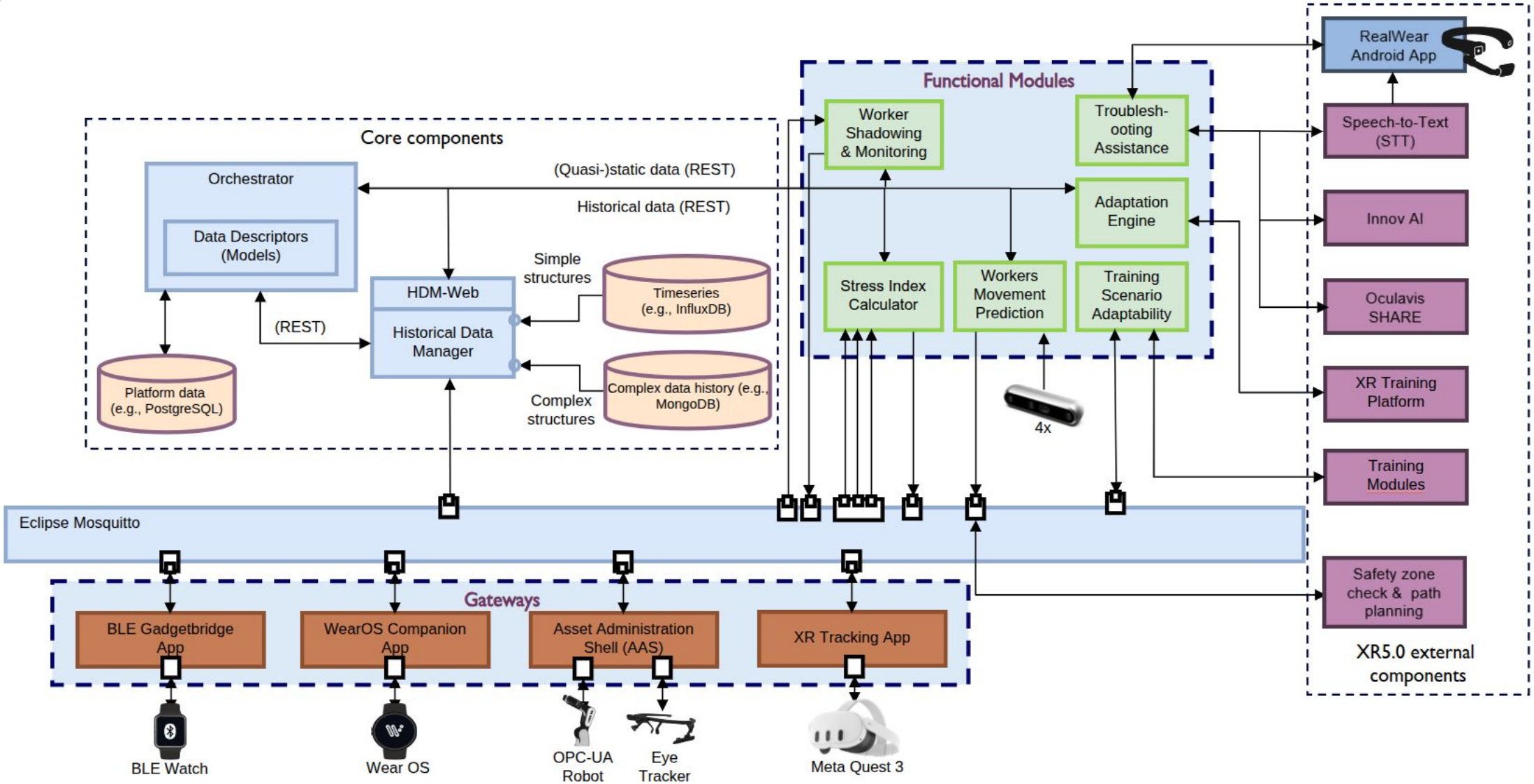
UC2: Develop a **Human Digital Twin (HDT)** to guide junior technicians in performing the maintenance process of the Wing Anti-Ice Valve (WAIV)



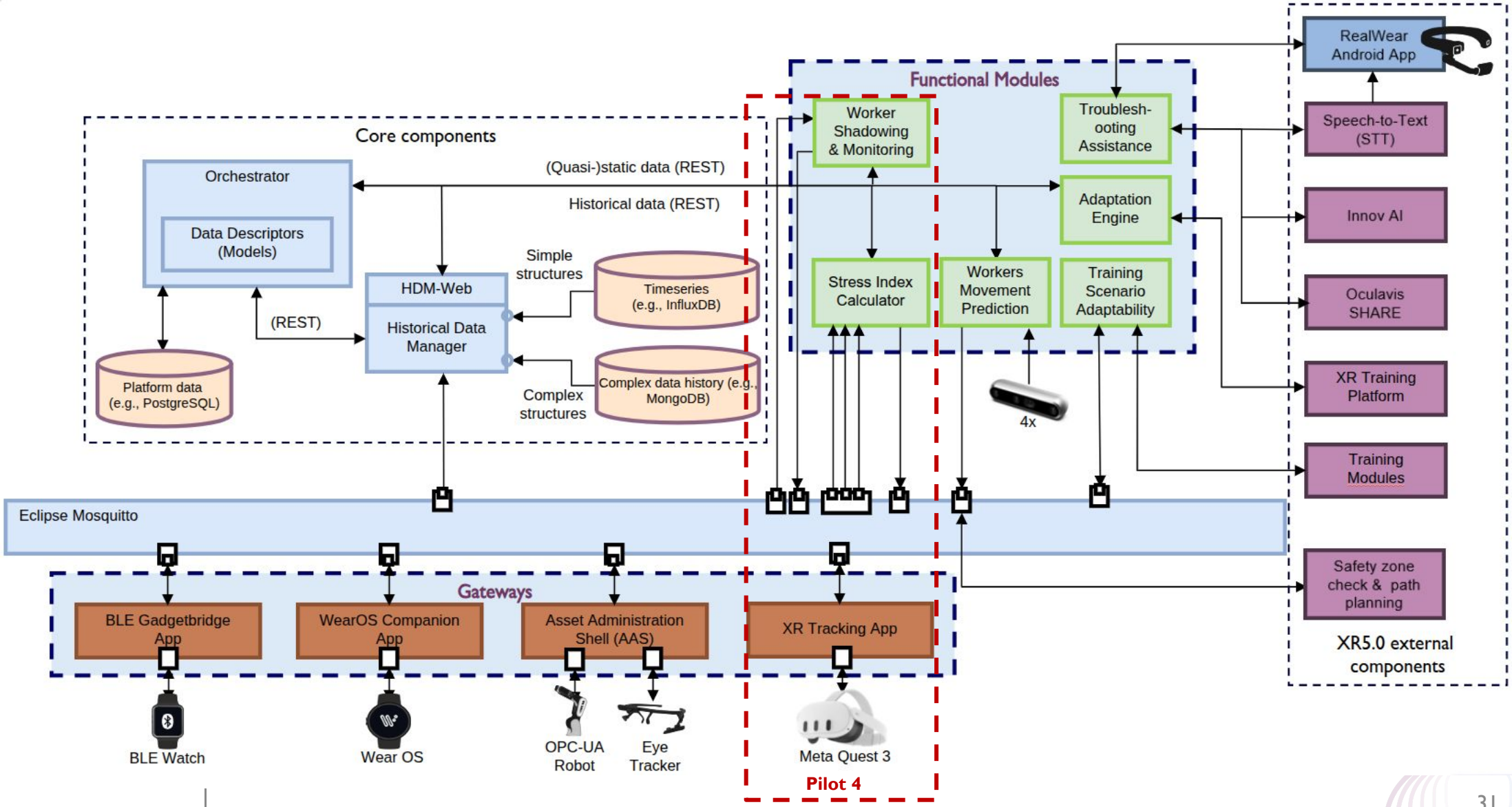
Clawdite

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

XR5.0 Clawdite Architecture



XR5.0 Clawdite Architecture



Worker Shadowing and Monitoring module Concept

***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

Worker Shadowing and Monitoring module
Our Approach

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

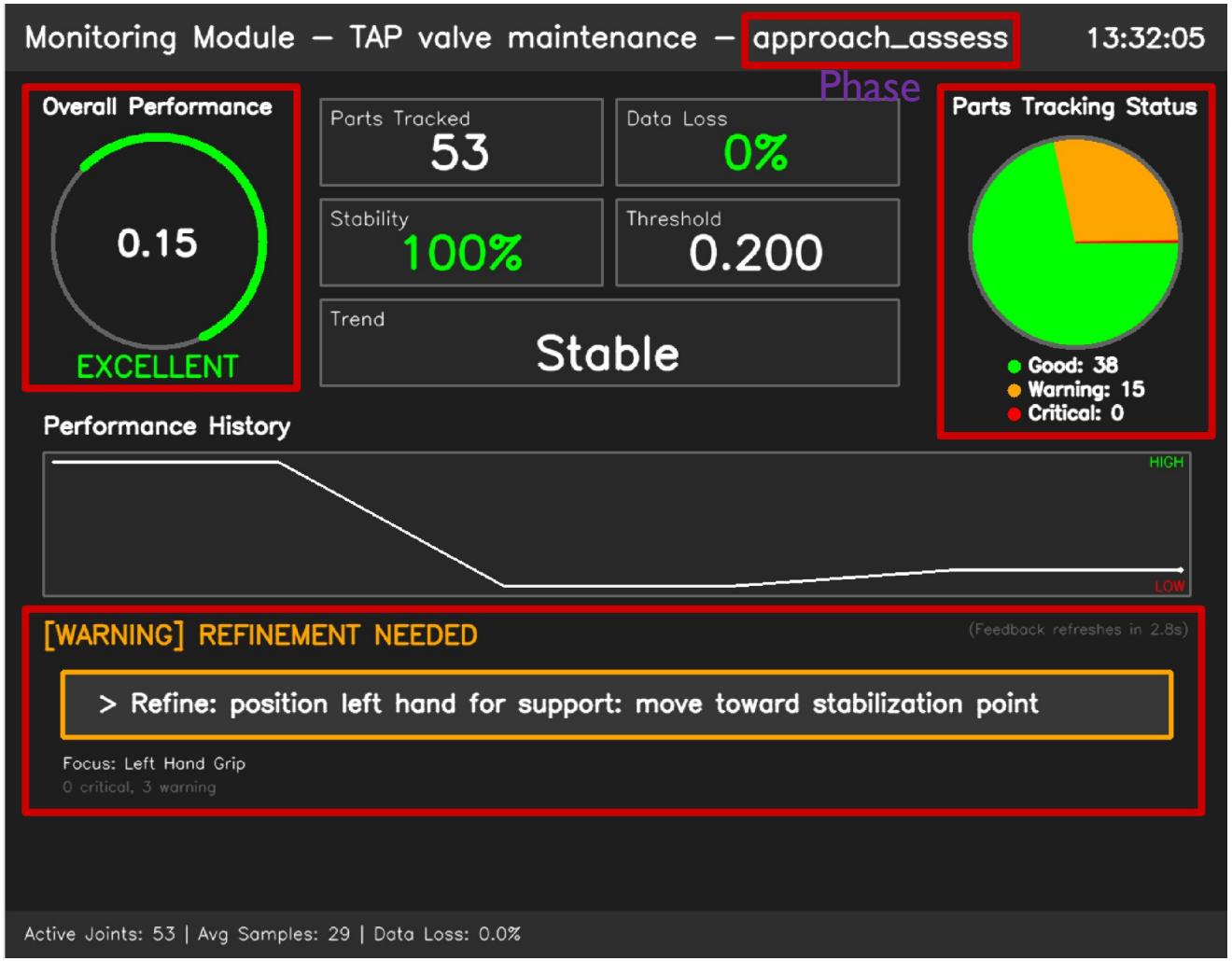
Benefits

- 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

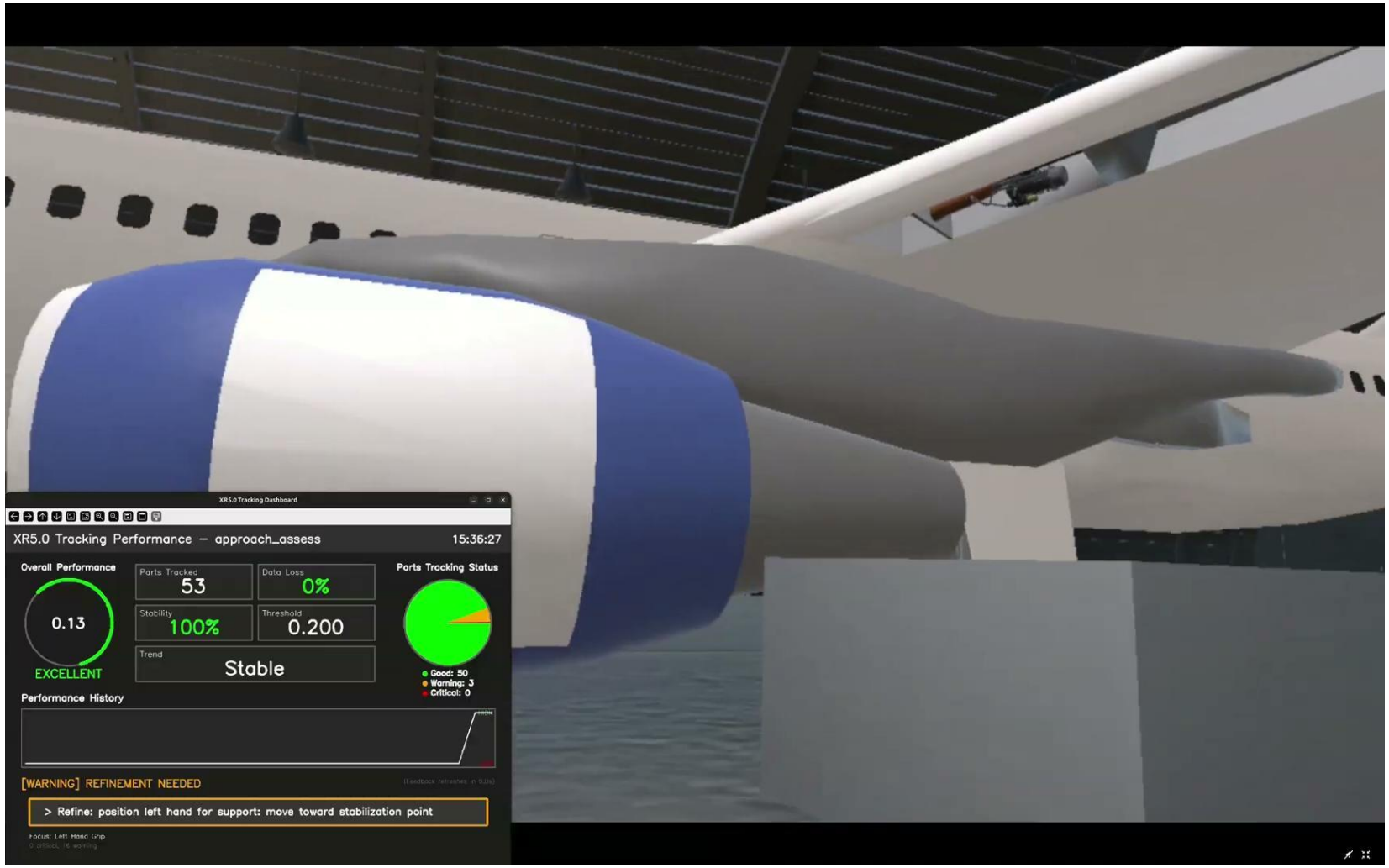
Activity score
Average body-part deviation from expert motion, visualized via a color-coded gauge with respect to the defined threshold (lower deviation = better performance)



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

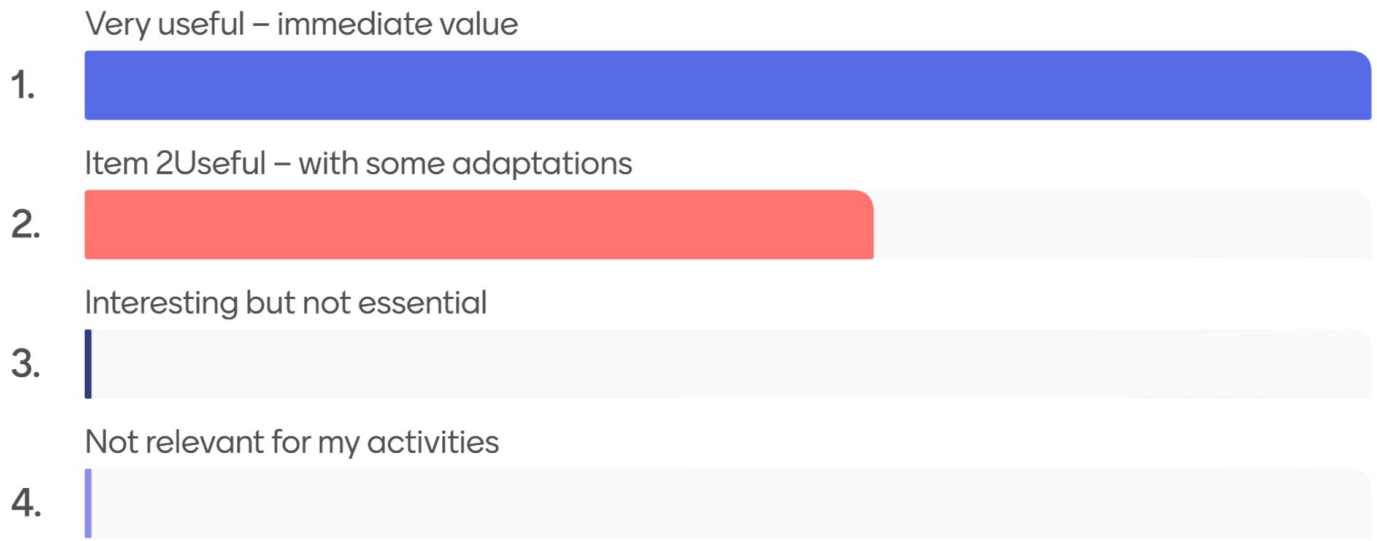


Live Audience Survey

Elina Papadopoulou

Questions for the audience

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



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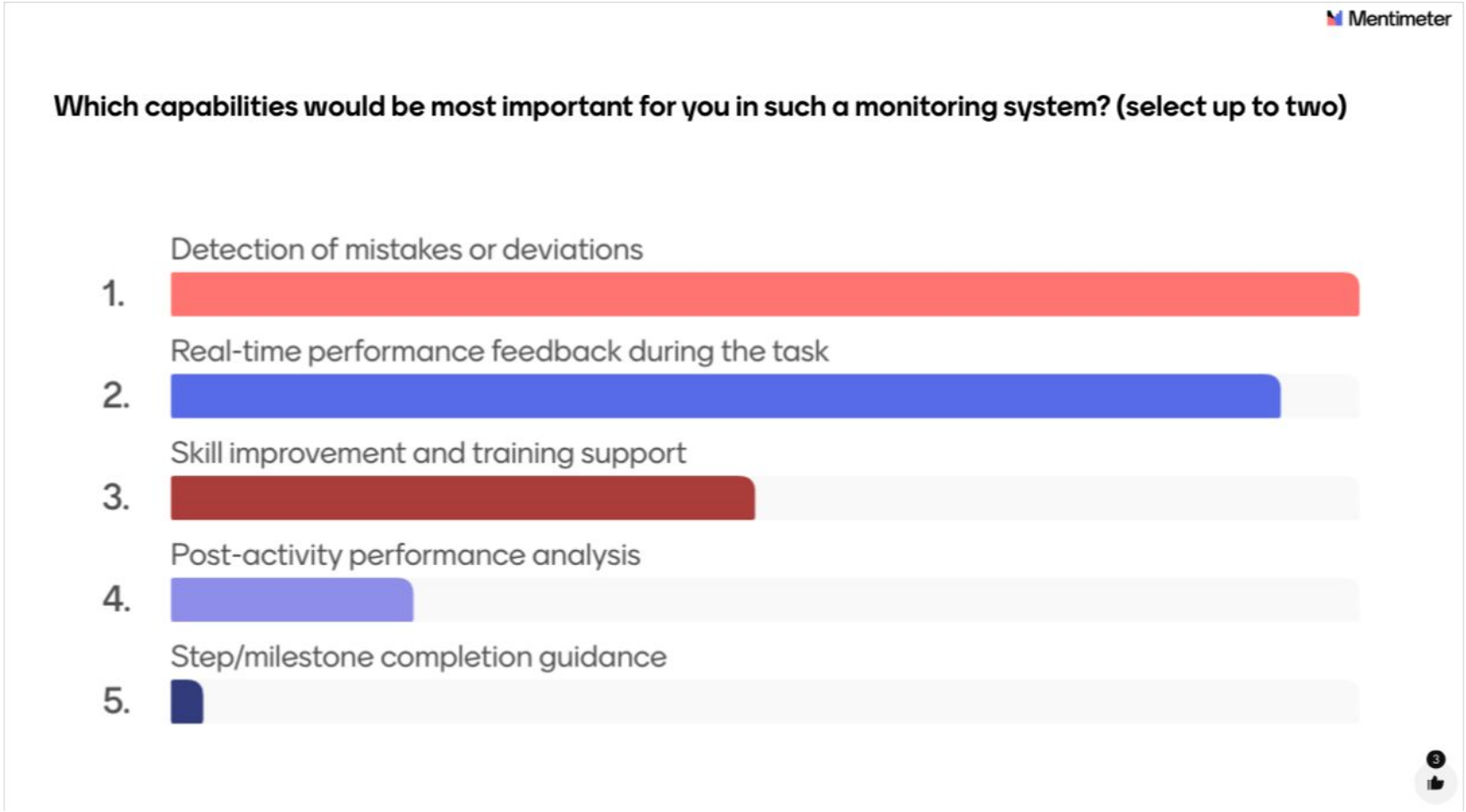

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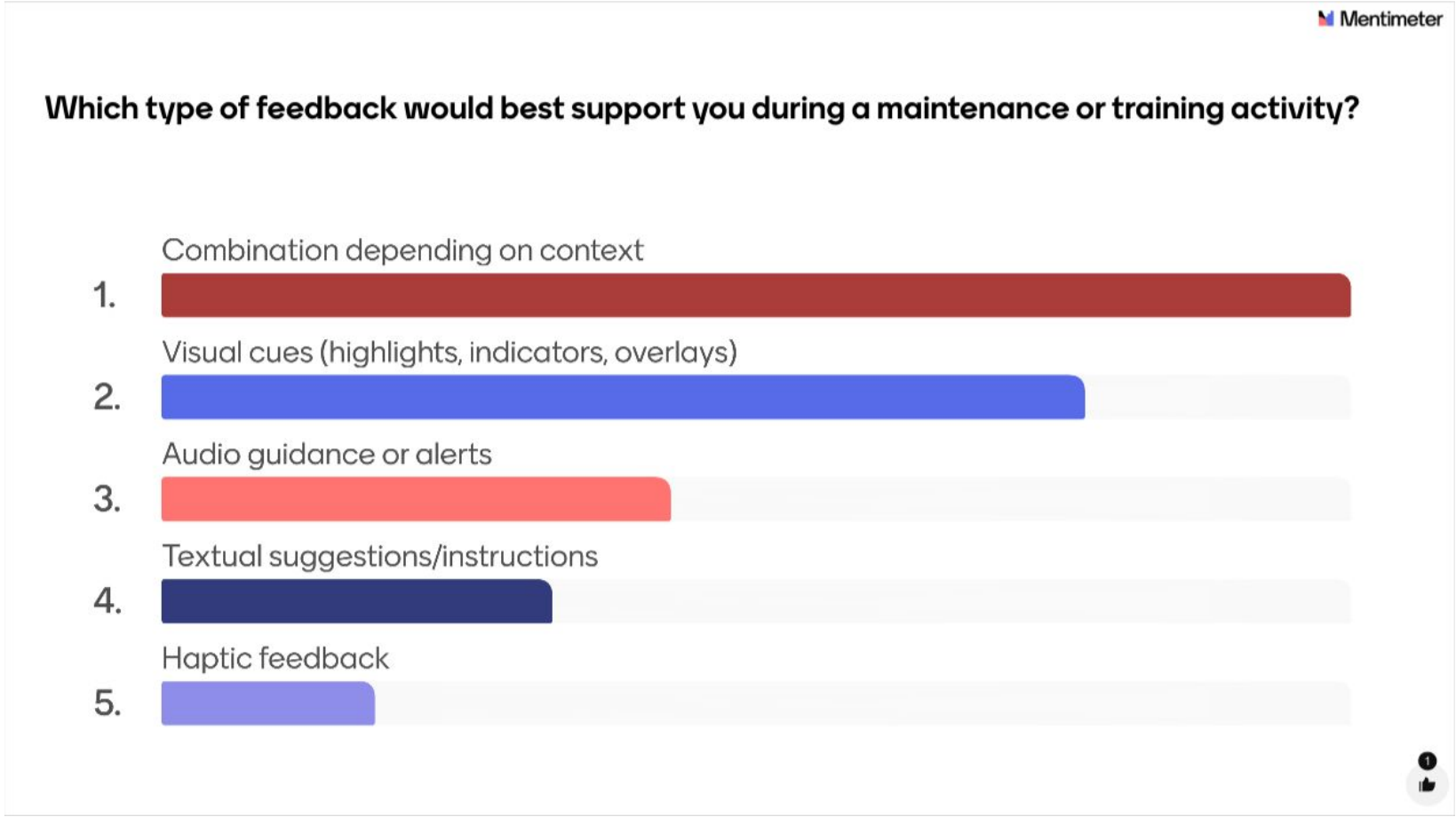

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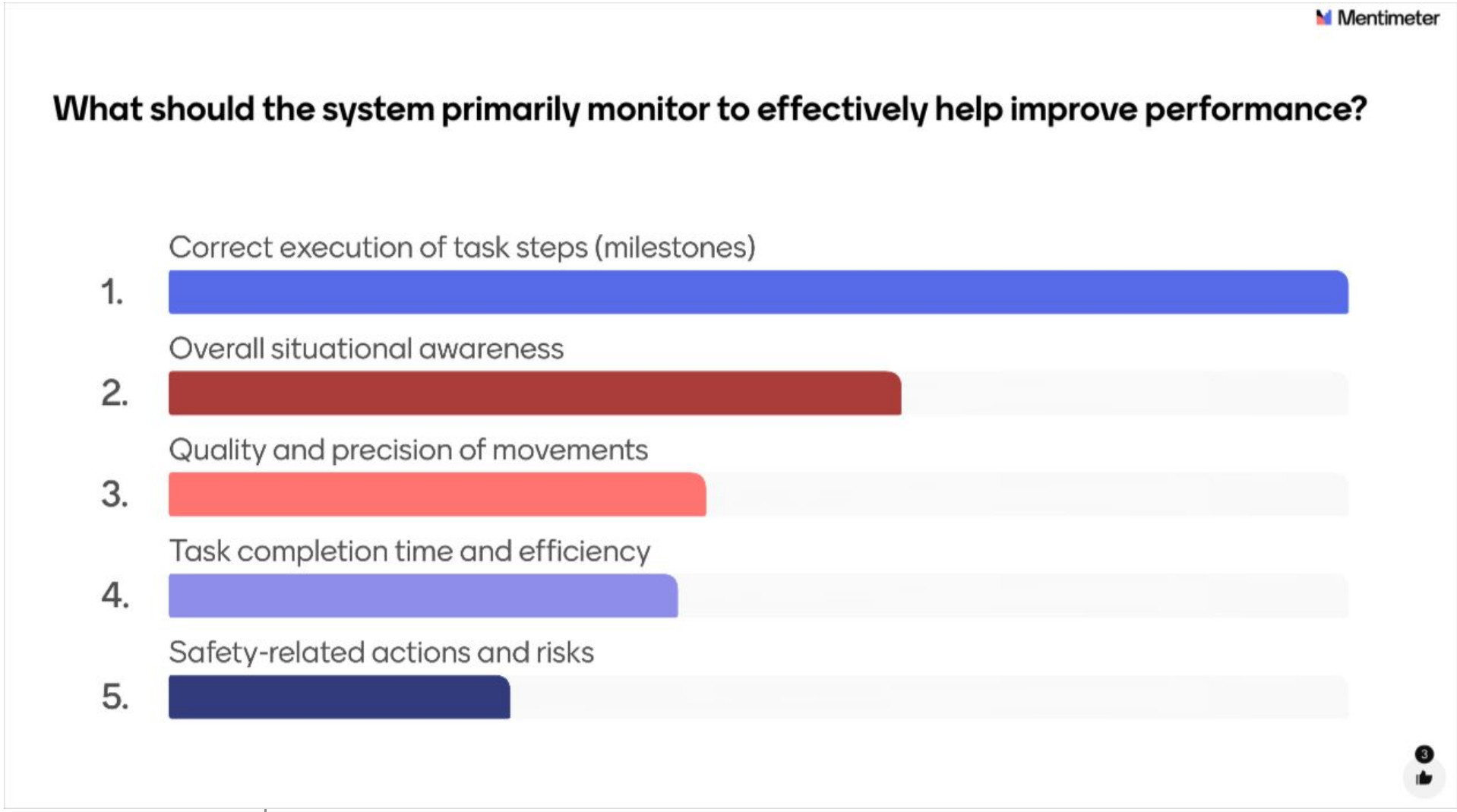

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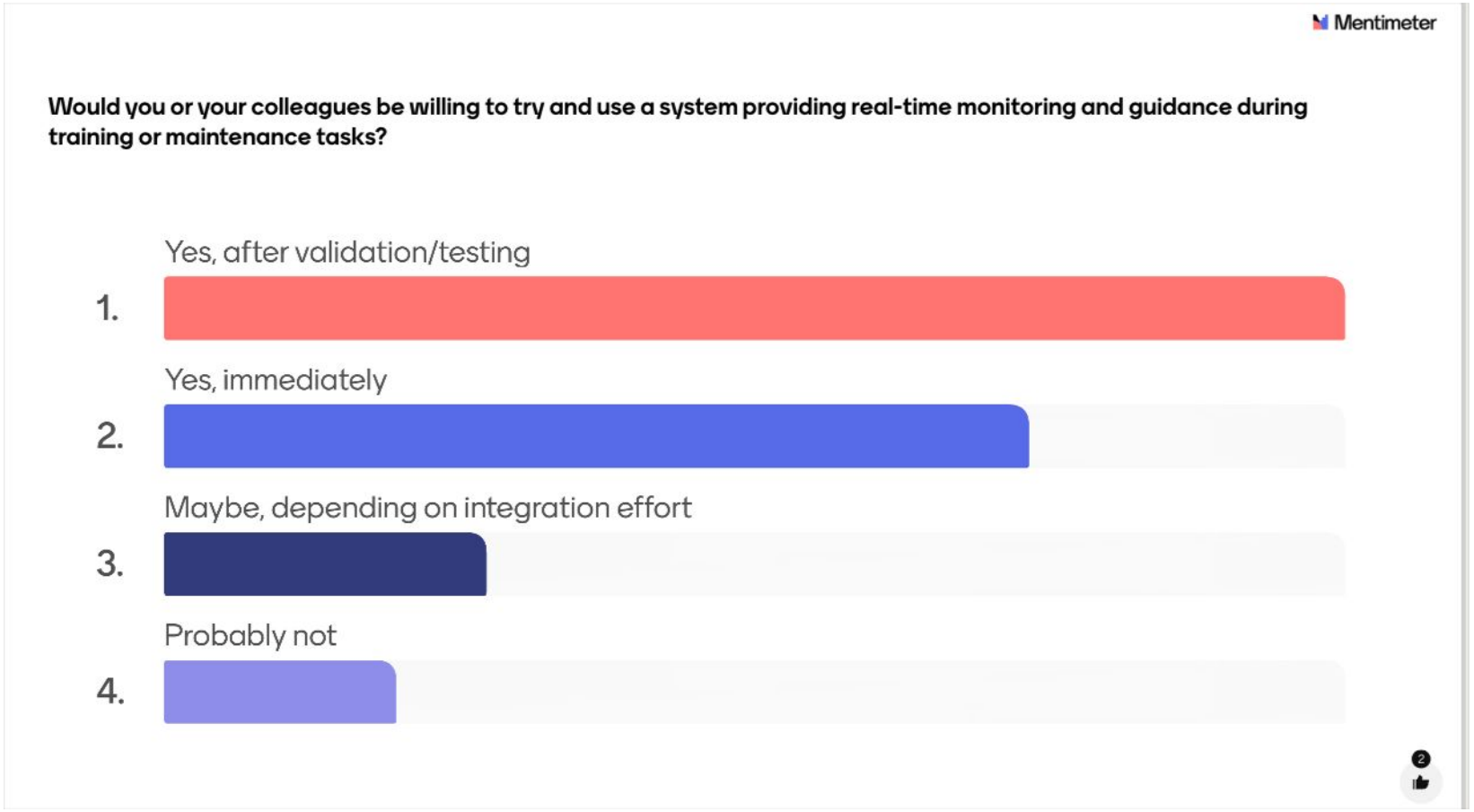

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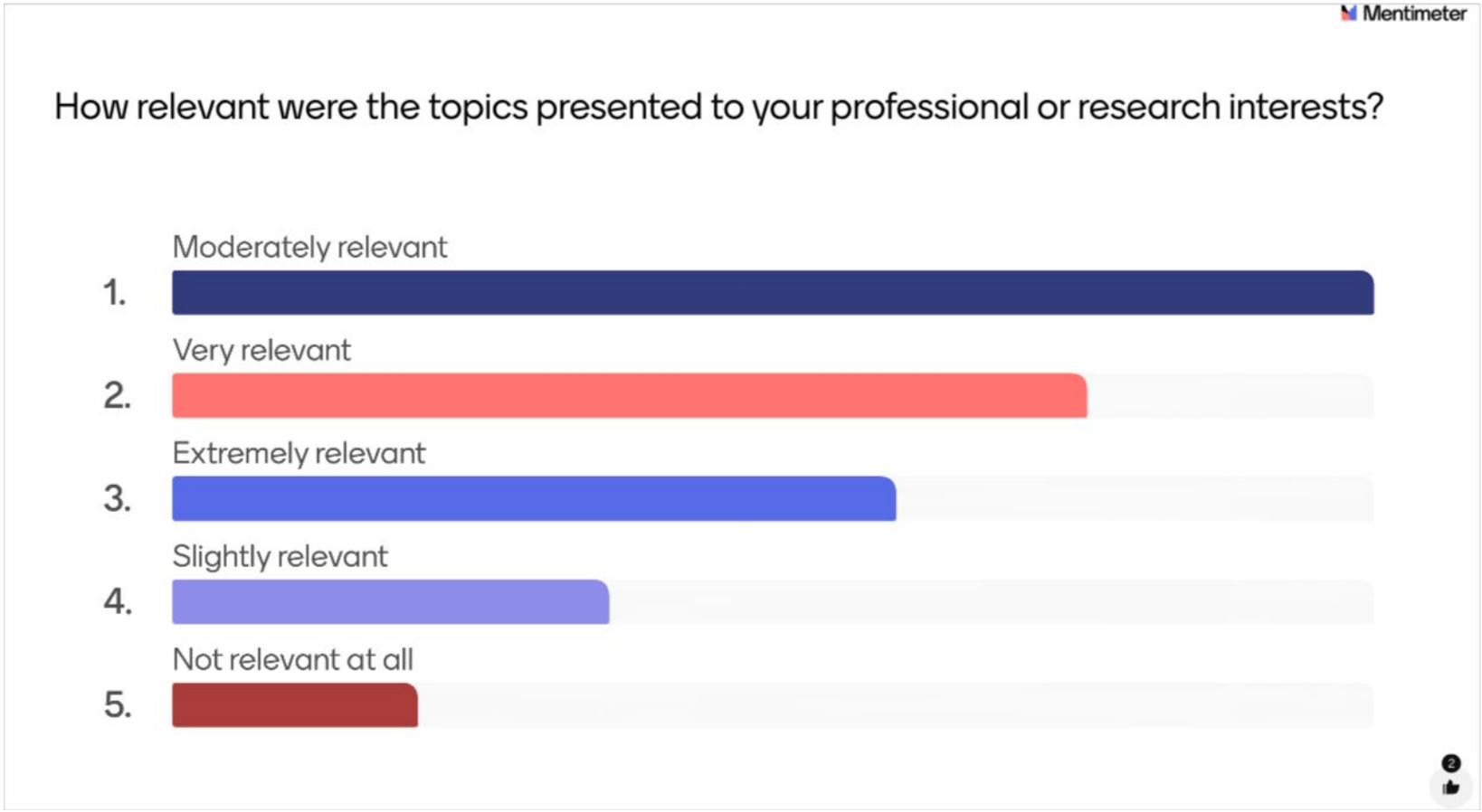

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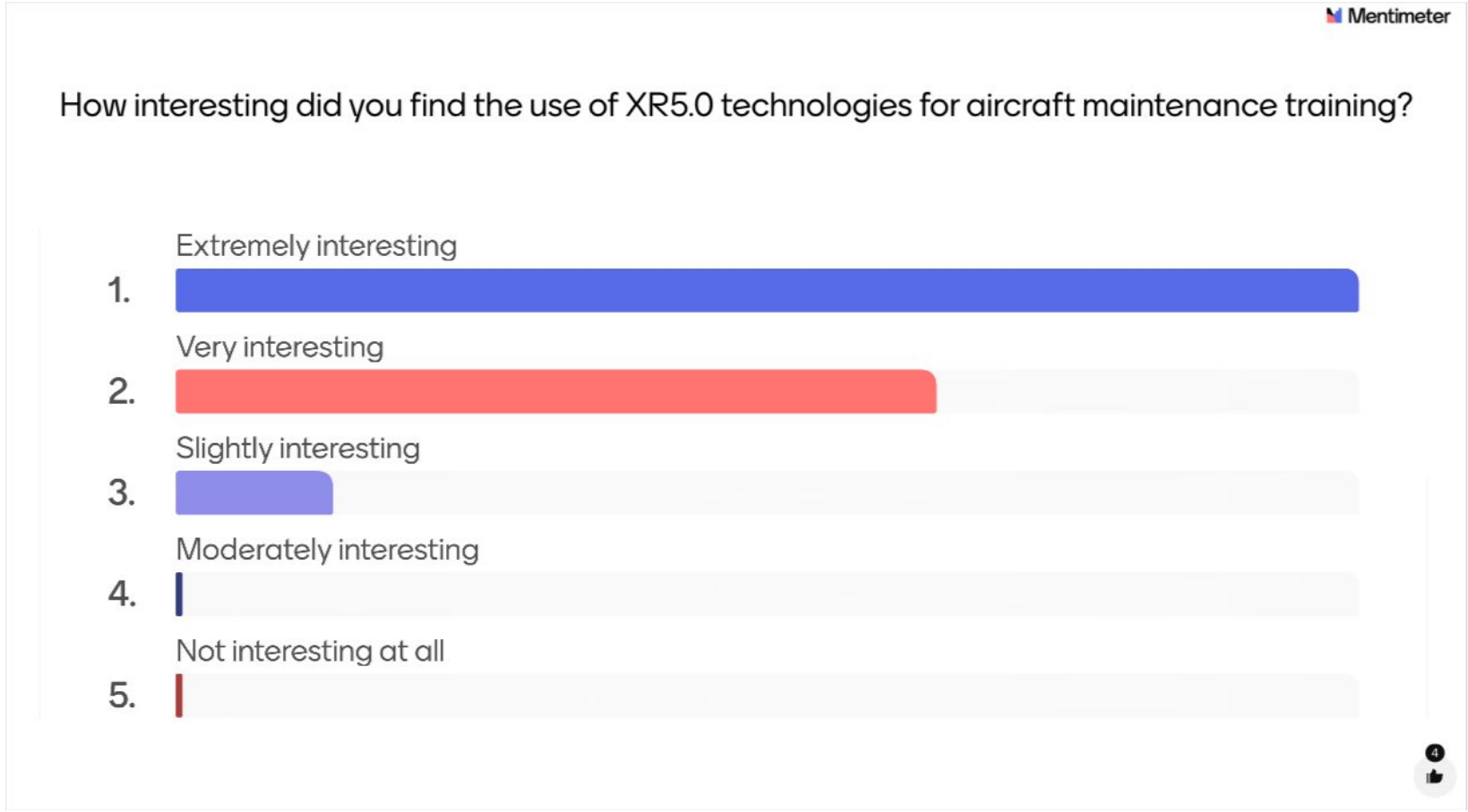

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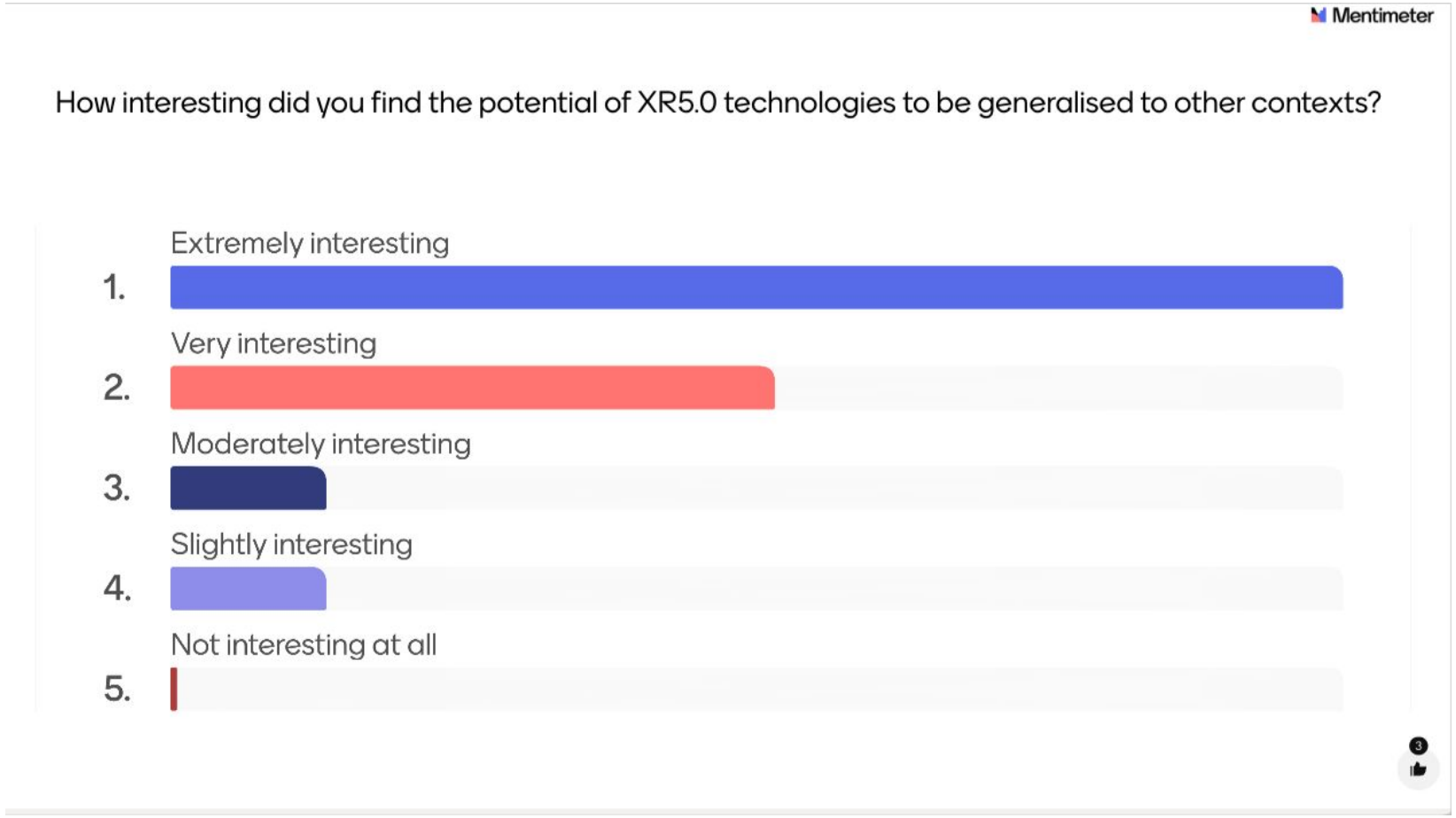

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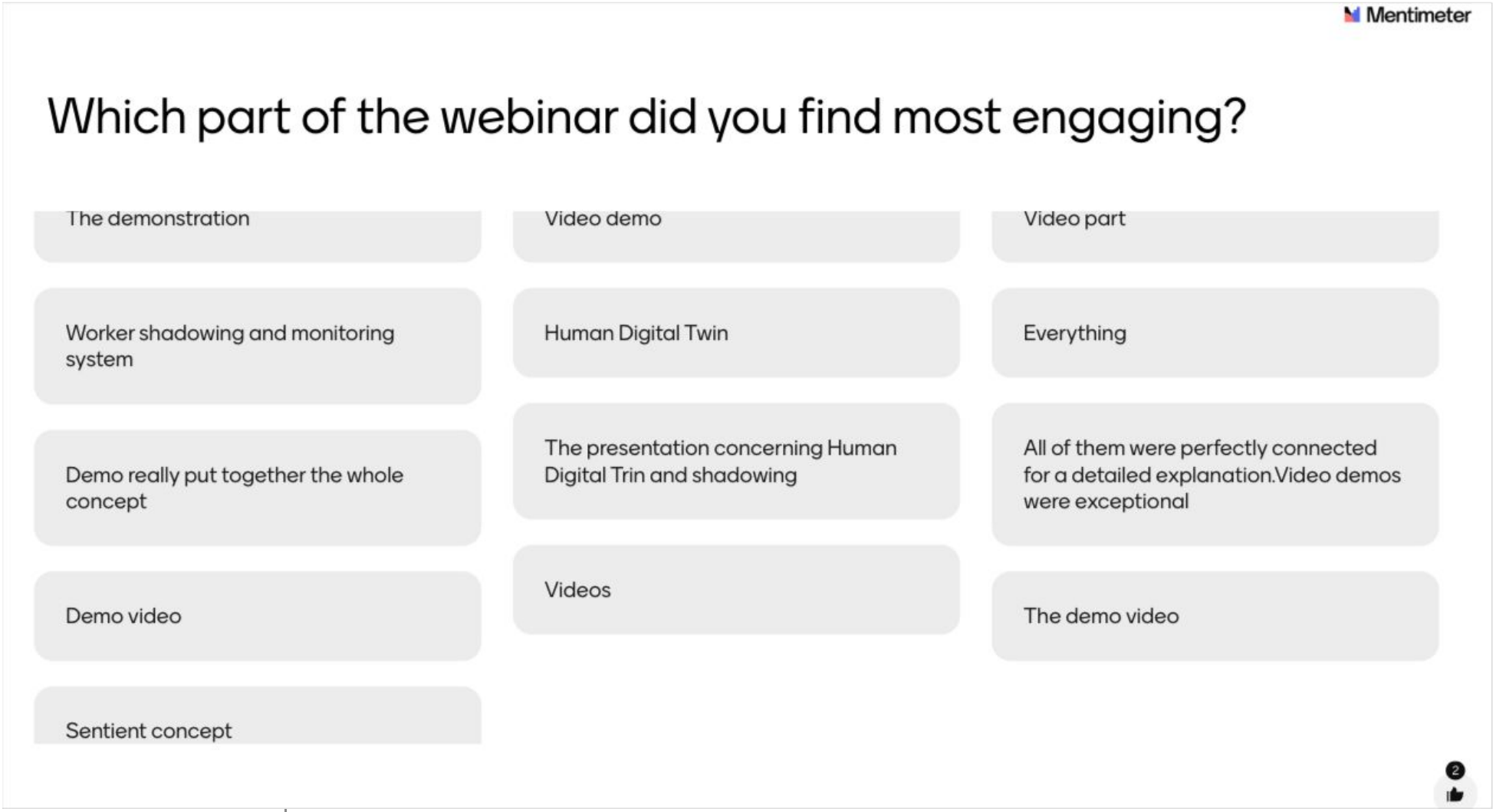

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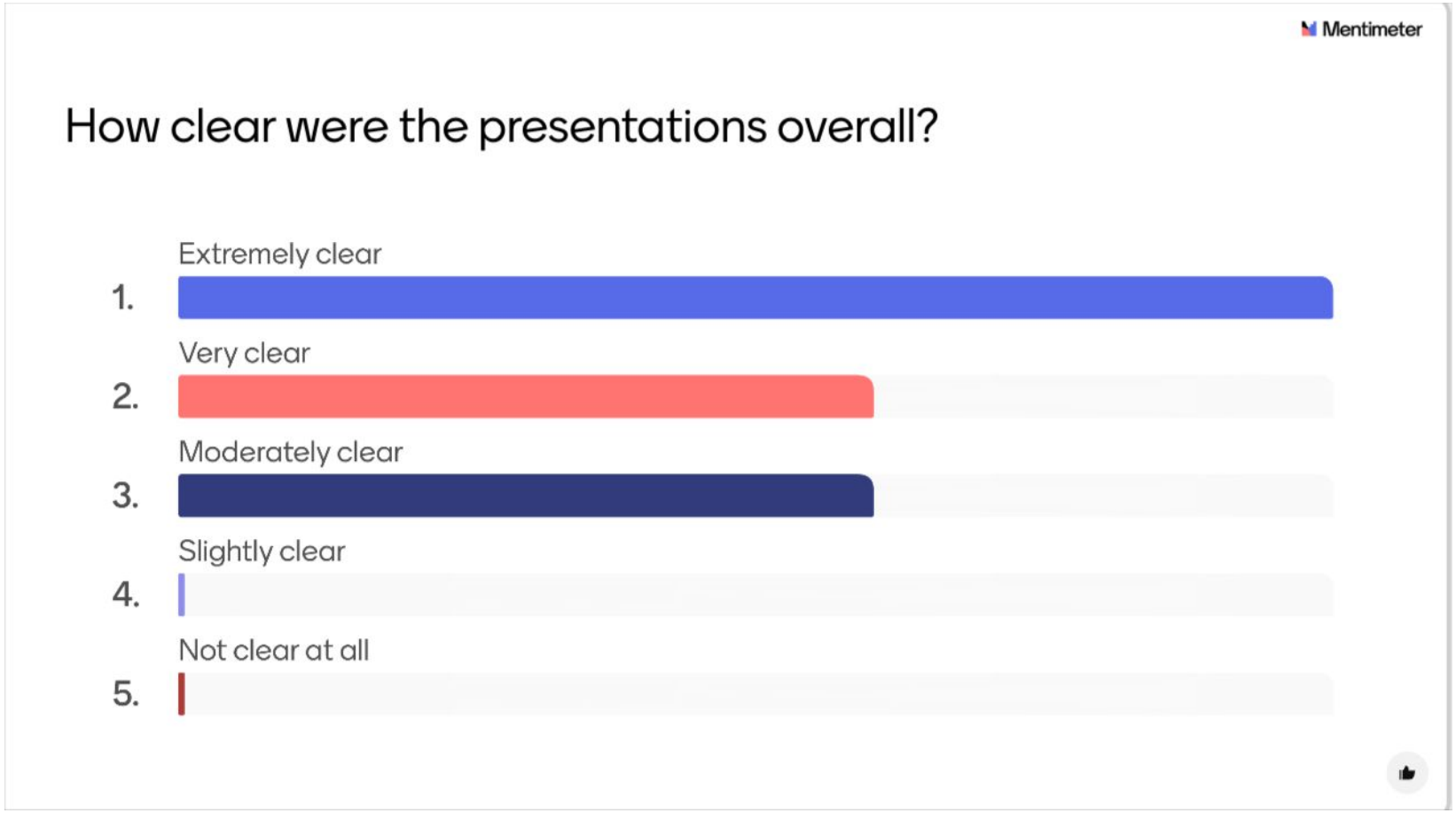

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Thank You!

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