HUMAN-CENTRIC AI-ENABLED EXTENDED REALITY APPLICATIONS FOR THE INDUSTRY 5.0 ERA

D2.1 – REQUIREMENTS AND REFERENCE SCENARIOS ANALYSIS

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REVISION HISTORY

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0.2	2024-03-08	UNP	Created the Pilots and Use Cases Description and Background Technologies templates
0.3	2024-04-12	UNP	Gathered all the Pilots' contributions for the Pilot and Use Case Description templates
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0.5	2024-04-30	UNP	Gathered all the Technical Partners' contributions for the Background Technologies templates
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3.0	2024-09-30		Version ready for the Submission

LIST OF ABBREVIATIONS

AI	Artificial Intelligence
AMT	Aircraft Maintenance Technician
API	Application Programming Interface
AR	Augmented Reality
CBM	Condition Based Maintenance
CCTV	Closed-Circuit Television
DT	Digital Twin
EU	European Union
HMI	Human Machine Interface
IoT	Internet of Things
ISAR	Interactive Streaming for Augmented Reality
KPI	Key Performance Indicator
LTE	Long Term Evolution Model
OS	Operating System
SLB	Systemic Lisbon Battery
UC	Use Case
VR	Virtual Reality
XAI	Explainable Artificial Intelligence
XR	Extended Reality
WAIV	Wing Anti-Ice Valve

EXECUTIVE SUMMARY

Deliverable D2.1, titled "Requirements and Reference Scenarios Analysis," is a key component of the XR5.0 project, developed under WP2: "Specifications, Architecture, and EU XR Platform Integration." This deliverable is associated with Task T2.1, "Analysis of Reference XR Scenarios for Industry 5.0 Applications." Its primary aim is to identify and analyse the requirements of reference XR scenarios within the context of Industry 5.0. This analysis outlines how XR5.0 can effectively address these challenges, providing a comprehensive framework for integrating XR technologies in Industry 5.0 applications.

The XR5.0 Project comprises six Pilots:

- Pilot 1 – Rapid Human Centric AI-Enabled Product Design
- Pilot 2 – Human Centred Remote Maintenance and Asset Management
- Pilot 3 – Operator 5.0 Training for Smart Water Pipes based on XR Streaming
- Pilot 4 – Worker Centric Aircraft Maintenance Training
- Pilot 5 – Increased Effectiveness and Safety of Product Assembly and Repair Processes
- Pilot 6 – Human Centric Guidance and Troubleshooting for Customer Service

These six Pilots are distributed across several European countries – Germany, Greece, Italy, Portugal and Switzerland –, each featuring at least two use cases to apply the project's reference technologies. This document begins with an overview of the Pilots and their respective Use Cases.

A User Story is a brief, concise description of a task from the user's perspective, illustrating how a software feature will provide value to the customer. It is a key tool for understanding the needs of the Pilots. Therefore, section three of this document is dedicated to the user stories provided by the Pilots and their Technical Partners.

Based on the collected user stories, nine reference scenarios were identified: Augmented Information, Immersive Training, Navigation Guidance, Personalization, Remote Assistant, Step by Step Guidance, Digital Twin, Generative AI and Chatbot. Alongside these reference scenarios, the related personas were also identified: Business Analyst, Concept Engineer, Customer, Field Technician, Mechanical Responsible, Project Manager, Quality Manager, Robot Programmer, Training Manager and Virtual Commissioner.

Finally, with the contributions from the Technical Partners, the main background technologies applicable to the XR5.0 Project were collected and documented. About eighteen technologies were shared by the Technical Partners of the project, more precisely: Oculavis Share Platform, Interactive 3D Maintenance Training, AR Assistant, IoT Edge Devices equipped with LTE connectivity, tailored for surveillance applications, Hololight Hub, Hololight Stream, Hololight Space, Neurosymbolic AI, LeanXcaleDB, Generative AI, Almer Arc 2, Almer OS – Operating System, Ultron – Smart Assistance, TeamViewer – Frontline, Clawdite, Wearable OS – Operating System, Service Connector Core and Context Extraction Framework.

This deliverable serves as a foundational analysis for the XR5.0 project, offering a detailed understanding of the requirements and scenarios necessary for the successful deployment of XR technologies in Industry 5.0 applications.

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1 INTRODUCTION

The main goal of this section is to introduce the deliverable by summarizing the objective of the current deliverable, presenting the methodology, its relation to the other tasks, and analysing its structure.

1.1 Objectives of the Deliverable

The present Deliverable D2.1 "Requirements and Reference Scenarios Analysis" of the XR5.0 project is part of the work conducted within the framework of WP2 "Specifications, Architecture and EU XR Platform Integration".

The task reference of this Deliverable is T2.1 "Analysis of Reference XR Scenarios for Industry 5.0 Apps". It aims to identify and analyse the requirements of reference XR scenarios in the context of Industry 5.0 applications, outlining how XR5.0 can address these challenges effectively. In this regard, the purpose of this document is to analyse requirements and reference scenarios.

A set of steps was developed to carry out this Deliverable, as the Figure 1 shows. The first step was to create the templates for the description of the Pilots and their Use Cases and circulate them among the Pilots' partners so they can provide the necessary information. The next step was the creation of the Background Technologies template and circulating it among the technical partners to have the technologies that can be applied to the XR5.0 Project. Then, the Pilots and their technical partners provided their validated User Stories, and with them, Reference Scenarios were defined, as well as the main personas of the User Stories.

Figure 1: Process of creation of the Deliverable

1.2 Insights from Other Tasks and Deliverables

The objective of this deliverable is to identify and analyse requirements and reference scenarios. Beyond the necessary work regarding the collection of the Pilots' requirements, Task T6.1 "Use Cases Co-Creation and Pilot Sites Preparation" was essential to the confirmation of the User Stories provided by the Pilots and their Technical partners and identified the Reference Scenarios. This task was devoted to preparation activities (including co-creation) of the XR5.0 Pilots and Use Cases. The activities included the design of the Use Cases systems, collection and management of the required datasets, mobilisation of domain experts at the various experimentation sites, and any relevant co-creation activities.

Beyond the insights from Task T6.1, the results from Task T2.1 will be considered for Task T2.3. This task will create a comprehensive Reference Architecture for XR applications in Industry 5.0. The Reference Architecture will address the unique challenges of Industry 5.0 applications, while ensuring seamless integration and compatibility with existing industrial systems, in line with the requirements of T2.1.

1.3 Structure

This deliverable comprises the following sections/chapters:

- Chapter 1 introduces the content of this deliverable.
- Chapter 2 presents the Pilots and the Use Case Overview.
- Chapter 3 presents the Requirements approach chosen, and the User Stories identified by the Pilots and the Technical Partners.
- Chapter 4 identifies the Reference Scenarios from the User Stories and respective Personas.
- Chapter 5 identifies the Personas from the User Stories
- Chapter 6 presents the Background Technologies that can be applied to the XR5.0 Project.
- Chapter 7 presents the main conclusions of this deliverable.

2 PILOTS OVERVIEW

Three templates were created for the characterization of the Pilots. One, focus on the Pilot with the variables: summary, description, motivation, and team roles. Another, with information on the Pilot's leading entity and the last one dedicated to the Use Cases of each Pilot, with the variables: Summary, Description, Value Propositions(s), KPIs, XR5.0 Technologies Requirements, Expected Functionalities, Deploy Characterization Place, Documentation, Image(s), Website and Keywords. The templates are available in the ANNEX I.I.

These three templates circulated among the Pilots' partners, who provided the necessary information to have a complete characterization of the Pilots and their Use Cases. The tables below show a resume of the complete templates that are in the Annex section from ANNEX II.I to ANNEX II.VI.

2.1 Pilot 1 – Rapid Human Centric AI-Enabled Product Design

Table 1: Pilot 1 and Use Cases

Pilot 1 **Rapid Human Centric AI-Enabled Product Design** KUKA, a leader in powertrain assembly, embraces XR5.0 for human-centric, AI-powered solutions. XR applications enhance training, reduce downtimes, and offer real-time feedback, addressing labour market changes. Adopting XR boosts KUKA's productivity, efficiency, sustainability, and competitiveness, fostering a more human-centric approach.	
Use Case 1.1 **Personalised XR in Assembly Line Production**	**Use Case 1.2** **Virtual Commissioning and Generative AI in Robotics**
This XR5.0 Use Case employs integrated results to simplify assembly lines and detect faults early. Digital embedding of products in the plant reduces trial parts, enabling real-time fault detection and personalized feedback. XR5.0 enhances human-machine interaction, helping KUKA optimize assembly lines for efficiency and sustainability	XR5.0's Use Case tackles challenges in robot-automated assembly by using AI and XAI to address complexity and the need for skilled workers. It employs generative AI for product variants, XR visualization, and virtual commissioning to enhance efficiency, mitigate worker shortages, and promote sustainability

2.2 Pilot 2 – Human Centred Remote Maintenance and Asset Management

Table 2: Pilot 2 and Use Cases

Pilot 2	
Human Centred Remote Maintenance and Asset Management Established in 1864, SH, a leading supplier, leverages XR5.0 for personalized AR solutions, optimizing service in over 80 countries. OCU's SHARE software integrates maintenance workflows, offering visual assistance enriched with AI content from human-AI collaboration, including neurosymbolic learning and XAI, along with GenAI algorithms. This enhances personalization and safety in remote maintenance applications.	
Use Case 2.1 **Expert Maintenance as a Service** This XR5.0 Use Case utilizes OCU's SHARE virtual assistance software for remote inspection and maintenances of lab instruments via XR. Enhanced with project AI visualizations, it efficiently harnesses technicians' expertise, reducing on-site work and enhancing resilience in SH's instrument industries.	**Use Case 2.2** **Immersive Retrofitting** This XR5.0 Use Case utilizes OCU's SHARE virtual assistance software for remote inspection and maintenance of lab instruments via XR. Enhanced with project AI visualizations, it efficiently harnesses technicians' expertise, reducing on-site work and enhancing resilience in SH's instrument industries.

2.3 Pilot 3 – Operator 5.0 Training for Smart Water Pipes based on XR Streaming

Table 3: Pilot 3 and Use Cases

Pilot 3

Operator 5.0 Training for Smart Water Pipes based on XR Streaming

EKSO's XR5.0 pilot transforms smart pipes maintenancve. Using embedded sensors, it monitors operativity and integrity of a pipe during its lifetime. EKSO aims to enhance worker training and operations by leveraging HOLO's XR training application hosted on HOLO's platform and streamed to the AR glasses by HOLO's XR streaming technology, providing hands-on experience without physical equipment. The training will be enhanced by INNOV's AI technology to interpret and utilise the sensor data for efficient and personalized activities and training. This fosters efficient, flexible, and scalable operation execution and training for Operator 5.0, emphasizing creativity and innovation in inspecting and servicing advanced pipes while minimizing costs and risks.

Use Case 3.1	Use Case 3.2	Use Case 3.2
XR-Based Training on Visual Inspection and Anomaly Detection	**XR-Based Training on Condition Based Maintenance**	**Immersive Retrofitting**
EKSO's XR5.0 Use Case integrates smart pipes interaction. Deployers use XR devices for immersive experiences with HOLO's XR technologies which include the XR training application, XR streaming plugin and the XR hosting platform. The application overlays real-time data, offering visual guidance and AI-driven anomaly detection. This accelerates issue identification, reduces unexpected failure risk, and enhances	This XR5.0 Use Case expands XR streaming to CBM. Utilizing HOLO's ISAR and AI algorithms, live training sessions offer realistic scenarios. A generative AI interface enhances Operator 5.0's interactions, using OpenAI platform with tailored data for effective XR engagement.	EKSO's XR5.0 Use Case revolutionises CCTV pipes inspection operations. Deployers use XR devices for immersive experiences with HOLO's XR technologies which include the XR training application, XR streaming plugin and the XR hosting platform. The training application overlays real-time data, offering visual guidance and AI-driven anomaly detection based on image detection. This accelerates issue identification, reduces maintenance intervention failure risk, and enhances overall service efficiency.

overall equipment efficiency.		

2.4 Pilot 4 – Worker Centric Aircraft Maintenance Training

Table 4: Pilot 4 and Use Cases

Pilot 4	
Worker Centric Aircraft Maintenance Training This XR5.0 pilot enhances WAIV maintenance for TAP's junior engineers. AI tools and XR environments, integrated into IML's VR platform, simulate skilled AMTs. The success enables human-centric XR applications in aviation, boosting safety, reliability, and benefiting passengers and airlines.	
Use Case 4.1 **Virtual Training** This XR5.0 Use Case enhances WAIV maintenance for AMTs using IML's SLB platform. AI in XR environments improves efficiency, accuracy, and safety, ensuring a reliable aircraft fleet for the benefit of passengers and airlines.	**Use Case 4.2** **AMT Digital Twin** This XR5.0 Use Case creates a Human DT emulating skilled AMTs, constantly improving through learning from failures. Utilizing XR5.0 visualization and AI-generated instructions, the DT guides and provides feedback to train new maintenance technicians, ensuring precise execution and preventing deviations.

2.5 Pilot 5 – Increased Effectiveness and Safety of Product Assembly and Repair Processes

Table 5: Pilot 5 and Use Cases

Pilot 5

Increased Effectiveness and Safety of Product Assembly and Repair Processes

This XR5.0 pilot showcases solutions for SPACE's worker training and support in edge device assembly. Emphasizing personalized instructions for different skill levels proves the effectiveness of tailored guidance in assembly and repairs, enhancing worker proficiency.

Use Case 5.1	Use Case 5.2
Personalized Training for Edge Devices Assembly	**Remote Instructions for Repairs**
This XR5.0 Use case will develop custom VR/AR training sessions tailored for assembling SPACE's edge devices, targeting different learner profiles. It utilizes SYN's Unity-based XR solutions and META Quest VR glasses to deliver personalized, AI-driven scenarios through immersive 3D visualizations.	This XR5.0 Use Case crafts personalized AR content for technicians to identify and fix defects. AI-driven, tailored guidance offers detailed help for novices and concise solutions for experts, enhancing repair efficiency and accuracy.

2.6 Pilot 6 – Human Centric Guidance and Troubleshooting for Customer Service

Table 6: Pilot 6 and Use Cases

Pilot 6

Human Centric Guidance and Troubleshooting for Customer Service

This XR5.0 pilot showcases AI-driven solutions addressing the challenge of "limited personalization" in XR environments. Tailored guidance for maintenance and troubleshooting adapts to individuals' experience, preferred interaction, and stress levels, utilizing ALMER's AR glasses and software alongside LNS bar feeder technology

Use Case 6.1	Use Case 6.2
Human Centred Preventive Maintenance guidance	**Trouble Shooting for Repair**
This XR5.0 pilot enhances predictive maintenance. AI-linked AR glasses guide technicians, offering customized instructions based on expertise. Human DTs detect stress, adjusting guidance. Quality assurance adapts to beginners' confirmation needs and automates documentation for experienced workers, optimizing efficiency and effectiveness.	Expanding on the first case, this XR5.0 Use Case employs AI for troubleshooting sudden machine malfunctions. Adaptive plans prioritize steps based on data, experience, and stress levels from the Human Digital Twin. XR glasses offer tailored representations and user-controlled data monitoring, optimizing identification of root causes for efficient repairs and documentation.

3 REQUIREMENTS

One of the goals of this deliverable is to identify and analyse the requirements of reference XR scenarios within the context of Industry 5.0. The most used approaches to identify and analyse requirements are the "traditional" approach of requirements and the User Stories. Both aim to define and understand the needs of end-users and develop products that provide solutions to their needs. However, the User Story approach focuses on the experience — what the person using the product wants to be able to do. The "traditional" requirement approach focuses on functionality — what the product should do. In this regard, the User Story approach is not as technical as the "traditional" one, which makes it easier to reach non-technical people and understand their needs. Adding this to the fact that this deliverable is public dissemination, the Agile User Stories, was used as an alternative to the “traditional” requirements approach.

A User Story is a requirement expressed from the perspective of an end-user goal[3]. It is an informal, general explanation of a software feature written from the end user's perspective. In other words, it is a brief description of what a product needs to do, who it is for, and why it is required. Its purpose is to articulate how a software feature will provide value to the customer.

A User Story is a well-expressed requirement. This format has become a popular way of expressing requirements because:

- It focuses on the viewpoint of a role who will use or be impacted by the solution.
- It defines the requirement in language that has meaning for that role.
- It helps to clarify the true reason for the requirement.
- It helps to define high level requirements without necessarily going into low level detail too early.

There are many ways of doing a user story. However, it is important to always consider the elements of user, action and benefit to provide a comprehensive picture of what exactly is needed. With these three elements, it is possible to write a brief user story regarding the feature of the persona needs and why they need it. Usually, it’s written in one or two sentences and follows a simple format to make it easy to understand and act on. The structure followed was: "As a ..., I want to ... so that ... ". as Figure 2 shows. This structure helps to understand what the user needs without getting into technical details. Every User Story is identified with the number of the Pilot first, followed by the number of the User Story (e.g.: User Story 2.5 means that User Story five belongs to Pilot 2).

[3] https://www.agilebusiness.org/dsdm-project-framework/requirements-and-user-stories.html

Data Struture	Example
As a <role>	**As a** technician
I want <goal>	**I want** personalized instructions
So that <benefit>	**So that** I can quickly and confidently perform maintenance tasks accurately and without errors
Acceptance criteria (conditions of satifastion)	**Acceptance criteria** 1. Instructions should be tailored to my technical levels 2. Instructions should be presented clearly and intuitively with visual and textual cues

Figure 2: User Stories Structure

3.1 User Stories

In this regard, with the contribution of the Pilots of the project was possible to identify sixty-nine valid user stories that will help to understand the needs of the end-users. All the user stories are identified in the table below.

Table 7: User Stories

Pilot #	User Story #	As a ...	I want to ...	So That ...
1	1.1	Virtual Commissioner	see the products to be manufactured digitally embedded in the production line	I can detect possible faults directly on the production line
1	1.2	Customer	see the products to be manufactured digitally embedded in the production line	I can reduce the need for test parts and waste
1	1.3	Customer	see instructions on how to use a cell directly in my field of vision	I can perform tasks accurately and without errors
1	1.4	Maintenance Engineer	receive step-by-step repair instructions directly in my field of vision through augmented reality glasses	I can perform maintenance tasks accurately and without errors
1	1.5	Virtual Commissioner	product variants are automatically identified and highlighted in AR glasses	efficiency/productivity is improved
1	1.6	Virtual Commissioner	see test results during virtual test campaigns directly visualised in AR glasses	efficiency/productivity is improved
1	1.7	Customer	see information about cycle times, lot sizes, etc.	I can see always the OOE
1	1.8	Maintenance Engineer	see all relevant information about the required spare part(s)	there is no risk of using wrong parts or any other misunderstandings
1	1.9	Maintenance Engineer	know how to get the desired parts as fast as possible	I can get the correct parts as soon as possible
1	1.10	Quality Manager	have the leaks found on the test part visualized by AR during leak tests	I see all detected leaks at a glance
1	1.11	Mechanical Engineer	to see the virtualized machineries parts shown	get a better impression of the current state and the relation to the still upcoming installation work start with my robot programming without having the completely

				machineries available have the information in which order parts needs to be installed
1	1.12	Robot Programmer	to see the virtualized machineries parts shown	get a better impression of the current state and the relation to the still upcoming installation work start with my robot programming without having the completely machineries available have the information in which order parts needs to be installed
1	1.13	Concept Engineer	to see the virtualized machineries parts shown	get a better impression of the current state and the relation to the still upcoming installation work start with my robot programming without having the completely machineries available have the information in which order parts needs to be installed
1	1.14	Project Manager	see the virtualized machineries parts shown	get a better impression of the current state and the relation to the still upcoming installation work start with my robot programming without having the completely machineries available have the information in which order parts needs to be installed
1	1.15	PLC Programmer	have step by step guideline, on how to set and optimize process parameters	easy step throw a virtual to-do list and can quickly see which parameters have already been edited/optimized and what still needs to be done
1	1.16	Mechanical Commissioner	have a step by step guideline throw all the mechanical adjustments	easy step throw a virtual to-do list
2	2.1	Service Technician Expert	create comprehensive training modules	I can resolve common issues independently
2	2.2	Service Technician Expert	access real-time data from field operations	I can provide precise guidance and troubleshooting support remotely

2	2.3	Service Technician Expert	develop a centralized knowledge base with troubleshooting solutions	common equipment issues can be quickly addressed by users themselves
2	2.4	Service Technician Expert	remotely view equipment status via AR visualizations	I can diagnose issues accurately without being physically present.
2	2.5	Service Technician Expert	receive feedback on the effectiveness of training materials and AR assistance	I can continuously improve the resources for better user independence
2	2.6	Field Service Technician	access AR content and visual aids	I can efficiently resolve issues on-site with expert guidance
2	2.7	Field Service Technician	receive step-by-step instructions for complex tasks	I can perform maintenance and repairs accurately and safely.
2	2.8	Field Service Technician	communicate in real-time with Service Technician Experts	I can get immediate assistance and clarification during critical tasks.
2	2.9	Field Service Technician	use devices that integrate seamlessly with AR technology	I can have hands-free access to data and instructions while working
2	2.10	Field Service Technician	log issues and solutions in a shared database	this information can help refine the knowledge base and training materials
2	2.11	Equipment Operator	access easy-to-follow AR guided instructions	I can attempt to solve simple issues myself before escalating to technical support
2	2.12	Equipment Operator	have a quick communication link to Service Technician Experts	I can receive immediate help if I encounter problems during DIY maintenance.
2	2.13	Equipment Operator	use a user-friendly interface for accessing the knowledge base	I can quickly find solutions without technical expertise
2	2.14	Equipment Operator	provide feedback on AR assistance and knowledge base effectiveness	the system can be improved for better self-service capabilities
3	3.1	Equipment Maintenance Operator	see the overall network/sensors structure (technology/connections/etc...)	I can understand the generate scheme
3	3.2	Equipment Maintenance Operator	see the malfunction indication located in space	I can understand where to intervene
3	3.3	Equipment Maintenance Operator	see the detailed scheme of the selected component	I can understand the single component potential defects

3	3.4	Pipe Maintenance Operator	see the over all scheme of the sensors located on the infrastructure	I can understand where the sensors have been installed on the infrastructure
3	3.5	Pipe Maintenance Operator	see the anomality located on the infrastructure/anomality development in time/ and anomality location in space4	I can intervene on the infrastructure with the highest precision directly on the problem
3	3.6	CCTV Operator	receive support during CCTV inspection	I can understand where the damages/animalities are located
3	3.7	CCTV Operator	receive immediate preliminary automatic anomaly evaluation and localization	I can seed up and increase precision in inspecting the pipe
4	4.1	Aircraft Maintenance Technician (AMT)	know which are the safety measures to handle a WAIV device maintenance	I do not put in risk myself and the device
4	4.2	Aircraft Maintenance Technician (AMT)	know how to access the WAIV device	I get to know what I need to do in order to reach the WAIV valve
4	4.3	Aircraft Maintenance Technician (AMT)	know which are the tools to disassemble the WAIV device	I collect and put next to me the necessary tools
4	4.4	Aircraft Maintenance Technician (AMT)	know how in what order should I disassemble the WAIV device	I am informed on what to do first and what follows
5	5.1	Training Manager	the ability to create training workflows personalized to individual technician skill level	I can minimize technician training time
5	5.2	Assembly Technician	be shown personalized feedback during assembly training	I can learn faster
5	5.3	Assembly Technician	the ability to identify defects trough the XR interface	I can complete the repair faster
5	5.4	Assembly Technician	be offered with repair suggestions	I can complete the repair faster
5	5.5	Assembly Technician	be offered with instructions to fast preform device commissioning	I can finish the set up faster
5	5.6	Assembly Technician	be offered with instructions to fast perform device operation verification	I can finish the set up faster

6	6.1	Technician	receive step-by-step repair instructions directly in my field of vision through augmented reality glasses	I can perform maintenance tasks accurately and without errors
6	6.2	Customer	receive step-by-step repair instructions directly in my field of vision through augmented reality glasses	I can perform maintenance tasks accurately and without errors
6	6.3	Technician	communicate in real-time with remote experts via augmented reality glasses	I can receive assistance and guidance during complex or unexpected situations
6	6.4	Customer	communicate in real-time with remote experts via augmented reality glasses	I can receive assistance and guidance during complex or unexpected situations
6	6.5	Technician	access a database of maintenance procedures and manuals through the augmented reality glasses	I can quickly reference technical information while performing tasks
6	6.6	Customer	access a database of maintenance procedures and manuals through the augmented reality glasses	I can quickly reference technical information while performing tasks
6	6.7	Customer	the ability to provide feedback through the augmented reality interface	I can communicate any concerns or suggestions directly to the maintenance team
6	6.8	Technician	the user experience to be intuitive and easy	I can quickly perform maintenance tasks accurately and without errors
6	6.9	Customer	the user experience to be intuitive and easy	I can quickly perform maintenance tasks accurately and without errors
6	6.10	Technician	I want personalized instructions	I can quickly and confidently perform maintenance tasks accurately and without errors
6	6.11	Customer	I want personalized instructions	I can quickly and confidently perform maintenance tasks accurately and without errors

6	6.12	Technician	receive alerts in case of danger	I am aware of the risks and can proceed confidently
6	6.13	Customer	receive alerts in case of danger	I am aware of the risks and can proceed confidently
6	6.14	Business Analyst	able to track the data generated by the system	I can make analyses, drive continuous improvement, and ensure efficient resource allocation
6	6.15	Technician	ensure that if I require assistance, the appropriate expert is promptly contacted	I receive the best advice in minimal time
6	6.16	Customer	ensure that if I require assistance, the appropriate expert is promptly contacted	I receive the best advice in minimal time
6	6.17	Customer	know the estimated duration of the entire procedure, with the option to pause and proceed later if needed	I am flexible in managing my time effectively during the maintenance task
6	6.18	Technician	a seamless transition of the instructions if my stress level is increasing or reducing	I'm not even more stressed or distracted
6	6.19	Customer	a seamless transition of the instructions if my stress level is increasing or reducing	I'm not even more stressed or distracted
6	6.20	Technician	register automatically the use cases and associated resolution tasks	further problems or questions can be answered rapidly
6	6.21	Service Team Manager	Technicians to be trained in XR methods	They can effectively utilize extended reality technologies in their work processes
6	6.22	Technical Documentation Worker	To be trained in XR tools for documentation compliance	I can create compliant documents effectively using XR tools

4 REFERENCE SCENARIOS

After collecting all the User Stories provided by the Pilots and analysing them, nine Reference Scenarios emerged: Augmented Information, Immersive Training, Navigation Guidance, Personalization, Remote Assistant, Step by Step Guidance, Digital Twin, Generative AI and Chatbot.

The analysis of the Reference Scenarios includes the definition of the scenario, the keywords, the KPIs, the objectives and the expected functionalities, as well as the number of User Stories it encompasses, the number and type of personas and the dispersion of the Reference Scenario across the six Pilots of the project.

As Figure 3 shows, all Pilots have, at least, one Reference Scenario, standing out Augmented Information, Step by Step Guidance and Digital Twin Reference Scenarios with more than three Pilots.

Figure 3: Matrix Reference Scenarios versus Pilots

Pilot	Augmented Information	Immersive Training	Navigation Guidance	Personalization	Remote Assistant	Step by Step Guidance	Digital Twin	Generative AI	Chatbot
1	✓					✓	✓	✓	
2	✓	✓	✓		✓	✓	✓		✓
3							✓		
4	✓					✓			
5	✓	✓			✓			✓	✓
6	✓	✓		✓	✓	✓	✓	✓	✓

4.1 Augmented Information

SCENARIO 1

AUGMENTED INFORMATION

Real-time feedback system | Fault detection | Augmented Reality

Augmented Information can be defined as digital information about a product, a machine, or a procedure that is displayed in the physical environment.

SCENARIO 1

12 USER STORIES

1.1 As a Virtual Commissioner, I want to see the products to be manufactured digitally embedded in the production line, so that I can detect possible faults directly on the production line.

1.2 As a Customer, I want to see the products to be manufactured digitally embedded in the production line, so that I can reduce the need for test parts and waste.

1.3 As a Customer, I want to see instructions on how to use a cell directly in my field of vision, so that I can perform tasks accurately and without errors.

1.6 As a Virtual Commissioner, I want to see test results during virtual test campaigns directly visualised in AR glasses, so that efficiency/productivity is improved.

1.7 As a Customer, I want to see information about cycle times, lot sizes, etc., so that I can see always the OOE.

1.8 As a Maintenance Engineer, I want to see all relevant information about the required spare part(s), so that there is no risk of using wrong parts or any other misunderstandings.

1.9 As a Maintenance Engineer, I want to know how to get the desired parts as fast as possible, so that I can get the correct parts as soon as possible.

2.2 As a Service Technician Expert, I want to access real-time data from field operations, so that I can provide precise guidance and troubleshooting support remotely.

2.6 As a Field Service Technician, I want to access AR content and visual aids, so that I can efficiently resolve issues on-site with expert guidance.

4.1 As an Aircraft Maintenance Technician (AMT), I want to know which the safety measures are to handle a WAIV device maintenance, so that I do not put in risk myself and the device.

5.3 As an Assembly Technician, I want to the ability to identify defects trough the XR interface, so that I can complete the repair faster.

6.12 As a Technician, I want to receive alerts in case of danger, so that I am aware of the risks and can proceed confidently.

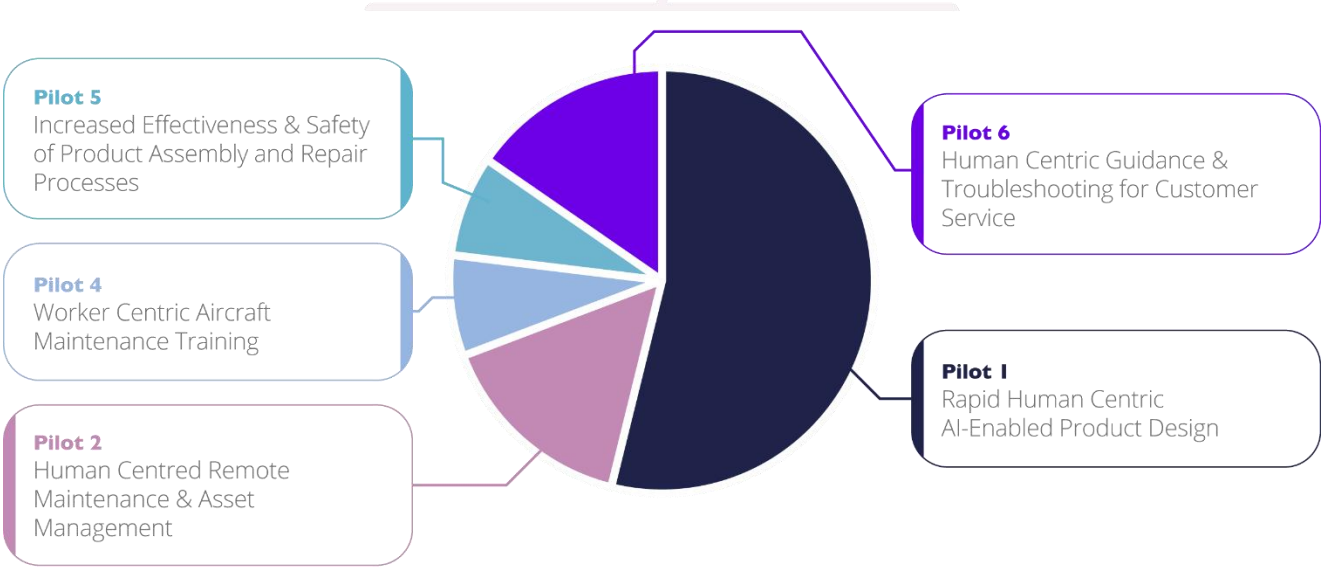
6.13 As a Customer, I want to receive alerts in case of danger, so that I am aware of the risks and can proceed confidently.

PERSONAS

7 Field Technician

4 Customer

2 Virtual Commissioner



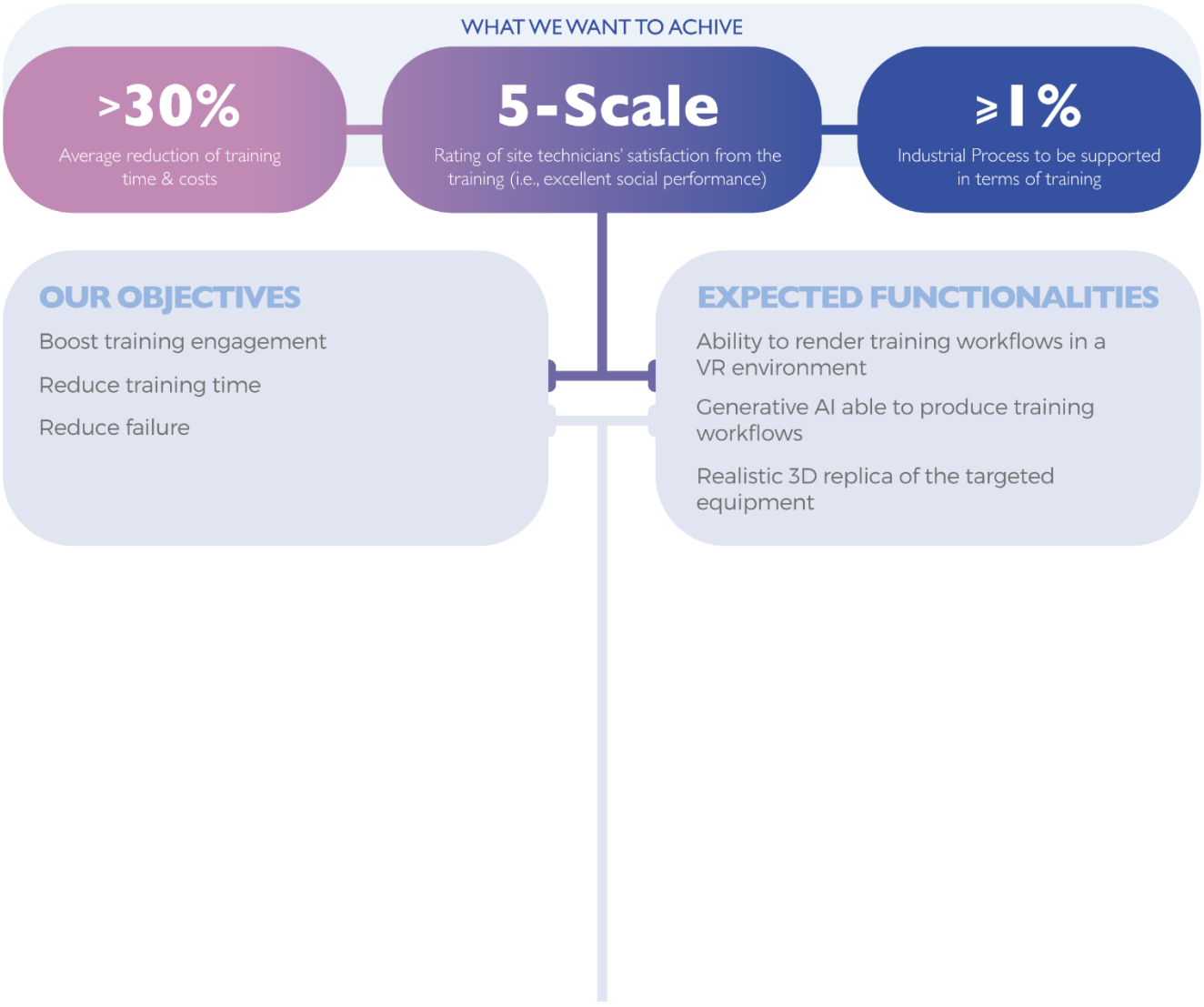
4.2 Immersive Training

SCENARIO 2

IMMERSIVE TRAINING

Neurosymbolic Learning | Personalized Training | Simulation-based Learning

Immersive Training is a methodology training that places individuals in an interactive learning environment, physically or virtually, to replicate possible scenarios or to teach specific skills or techniques.



SCENARIO 2

6 USER STORIES

2.1 As a Service Technician Expert create, I want to comprehensive training modules, so that Field Service Technicians and Equipment Operators can resolve common issues independently.

2.3 As a Service Technician Expert, I want to develop a centralized knowledge base with troubleshooting solutions, so that the common equipment issues can be quickly addressed by users themselves

2.5 As a Service Technician Expert, I want to receive feedback on the effectiveness of training materials and AR assistance, so that I can continuously improve the resources for better user independence.

5.1 As a Training Manager, I want to the ability to create training workflows personalized to individual technician skill level, so that I can minimize technician training time.

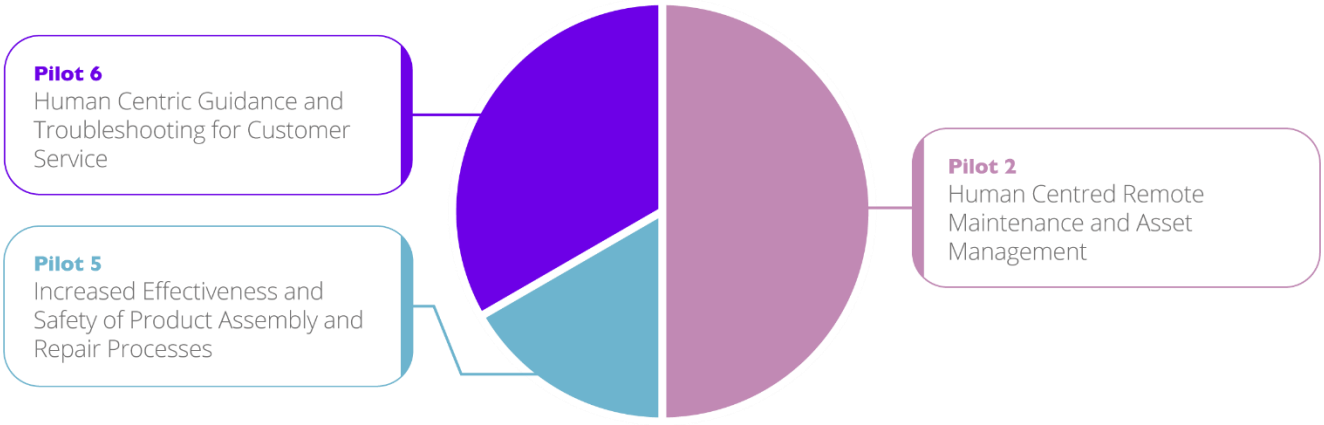
6.21 As a Service Team Manager, I want to Technicians to be trained in XR methods, so that they can effectively utilize extended reality technologies in their work processes

6.22 As a Technical Documentation Worker I want to be trained in XR tools for documentation compliance, so that I can create compliant documents effectively using XR tools.

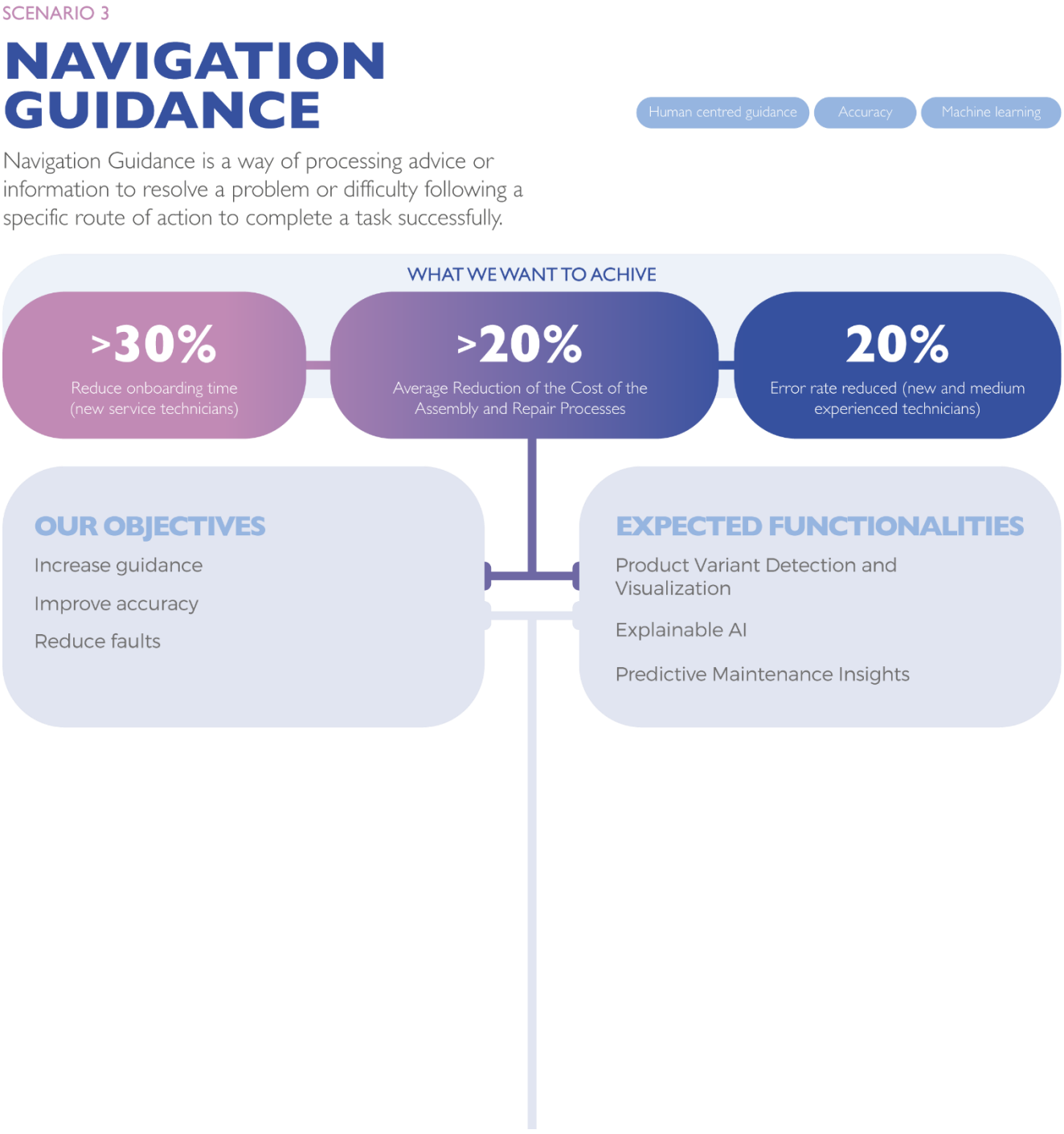
PERSONAS

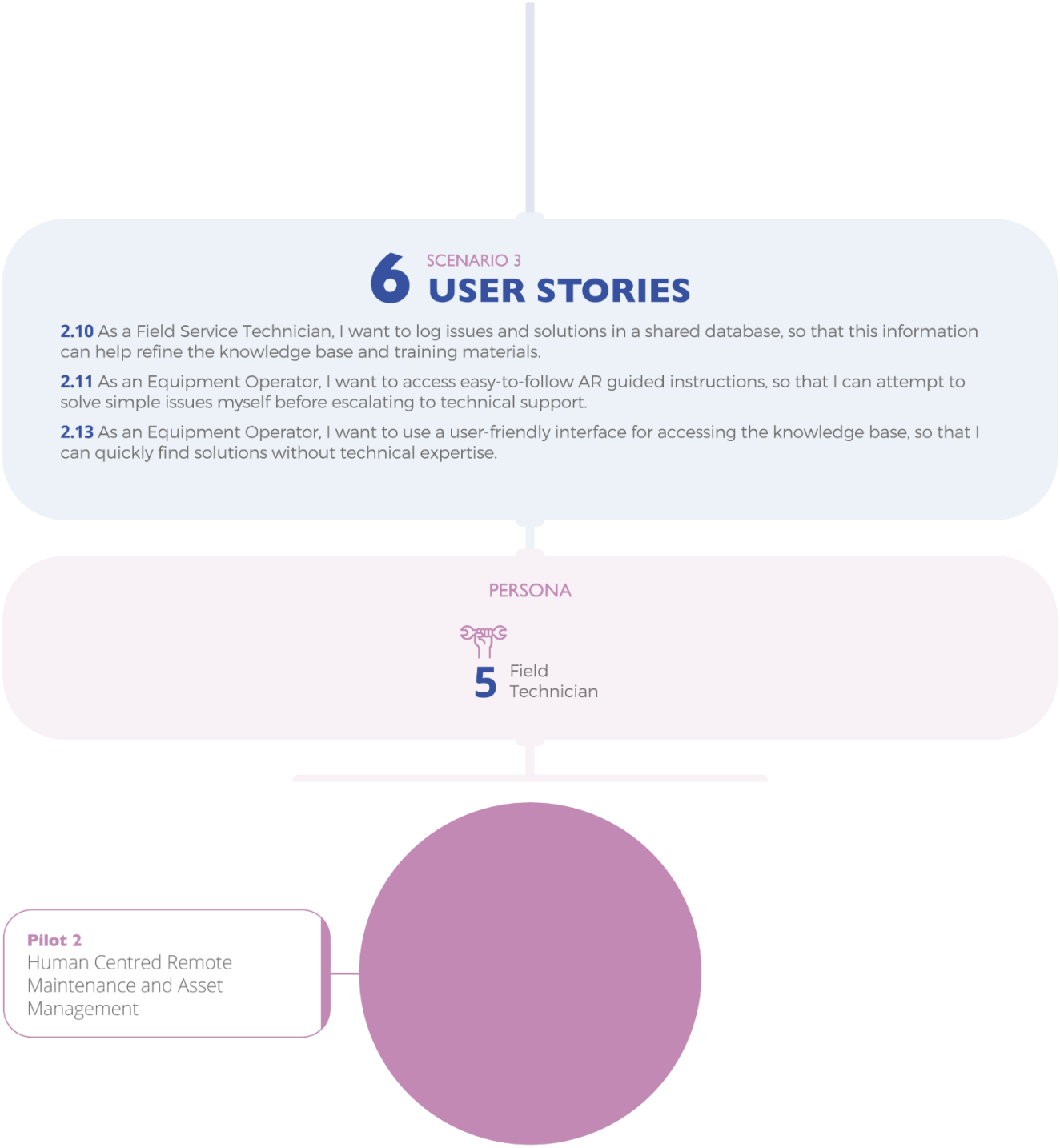
5 Field Technician

1 Training Manager



4.3 Navigation Guidance




6 SCENARIO 3
USER STORIES
2.10 As a Field Service Technician, I want to log issues and solutions in a shared database, so that this information can help refine the knowledge base and training materials.
2.11 As an Equipment Operator, I want to access easy-to-follow AR guided instructions, so that I can attempt to solve simple issues myself before escalating to technical support.
2.13 As an Equipment Operator, I want to use a user-friendly interface for accessing the knowledge base, so that I can quickly find solutions without technical expertise.
PERSONA
5 Field Technician
Pilot 2
Human Centred Remote Maintenance and Asset Management

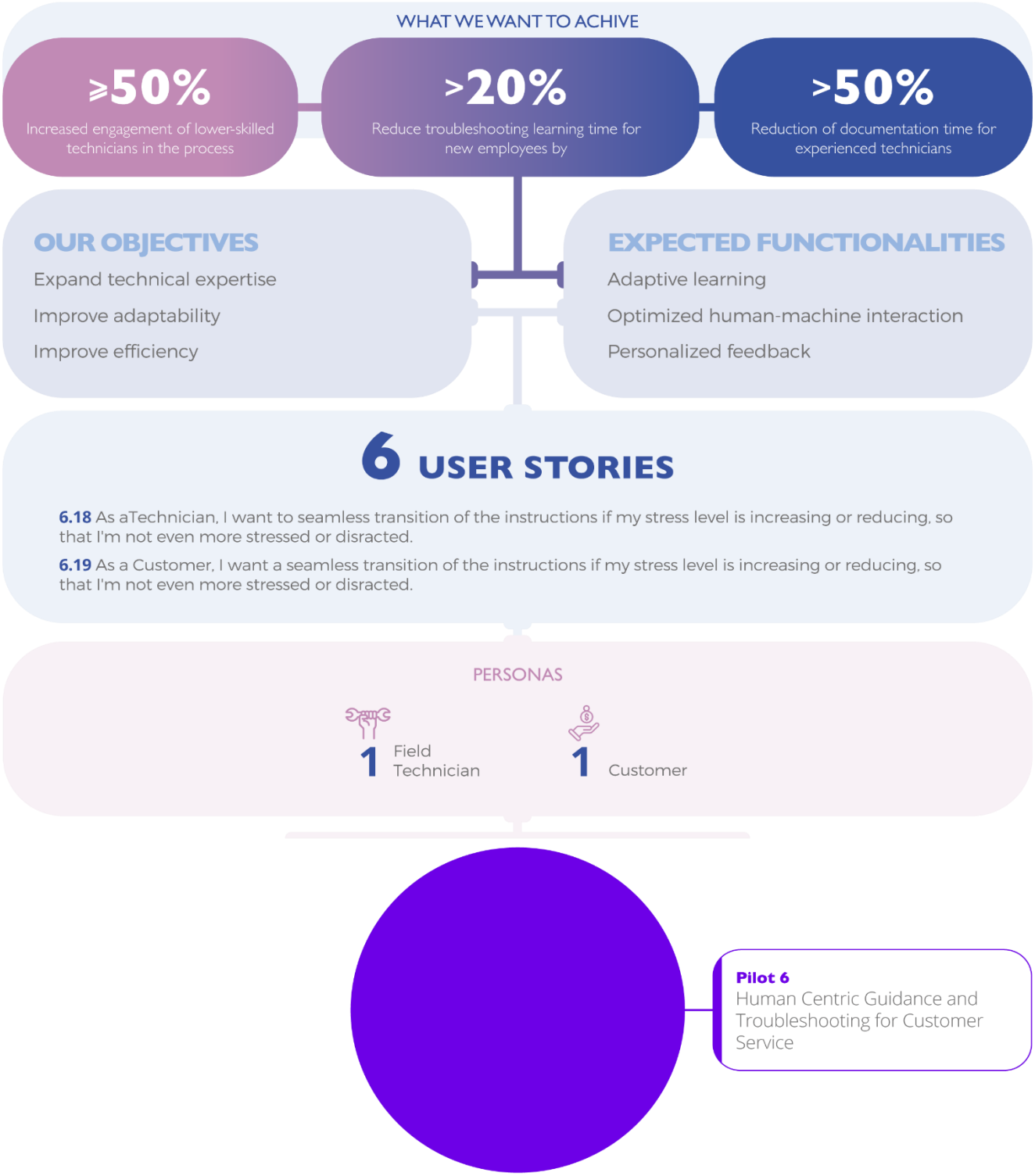
4.4 Personalization

SCENARIO 4

PERSONALIZATION

Extended Reality | Personalization | Stress level adaptive guidance

Personalization is the action of designing or producing something to meet someone's requirements.



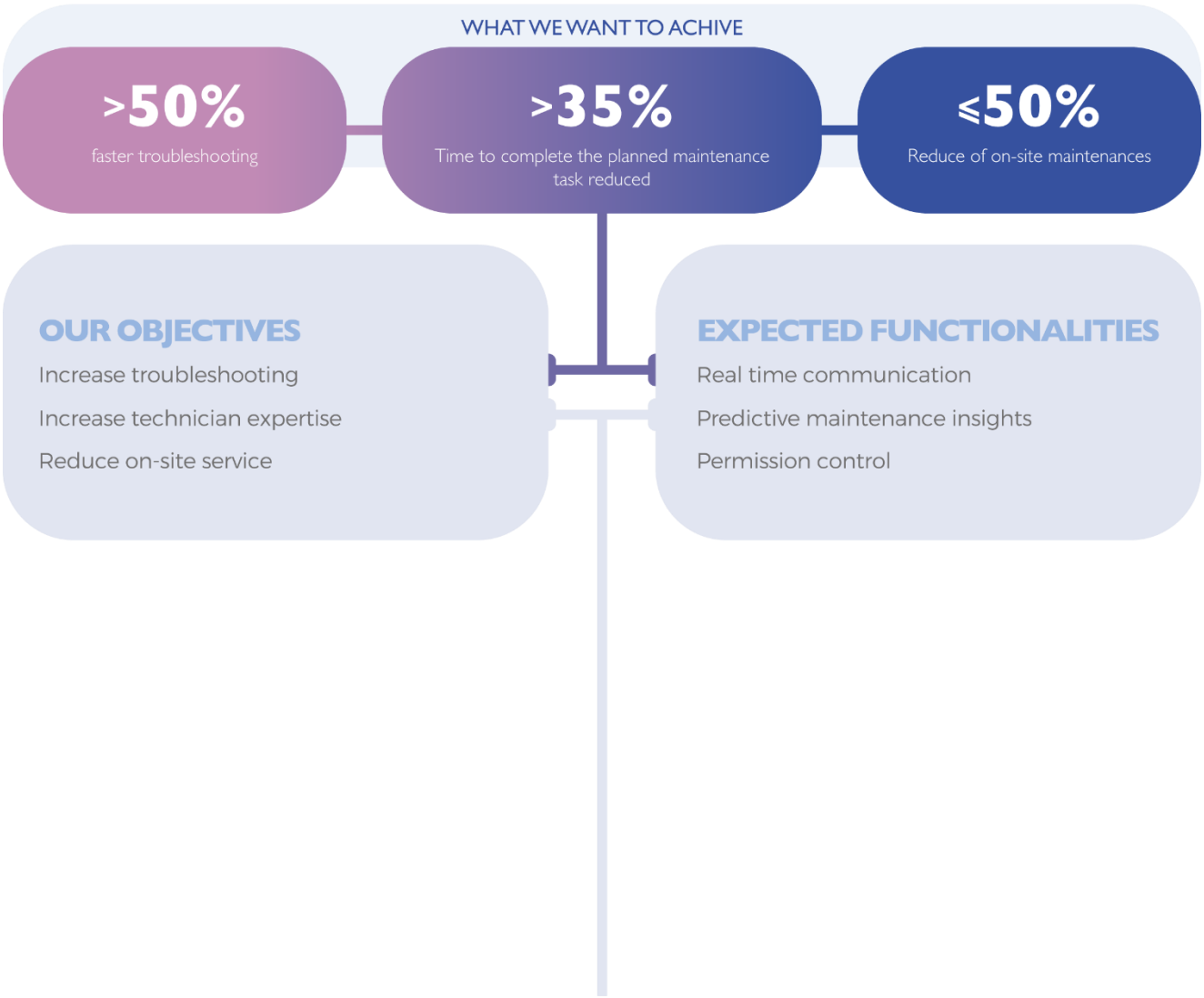
4.5 Remote Assistant

SCENARIO 5

REMOTE ASSISTANT

Remote Support | Virtual Commissioning | Virtual Maintenance Training

The Remote Assistant is a connection between a user and technician that allows technicians and remote collaborators to view and operate the user's device as if they were an administrator.



SCENARIO 5

9 USER STORIES

2.8 As a Field Service Technician, I want to communicate in real-time with Service Technician Experts, so that I can get immediate assistance and clarification during critical tasks.

2.12 As an Equipment Operator, I want to have a quick communication link to Service Technician Experts, so that I can receive immediate help if I encounter problems during DIY maintenance.

5.5 As an Assembly Technician, I want to be offered with instructions to fast preform device commissioning , so that I can finish the set up faster.

5.6 As an Assembly Technician, I want to be offered with instructions to fast preform device operation verification, so that I can finish the set up faster.

6.3 As a Technician, I want to communicate in real-time with remote experts via augmented reality glasses, so that I can receive assistance and guidance during complex or unexpected situations.

6.4 As Customer, I want to communicate in real-time with remote experts via augmented reality glasses, so that I can receive assistance and guidance during complex or unexpected situations.

6.10 As a Technician, I want to personalized instructions, so that I can quickly and confidently perform maintenance tasks accurately and without errors.

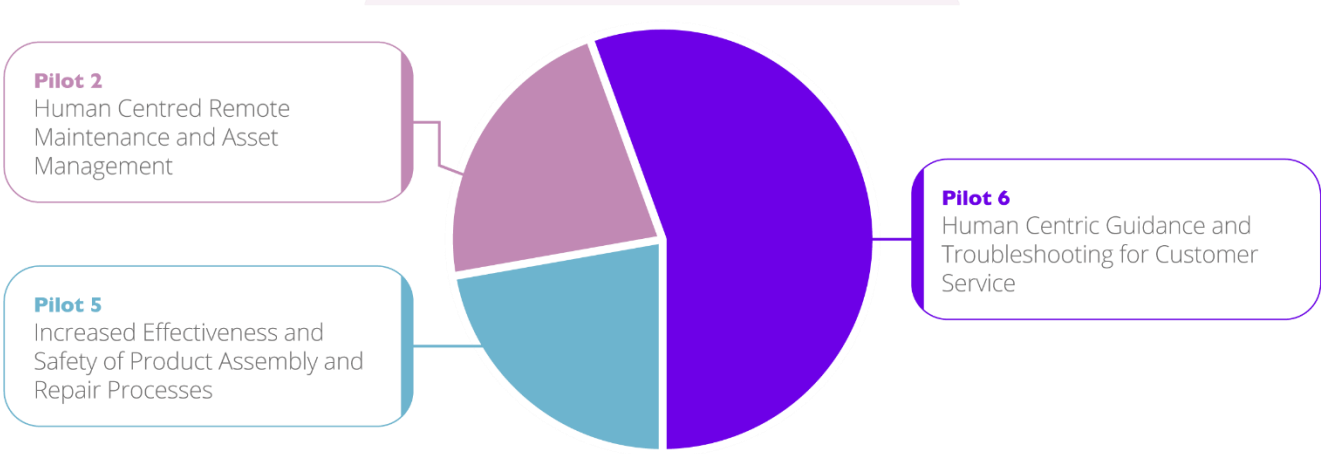
6.11 As a Customer, I want to personalized instructions, so that I can quickly and confidently perform maintenance tasks accurately and without errors.

6.15 As a Technician, I want to ensure that if I require assistance, the appropriate expert is promptly contacted, so that I receive the best advice in minimal time.

PERSONAS

7 Field Technician

2 Customers



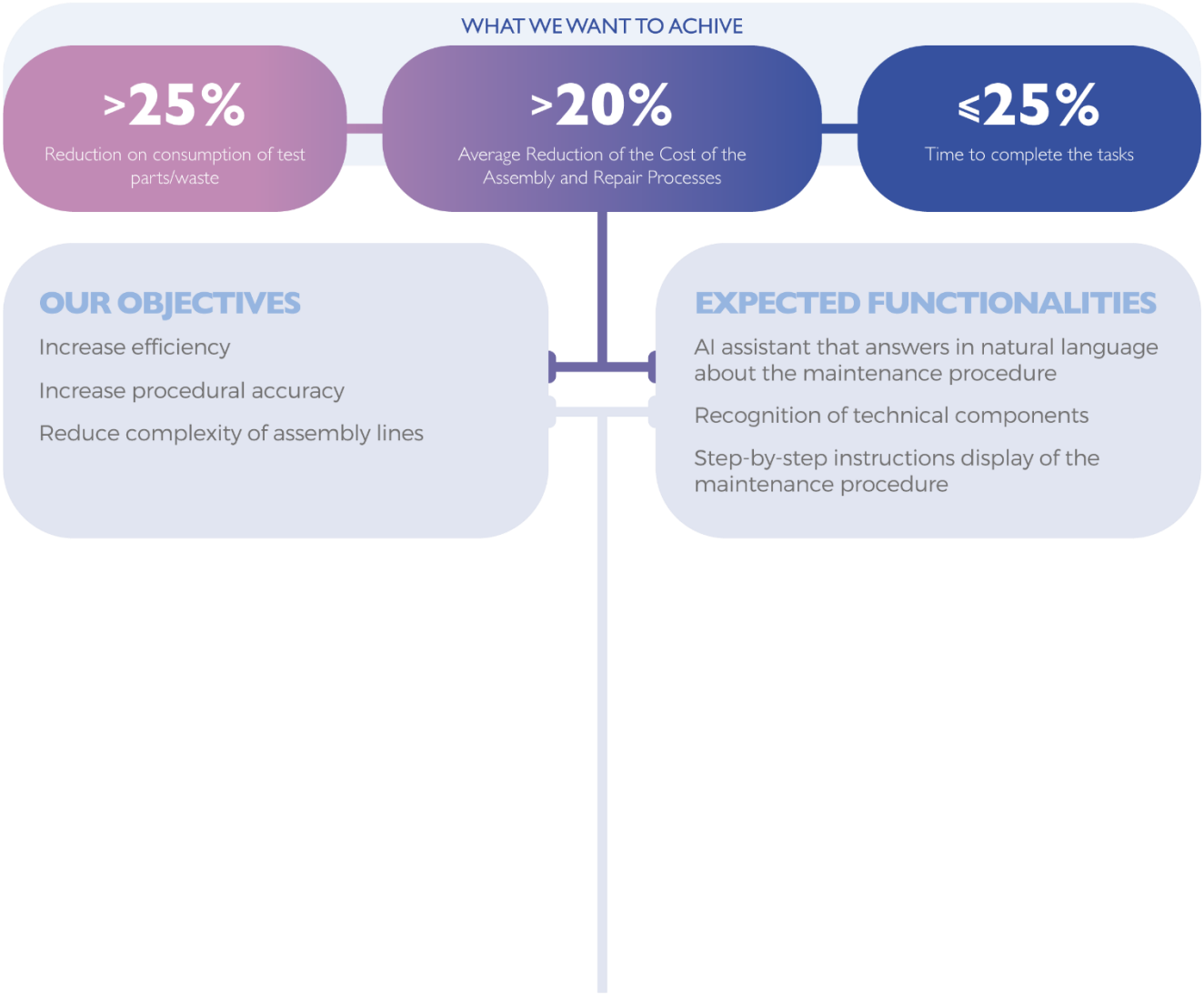
4.6 Step by Step Guidance

SCENARIO 6

STEP BY STEP GUIDANCE

Mixed reality | AI assistance | XR

The Step by Step Guidance is a methodology that helps the user with tips for progressing gradually from one stage to the next.



14 SCENARIO 6 USER STORIES

1.4 As a Maintenance Engineer, I want to receive step-by-step repair instructions directly in my field of vision through augmented reality glasses, so that I can perform maintenance tasks accurately and without errors.

1.11 As Mechanical Engineer, I want to see the virtualized machineries parts shown, so that get an better impression of the current state and the relation to the still upcoming installation work/start with my robot programming without having the completely machineries available/have the information in which order parts needs to be installed.

1.12 As a Robot Programmer, I want to see the virtualized machineries parts shown, so that get a better impression of the current state and the relation to the still upcoming installation work/start with my robot programming without having the completely machineries available/have the information in which order parts needs to be installed"

1.13 As a Concept Engineer, I want to see the virtualized machineries parts shown, so that get a better impression of the current state and the relation to the still upcoming installation work/ start with my robot programming without having the completely machineries available/have the information in which order parts needs to be installed.

1.14 As a Project Manager, I want to see the virtualized machineries parts shown, so that get a better impression of the current state and the relation to the still upcoming installation work/start with my robot programming without having the completely machineries available/have the information in which order parts needs to be installed.

1.15 As a PLC Programmer, I want to have step by step guideline on how to set and optimize process parameters, so that easy step throws a virtual to-do list and can quickly see which parameters have already been edited/optimized and what still needs to be done.

6.16 As a Mechanical Commissioner, I want to have a step by step guideline throw all the mechanical adjustments, so that easy step throw a virtual to-do list.

2.7 As a Field Service Technician, I want to receive step-by-step instructions for complex tasks, so that I can perform maintenance and repairs accurately and safely.

4.2 As an Aircraft Maintenance Technician (AMT), I want to know how to access the WAIV device, so thatI get to know what I need to do in order to reach the WAIV valve.

4.3 As an Aircraft Maintenance Technician (AMT), I want to know which the tools are to disassemble the WAIV device, so that I collect and put next to me the necessary tools.

4.4 As an Aircraft Maintenance Technician (AMT), I want to know how in what order should I disassemble the WAIV device, so that I am informed on what to do first and what follows.

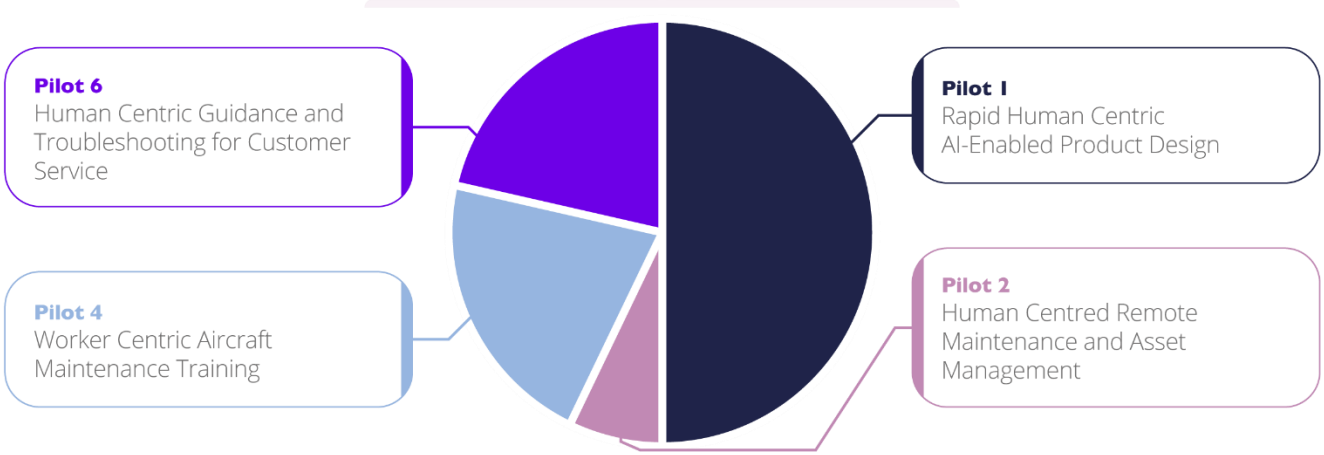
6.1 As a Technician I want to receive step-by-step repair instructions directly in my field of vision through augmented reality glasses, so that I can perform maintenance tasks accurately and without errors.

6.2 As a Customer, I want to receive step-by-step repair instructions directly in my field of vision through augmented reality glasses, so that I can perform maintenance tasks accurately and without errors.

6.20 As a Technician, I want to register automatically the use cases and associated resolution tasks, so that further problems or questions can be answered rapidly.

PERSONAS

- **1** Concept Engineer
- **7** Field Technician
- **1** Customer
- **2** Mechanical Responsable
- **1** Project Manager
- **2** Robot Programmer



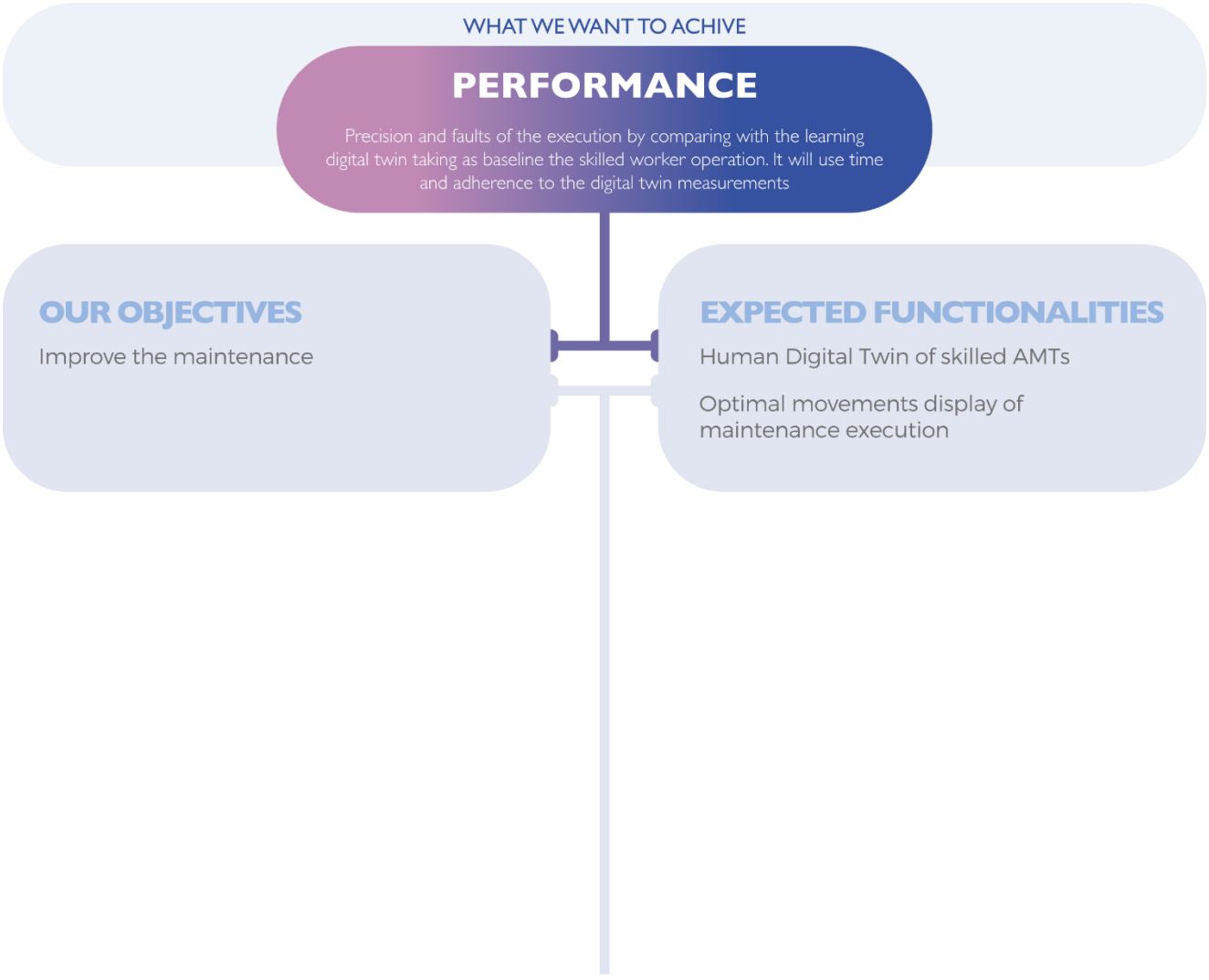
4.7 Digital Twin

SCENARIO 7

DIGITAL TWIN

Human-Machine Interaction | Mixed reality

Is a virtual representation of an object or system designed to reflect a physical object accurately. It spans the object's lifecycle, is updated from real-time data and uses simulation, machine learning and reasoning to help make decisions.



SCENARIO 7

10 USER STORIES

1.10 As a Quality Manager, I want to have the leaks found on the test part visualized by AR during leak tests, so that I see all detected leaks at a glance.

2.4 As a Service Technician Expert remotely, I want to view equipment status via AR visualizations, so that I can diagnose issues accurately without being physically present.

3.1 As an Equipment Maintenance Operator, I want to see the overall network/sensors structure (technology/connections/etc...), so that I can understand the generate scheme.

3.2 As an Equipment Maintenance Operator, I want to see the malfunction indication located in space, so that I can understand where to intervene.

3.3 As an Equipment Maintenance Operator, I want to see the detailed scheme of the selected component, so that I can understand the single component potential defects.

3.4 As a Pipe Maintenance Operator, I want to see the overall scheme of the sensors located on the infrastructure, so that I can understand where the sensors have been installed on the infrastructure.

3.5 As a Pipe Maintenance Operator, I want to see the anomality located on the infrastructure/anomality development in time/ and anomality location in space4, so that I can intervene on the infrastructure with the highest precision directly on the problem.

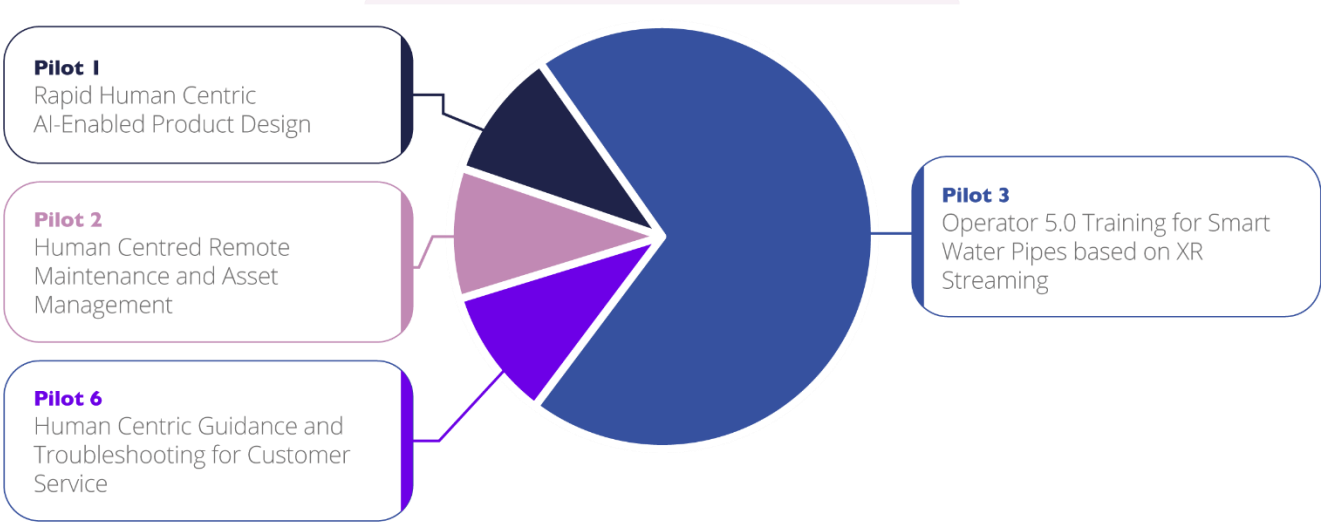
3.6 As a CCTV Operator, I want to receive support during CCTV inspection, so that I can understand where the damages/animalities are located.

3.7 As a CCTV Operator, I want to receive immediate preliminary automatic anomaly evaluation and localization, so that I can seed up and increase precision in inspecting the pipe.

6.14 As the Business Analyst, I want to able to track the data generated by the system, so that I can make analyses, drive continuous improvement, and ensure efficient resource allocation.

PERSONAS

- **8** Field Technician
- **1** Business Analyst
- **1** Quality Manager



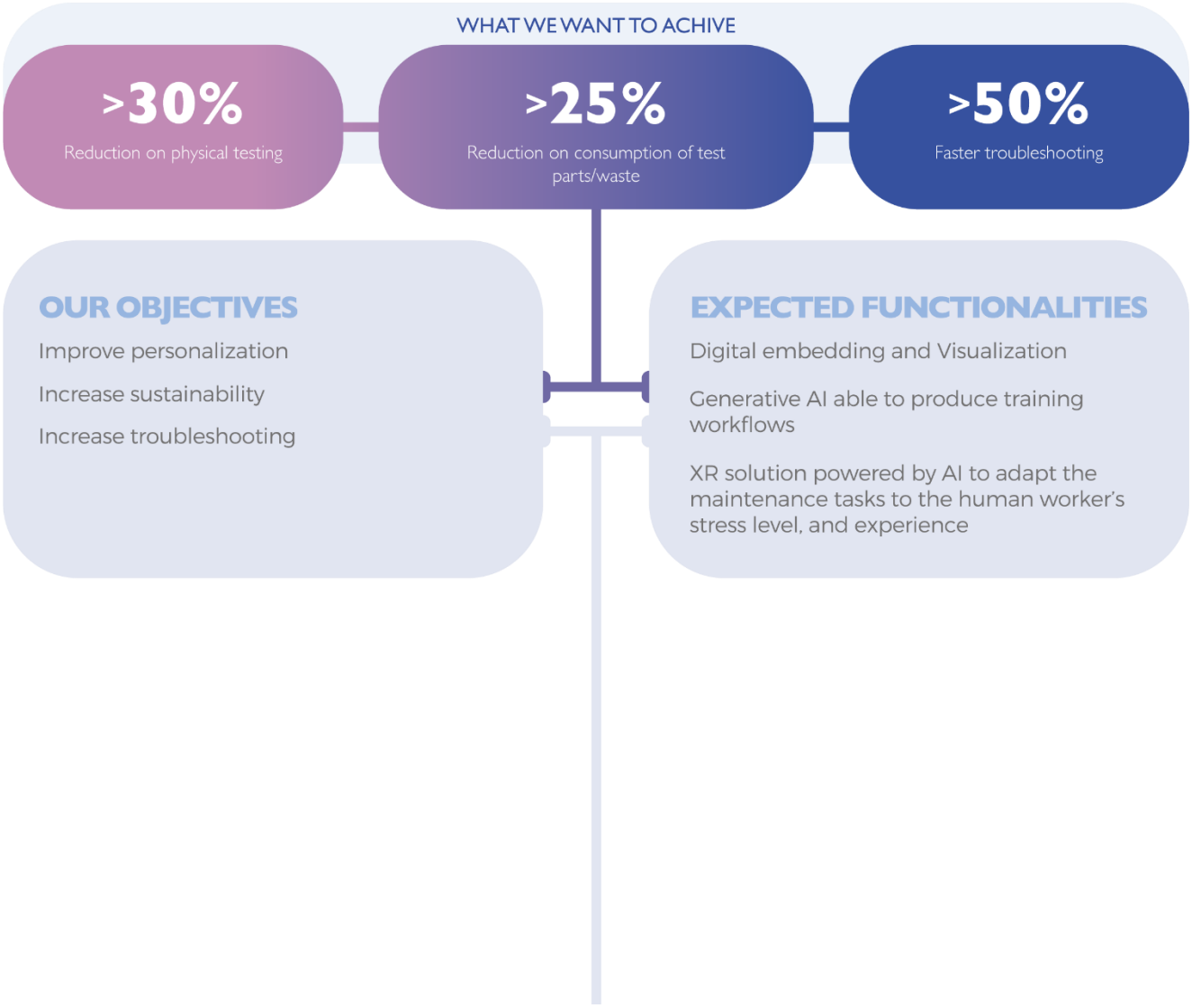
4.8 Generative AI

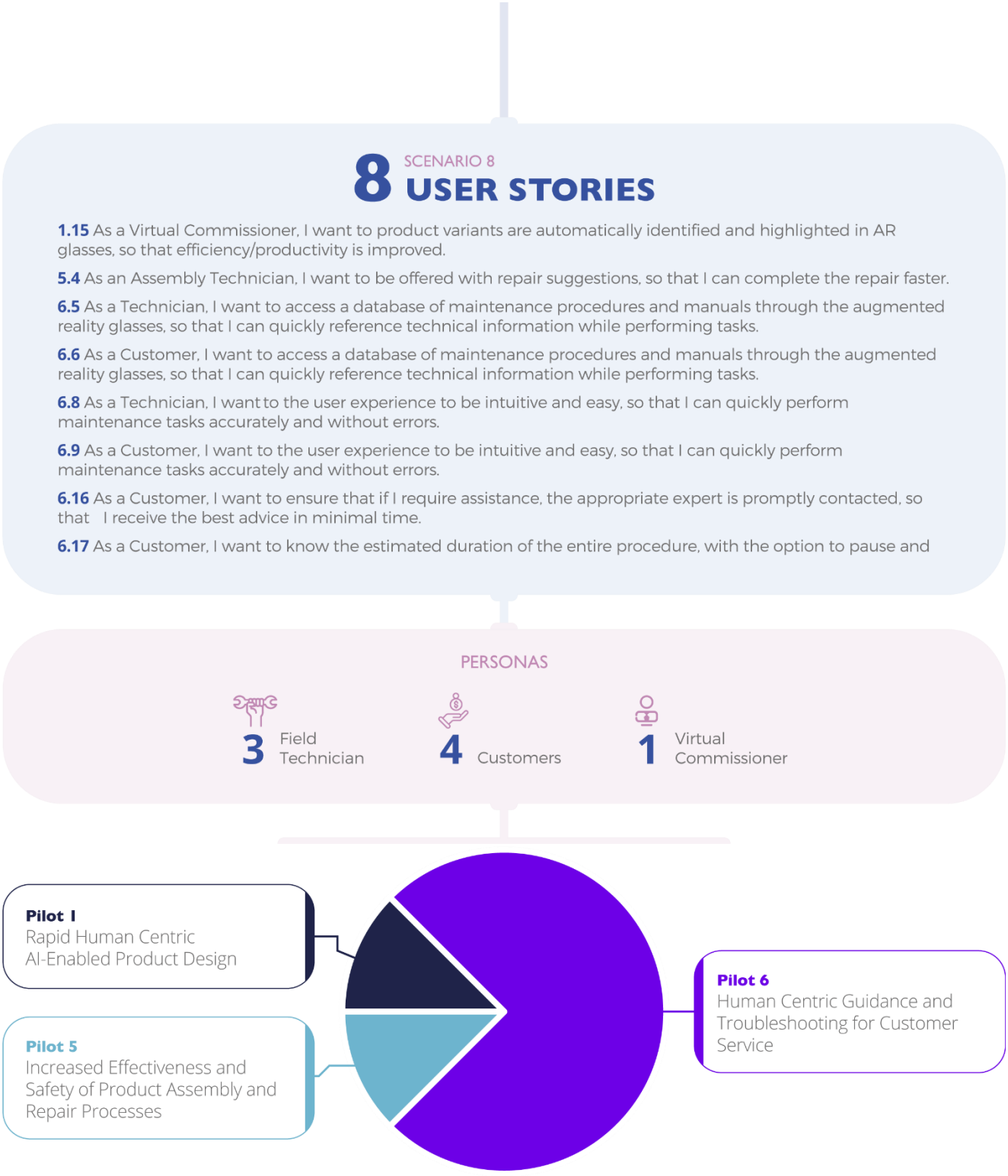
SCENARIO 8

GENERATIVE AI

Personalized AI | Explainable AI

Refers to deep-learning models that can take raw data and "learn" to generate statistically probable outputs when prompted.




8 SCENARIO 8
USER STORIES
1.15 As a Virtual Commissioner, I want to product variants are automatically identified and highlighted in AR glasses, so that efficiency/productivity is improved.
5.4 As an Assembly Technician, I want to be offered with repair suggestions, so that I can complete the repair faster.
6.5 As a Technician, I want to access a database of maintenance procedures and manuals through the augmented reality glasses, so that I can quickly reference technical information while performing tasks.
6.6 As a Customer, I want to access a database of maintenance procedures and manuals through the augmented reality glasses, so that I can quickly reference technical information while performing tasks.
6.8 As a Technician, I want to the user experience to be intuitive and easy, so that I can quickly perform maintenance tasks accurately and without errors.
6.9 As a Customer, I want to the user experience to be intuitive and easy, so that I can quickly perform maintenance tasks accurately and without errors.
6.16 As a Customer, I want to ensure that if I require assistance, the appropriate expert is promptly contacted, so that I receive the best advice in minimal time.
6.17 As a Customer, I want to know the estimated duration of the entire procedure, with the option to pause and
PERSONAS
3 Field Technician
4 Customers
1 Virtual Commissioner
Pilot 1
Rapid Human Centric AI-Enabled Product Design
Pilot 5
Increased Effectiveness and Safety of Product Assembly and Repair Processes
Pilot 6
Human Centric Guidance and Troubleshooting for Customer Service

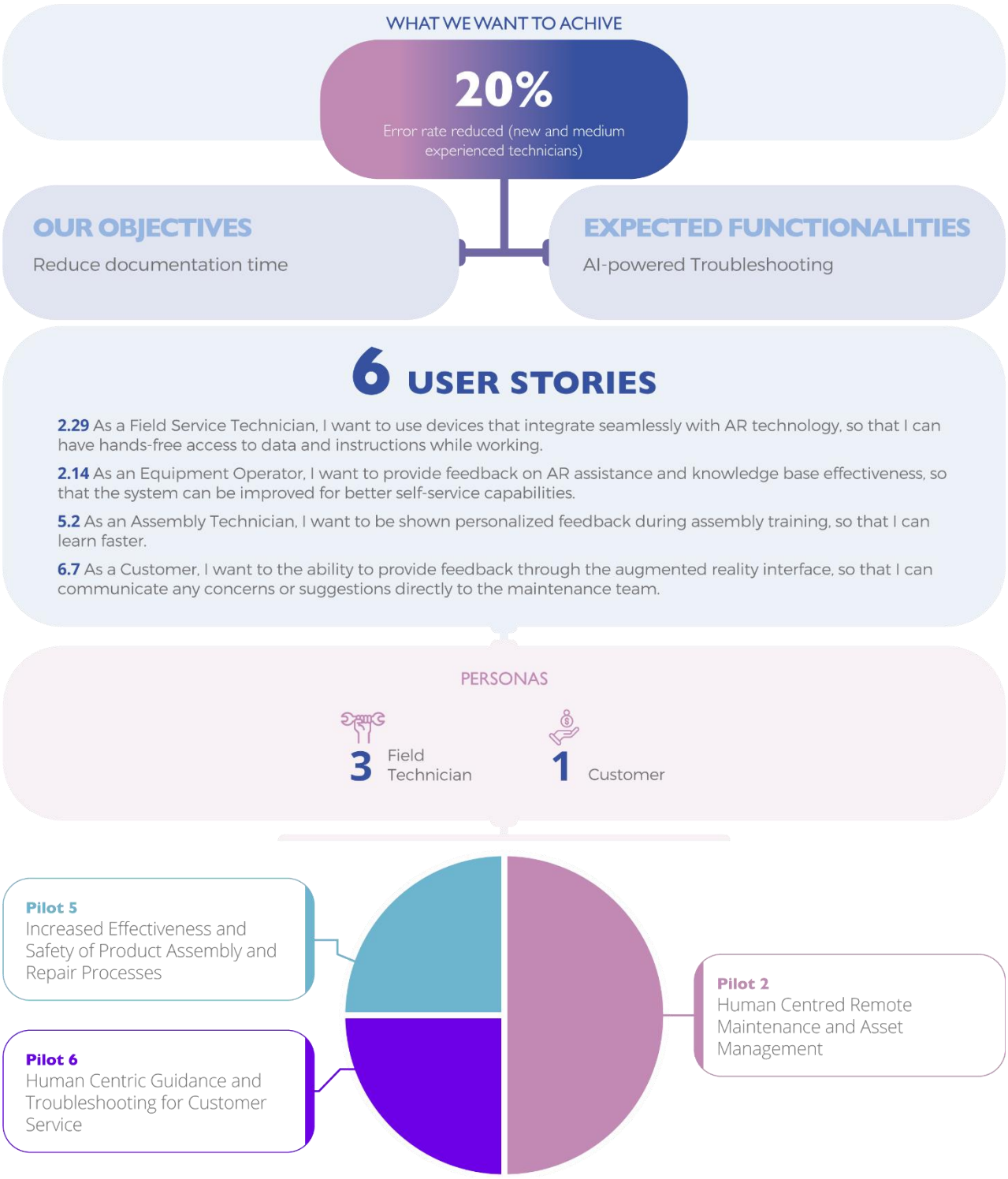
4.9 Chatbot

SCENARIO 9

CHATBOT

AI assistance | Real-time feedback system

Is a software or computer program that simulates human conversation or chatter through text or voice interactions.



5 PERSONAS

After collecting all the User Stories provided by the Pilots and analysing them, ten personas emerged: Business Analyst, Concept Engineer, Customer, Field Technician, Mechanical, Responsible, Project Manager, Quality Manager, Robot Programmer, Training Manager and Virtual Commissioner.

Table 8: Matrix Personas vs. Reference Scenarios

Personas	Augmented Information	Immersive Training	Navigation Guidance	Personalization	Remote Assistant	Step by Step Guidance	Digital Twin	Generative AI	Chatbot
Business Analyst							☒		
Concept Engineer						☒			
Customer	☒			☒	☒	☒		☒	☒
Field Technician	☒	☒	☒	☒	☒	☒	☒	☒	☒
Mechanical Responsible						☒			
Project Manager						☒			
Quality Manager							☒		
Robot Programmer						☒			
Training Manager		☒							

Virtual Commissioner	?							?	

CUSTOMER

5 SCENARIOS

- SCENARIO 1 — Augmented Information
- SCENARIO 4 — Personalization
- SCENARIO 5 — Remote Assistant
- SCENARIO 8 — Generative AI
- SCENARIO 9 — Chatbot

2 PILOTS

Pilot 1 Rapid Human Centric AI-Enabled Product Design

Pilot 6 Human Centric Guidance and Troubleshooting for Customer Service

13 USER STORIES

1.2 As a Customer, I want to see the products to be manufactured digitally embedded in the production line, so that I can reduce the need for test parts and waste.

1.3 As a Customer, I want to see instructions on how to use a cell directly in my field of vision, so that I can perform tasks accurately and without errors.

1.7 As a Customer, I want to see information about cycle times, lot sizes, etc., so that I can see always the OOE.

6.2 As a Customer, I want to receive step-by-step repair instructions directly in my field of vision through augmented reality glasses, so that I can perform maintenance tasks accurately and without errors.

6.4 As Customer, I want to communicate in real-time with remote experts via augmented reality glasses, so that I can receive assistance and guidance during complex or unexpected situations.

6.6 As a Customer, I want to access a database of maintenance procedures and manuals through the augmented reality glasses, so that I can quickly reference technical information while performing tasks

6.7 A.s a Customer, I want to the ability to provide feedback through the augmented reality interface, so that I can communicate any concerns or suggestions directly to the maintenance team.

6.9 As a Customer, I want to the user experience to be intuitive and easy, so that I can quickly perform maintenance tasks accurately and without errors.

6.11 As a Customer, I want to personalized instructions, so that I can quickly and confidently perform maintenance tasks accurately and without errors.

6.13 – As a Customer, I want to receive alerts in case of danger, so that I am aware of the risks and can proceed confidently.

6.16 As a Customer, I want to ensure that if I require assistance, the appropriate expert is promptly contacted, so that I receive the best advice in minimal time.

6.17 As a Customer, I want to know the estimated duration of the entire procedure, with the option to pause and proceed later if needed, so that I am flexible in managing my time effectively during the maintenance task.

6.19 As a Customer, I want a seamless transition of the instructions if my stress level is increasing or reducing, so that I'm not even more stressed or disracted.

FIELD TECHNICIAN

9 SCENARIOS

- SCENARIO 1 — Augmented Information
- SCENARIO 2 — Immersive Training
- SCENARIO 3 — Navigation Guidance
- SCENARIO 4 — Personalization
- SCENARIO 5 — Remote Assistant
- SCENARIO 6 — Step by Step Guidance
- SCENARIO 7 — Digital Twin
- SCENARIO 8 — Generative AI
- SCENARIO 9 — Chatbot

6 PILOTS

- **Pilot 1** — Rapid Human Centric AI-Enabled Product Design
- **Pilot 2** — Human Centred Remote Maintenance and Asset Management
- **Pilot 3** — Operator 5.0 Training for Smart Water Pipes based on XR Streaming
- **Pilot 4** — Worker Centric Aircraft Maintenance Training
- **Pilot 5** — Increased Effectiveness and Safety of Product Assembly and Repair Processes
- **Pilot 6** — Human Centric Guidance and Troubleshooting for Customer Service

44 USER STORIES

1.4 As a Maintenance Engineer, I want to receive step-by-step repair instructions directly in my field of vision through augmented reality glasses, so that I can perform maintenance tasks accurately and without errors.

2.1 As a Service Technician Expert create, I want to comprehensive training modules, so that Field Service Technicians and Equipment Operators can resolve common issues independently.

2.2 As a Service Technician Expert, I want to access real-time data from field operations, so that I can provide precise guidance and troubleshooting support remotely.

2.3 As a Service Technician Expert, I want to develop a centralized knowledge base with troubleshooting solutions, so that the common equipment issues can be quickly addressed by users themselves

2.4 As a Service Technician Expert remotely, I want to view equipment status via AR visualizations, so that I can diagnose issues accurately without being physically present.

2.5 As a Service Technician Expert, I want to receive feedback on the effectiveness of training materials and AR assistance, so that I can continuously improve the resources for better user independence.

2.6 As a Field Service Technician, I want to access AR content and visual aids, so that I can efficiently resolve issues on-site with expert guidance.

2.7 As a Field Service Technician, I want to receive step-by-step instructions for complex tasks, so that I can perform maintenance and repairs accurately and safely.

2.8 As a Field Service Technician, I want to communicate in real-time with Service Technician Experts, so that I can get immediate assistance and clarification during critical tasks.

2.9 As a Field Service Technician, I want to use devices that integrate seamlessly with AR technology, so that I can have hands-free access to data and instructions while working.

2.10 As a Field Service Technician, I want to log issues and solutions in a shared database, so that this information can help refine the knowledge base and training materials.

2.11 As an Equipment Operator, I want to access easy-to-follow AR guided instructions, so that I can attempt to solve simple issues myself before escalating to technical support.

2.12 As an Equipment Operator, I want to have a quick communication link to Service Technician Experts, so that I can receive immediate help if I encounter problems during DIY maintenance.

2.13 As an Equipment Operator, I want to use a user-friendly interface for accessing the knowledge base, so that I can quickly find solutions without technical expertise.

2.14 As an Equipment Operator, I want to provide feedback on AR assistance and knowledge base effectiveness, so that the system can be improved for better self-service capabilities.

3.1 As an Equipment Maintenance Operator, I want to see the overall network/sensors structure (technology/connections/etc…), so that I can understand the generate scheme.

3.2 As an Equipment Maintenance Operator, I want to see the malfunction indication located in space, so that I can understand where to intervene.

3.3 As an Equipment Maintenance Operator, I want to see the detailed scheme of the selected component, so that I can understand the single component potential defects.

3.4 As a Pipe Maintenance Operator, I want to see the overall scheme of the sensors located on the infrastructure, so that I can understand where the sensors have been installed on the infrastructure.

3.5 As a Pipe Maintenance Operator, I want to see the anomality located on the infrastructure/anomality development in time/ and anomality location in space4, so that I can intervene on the infrastructure with the highest precision directly on the problem.

3.6 As a CCTV Operator, I want to receive support during CCTV inspection, so that I can understand where the damages/animalities are located.

3.7 As a CCTV Operator, I want to receive immediate preliminary automatic anomaly evaluation and localization, so that I can seed up and increase precision in inspecting the pipe.

4.1 As an Aircraft Maintenance Technician (AMT), I want to know which the safety measures are to handle a WAIV device maintenance, so that I do not put in risk myself and the device.

4.2 As an Aircraft Maintenance Technician (AMT), 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.

4.3 As an Aircraft Maintenance Technician (AMT), I want to know which the tools are to disassemble the WAIV device, so that I collect and put next to me the necessary tools.

4.4 As an Aircraft Maintenance Technician (AMT), I want to know how in what order should I disassemble the WAIV device, so that I am informed on what to do first and what follows.

5.2 As an Assembly Technician, I want to be shown personalized feedback during assembly training, so that I can learn faster.

5.3 As an Assembly Technician, I want to the ability to identify defects trough the XR interface, so that I can complete the repair faster.

5.4 As an Assembly Technician, I want to be offered with repair suggestions, so that I can complete the repair faster.

5.5 As an Assembly Technician, I want to be offered with instructions to fast preform device commissioning , so that I can finish the set up faster.

5.6 As an Assembly Technician, I want to be offered with instructions to fast preform device operation verification, so that I can finish the set up faster.

6.1 As a Technician I want to receive step-by-step repair instructions directly in my field of vision through augmented reality glasses, so that I can perform maintenance tasks accurately and without errors.

6.3 As a Technician, I want to communicate in real-time with remote experts via augmented reality glasses, so that I can receive assistance and guidance during complex or unexpected situations.

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6.10 As a Technician, I want to personalized instructions, so that I can quickly and confidently perform maintenance tasks accurately and without errors.

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6.18 As a Technician, I want to seamless transition of the instructions if my stress level is increasing or reducing, so that I'm not even more stressed or distracted.

6.20 As a Technician, I want to register automatically the use cases and associated resolution tasks, so that further problems or questions can be answered rapidly.

6.21 As a Service Team Manager, I want to Technicians to be trained in XR methods, so that they can effectively utilize extended reality technologies in their work processes

6.22 As a Technical Documentation Worker, I want to be trained in XR tools for documentation compliance, so that I can create compliant documents effectively using XR tools.

MECHANICAL RESPONSABLE

SCENARIO

SCENARIO 6
Step by Step Guidance

PILOT

Pilot I
Rapid Human Centric AI-Enabled Product Design

2 USER STORIES

1.11 As Mechanical Engineer, I want to see the virtualized machineries parts shown, so that get a better impression of the current state and the relation to the still upcoming installation work/start with my robot programming without having the completely machineries available/have the information in which order parts needs to be installed.

1.16 As a Mechanical Commissioner, I want to have a step by step guideline throw all the mechanical adjustments, so that easy step throw a virtual to-do list.

CONCEPT ENGINEER

SCENARIO

SCENARIO 6
Step by Step Guidance

PILOT

Pilot I
Rapid Human Centric AI-Enabled Product Design

USER STORY

1.13 As a Concept Engineer, I want to see the virtualized machineries parts shown, so that get a better impression of the current state and the relation to the still upcoming installation work/ start with my robot programming without having the completely machineries available/have the information in which order parts needs to be installed.

PROJECT MANAGER

SCENARIO

SCENARIO 6
Step by Step Guidance

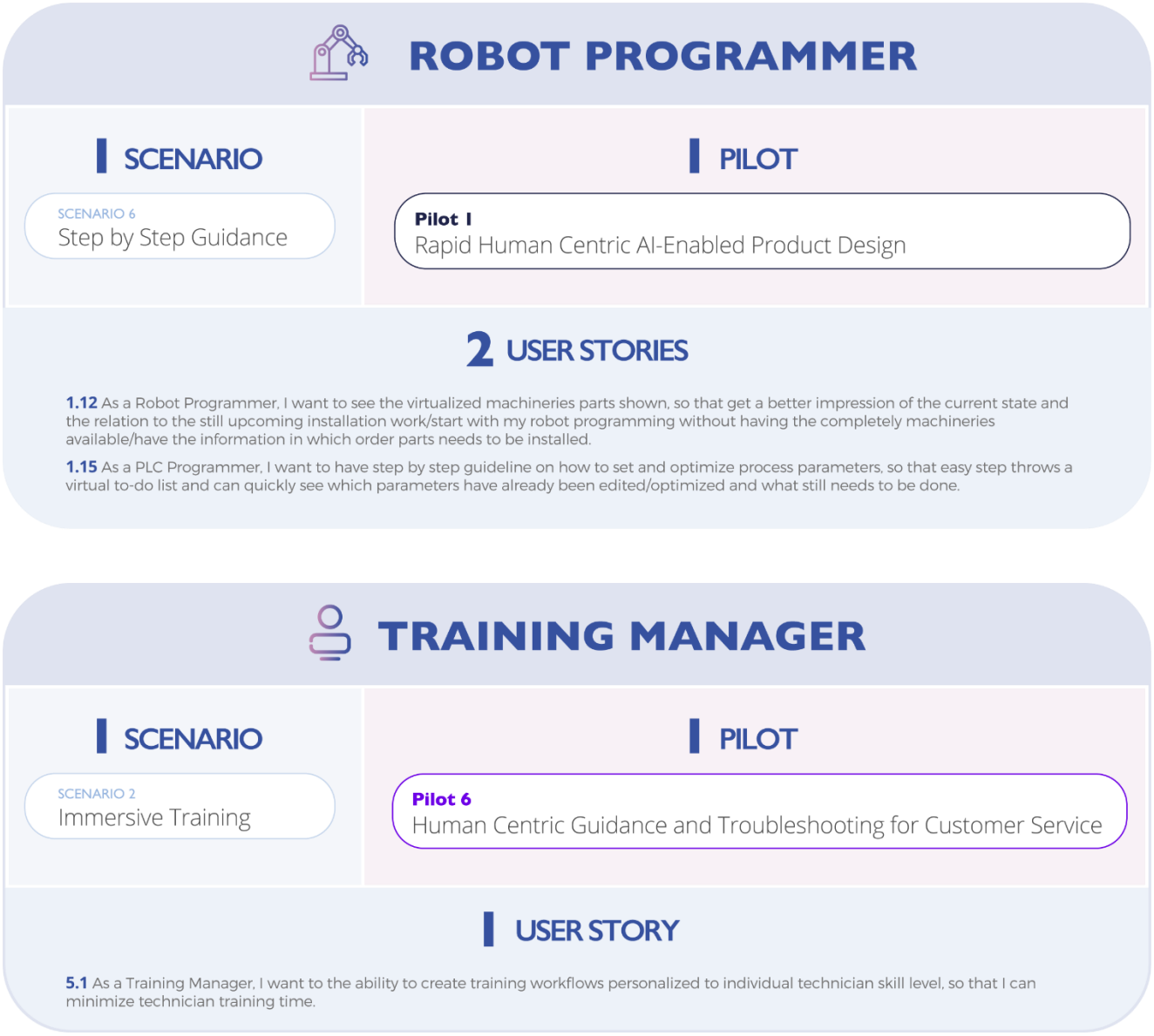
PILOT

Pilot I
Rapid Human Centric AI-Enabled Product Design

USER STORY

1.14 As a Project Manager, I want to see the virtualized machineries parts shown, so that get a better impression of the current state and the relation to the still upcoming installation work/start with my robot programming without having the completely machineries available/have the information in which order parts needs to be installed.


VIRTUAL COMMISSIONER
SCENARIO
SCENARIO 1
Augmented Information
PILOT
Pilot 1
Rapid Human Centric AI-Enabled Product Design
3 USER STORIES
1.1 As a Virtual Commissioner, I want to see the products to be manufactured digitally embedded in the production line, so that I can detect possible faults directly on the production line.
1.5 As a Virtual Commissioner, I want to product variants are automatically identified and highlighted in AR glasses, so that efficiency/productivity is improved.
1.6 As a Virtual Commissioner, I want to see test results during virtual test campaigns directly visualised in AR glasses, so that efficiency/productivity is improved.
BUSINESS ANALYST
SCENARIO
SCENARIO 7
Digital Twin
PILOT
Pilot 6
Human Centric Guidance and Troubleshooting for Customer Service
USER STORY
6.14 As the Business Analyst, I want to able to track the data generated by the system, so that I can make analyses, drive continuous improvement, and ensure efficient resource allocation.
QUALITY MANAGER
SCENARIO
SCENARIO 7
Digital Twin
PILOT
Pilot 6
Human Centric Guidance and Troubleshooting for Customer Service
USER STORY
1.10 As a Quality Manager, I want to have the leaks found on the test part visualized by AR during leak tests, so that I see all detected leaks at a glance.


ROBOT PROGRAMMER
SCENARIO
SCENARIO 6
Step by Step Guidance
PILOT
Pilot I
Rapid Human Centric AI-Enabled Product Design
2 USER STORIES
1.12 As a Robot Programmer, I want to see the virtualized machineries parts shown, so that get a better impression of the current state and the relation to the still upcoming installation work/start with my robot programming without having the completely machineries available/have the information in which order parts needs to be installed.
1.15 As a PLC Programmer, I want to have step by step guideline on how to set and optimize process parameters, so that easy step throws a virtual to-do list and can quickly see which parameters have already been edited/optimized and what still needs to be done.
TRAINING MANAGER
SCENARIO
SCENARIO 2
Immersive Training
PILOT
Pilot 6
Human Centric Guidance and Troubleshooting for Customer Service
USER STORY
5.1 As a Training Manager, I want to the ability to create training workflows personalized to individual technician skill level, so that I can minimize technician training time.

6 BACKGROUND TECHNOLOGIES

For Background Technologies, a template was created with the variables: Name, Summary, Description, Website, Manufacturer/Provider, Contact, Type, Features/Capabilities, Standards, License, Reference, Linked Components, Media Gallery and Applied in Pilot #. The template is available in the ANNEX I.II.

This template circulated among technological partners, and they provided eighteen technologies that can be applied to the XR5.0 Project.

Table 9 shows resumed information on these technologies. The complete description of those technologies is in the tables from ANNEX III.I to ANNEX III.XVIII.

Table 9: Background Technologies

Technology Name	Owner/Provider	Summary	Relevant features	Applied in Pilot	Website
Oculavis Share Platform	Oculavis GmbH	Remote Maintenance Platform (iOs, Android, Web-App and XR-App)	- Workflow (Digital Step-by-Step Instructions) - AR and MR Videocall - Asset Management - Ticketing - AR and MR 3D-Viewer	#2	https://oculavis.de/web/en/release-notes-and-support/
Interactive 3D Maintenance Training	Immersive Lives	An immersive tool accessible via XR devices that allows technicians to explore and manipulate virtual equipment and practise step-by-step maintenance procedures	- Display realistic 3D replicas of the targeted equipment - Display step-by-step instruction of the maintenance procedure - React to user hand interactions	#4	http://www.airmes-project.eu/

AR Assistant	Extended Experiences Research Group CYENS Centre of Excellence	AI/XAI explanations and AI recommendations and visualisations in XR environments to be rendered in the target XR device/platform in real-time, ensuring also that the positioning of the XAI visualisations in the XR environment meet the users' needs. The solution comprises interfaces, tools, and algorithms for the integration of human XAI models for industrial applications.	- Integration and visualisation of AI/XAI explanations and recommendations in XR environments - Rendering of 3D virtual content to real environments - Positioning of XAI visualisations and 3D content in XR environment - Integration of human-centric XAI models in real-world applications - Right positioning of 3D content in real time	All Pilots	https://www.cyens.org.cy https://www.cyens.org.cy/en-gb/research/pillars-groups/human-factors-design/extended-experiences/
IoT Edge Devices equipped with LTE connectivity, tailored for surveillance applications	SPACE HELLAS	This XR5.0 Use Case crafts personalized AR content for technicians to identify and fix defects. AI-driven, tailored guidance offers detailed help for novices and concise solutions for experts, enhancing repair efficiency and accuracy	- VR/AR cyber-representations - LTE modem connectivity - Lightweight compute node hosting IoT edge logic	#5	https://www.space.gr/en
Hololight Hub	HOLO-Industrie 4.0 Software GmbH (Hololight)	Hololight Hub is an easy-to-use orchestration platform for hosting, managing, and streaming AR/VR applications to head-mounted displays (HMDs) and mobile devices – from the cloud or on-premises servers	- Unify all XR Apps under one platform allowing multiple AR/VR devices to connect to and utilize a centralized library of managed and distributed applications, ensuring easy access for users. - Stream XR applications on-demand at the highest quality and original complexity, giving users an immersive and engaging XR experience.	#3 (can be applied to all pilots, need to align and discuss)	https://hololight.com/products/hololight-hub-industrial-metaverse-platform/

			- Manage and deploy XR applications - Manage resources – users, assets - Maintain high data security standards ensured as data is never stored on the end devices - Seamless 3D data pipeline - Multiple data connectors/services - PLM, ERP, CRM etc - High scalability and flexibility - Enables high XR performance - Global availability and collaboration		
Hololight Stream	HOLO-Industrie 4.0 Software GmbH (Hololight)	Hololight Stream is a powerful remote rendering solution designed to stream high-quality XR experiences from local servers or cloud-based infrastructure to AR/VR glasses, smartphones, and tablets.	- Real-time streaming - Streams high polygonal, data-intensive 3D CAD contents to XR applications - Improve data security - Stream your XR applications over networks you control and protect your critical data by never storing it on endpoints - Remote rendering - Device-agnostic, cross-platform approach	#3 (can be applied to all pilots, need to align and discuss)	hololight.com/products/hololight-stream-software-development-kit/

			- Easy integration - Eliminate the need for reduction, simplification, or preparation of data - Simplify and accelerate XR development with a device-agnostic approach, native Unity 3D integration, and rapid application deployment		
Hololight Space	HOLO-Industrie 4.0 Software GmbH (Hololight)	Hololight Space is the industrial VR and AR visualization software that helps streamline engineering and product development workflows	- Import and manage 3D CAD files - Interact with 3D content using multiple tools – measurement, explosion, annotation etc - Multi-user remote collaboration - Visualise high quality polygonal data - High performance through XR streaming - Device agnostic - Real-world referencing using QR codes or object tracking - Perform design review, rapid prototyping, factory planning, risk assessment, quality assurance and product presentation	#3	https://hololight.com/products/hololight-space-enduser-application/

Neurosymbolic AI	UPRC	AI system that combines deep learning along with context based features in order to provide explainable solutions for the results of Deep Learning process.	- Provide predictions along with explainability, able to reach a conclusion based on the concepts of the required problem	#2 and possibly #4 and #6	https://ibm.github.io/neuro-symbolic-ai/toolkit/ https://github.com/pietrobarbiero/pytorch_explain
LeanXcaleDB	LeanXcale SL	An ultra-scalable relational database with innovative features for big data management and real-time analytics	- Ingests data at very high rates - Calculates analytical queries in real time - Supports all data management operations expected in a relational database	All Pilots	https://www.leanxcale.com/
Generative AI	Innov-Acts Ltd	A FastAPI-based web service offering chat and file upload functionalities integrated with OpenAI API for enhanced interactive capabilities. Supports CORS, modular API routing, and robust context management for efficient data processing and context aware responses	- [Handle] chat messages via OpenAI API - [Upload] and process files - [Configure] environment securely - [Manage] CORS policies - [Route] API endpoints modularly - [Create] and manage service context via Embeddings - [Support] Retrieval-Augmented Generation (RAG) operations for context-aware responses	All Pilots	https://github.com/giorgosfatouros/llm-chat-engine
Almer Arc 2	Almer	The Almer Arc 2 is the second-generation hardware from Almer Technologies. It is a lightweight AR headset that can be used for a variety of industry use	- AR Headset	#6 and maybe others	https://almer.com/almer-arc2/

		cases, from logistics to remote support. Everything is possible.			
Almer OS – Operating System	Almer	The Almer OS is an Android-based operating system used in AR headsets to enhance ease of use and user-friendliness. It improves UX/UI aspects to make using AR devices effortless. The operating system is also installed on the Almer Arc 2.	- AR Operating System	#6 and maybe others	https://almer.com/almer-arc2/
Ultron – Smart Assistance	Almer	Ultron is a smart assistant for AR devices and other mobile devices.	- Smart Assistance	#6 and maybe others	https://almer.com/almer-arc2/
TeamViewer – Frontline	Almer	Teamviewer Frontline is installed by default on the Almer Arc 2. It's a AR software solution tailored for industrial use. It overlays digital information, like instructions and data, onto the real world via smart glasses or mobile devices, enabling hands-free operation. The software features remote assistance, allowing experts to provide live support and guidance from afar. Additionally, it offers step-by-step instructions for training, integrates with enterprise systems such as ERP or CRM, and facilitates data capture for compliance and optimization. Primarily beneficial in manufacturing, logistics, and maintenance, TeamViewer Frontline enhances worker efficiency and productivity through advanced AR tools.	- Workflow - Videocall - Products and AR Viewer	#6 and maybe others	https://www.teamviewer.com/en-us/products/frontline/

Clawdite	SUPSI	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.	N/A	All Pilots	An IIoT Platform For Human-Aware Factory Digital Twins https://gitlab-core.supsi.ch/dti-isteps/spslab/public/clawdite
Wearable OS – Operating System	Pine64	Wearable OS is an operating system used by the PineTime SmartWatch. It is based on the InfiniTime OS and can run in low powered devices, allowing not only the collection of relevant measurements, but also enabling the execution of small-factor algorithms.	- Accelerometer - PPG Heart Rate Sensor	All Pilots	https://pine64.org/devices/pinetime/
Service Connector Core	Unparallel Innovation	The Sensor Platform allows the users to easily create a service to connect different clouds, databases, APIs, services, and others.	- Provides parsers to any data format - Transforms data from one format to another - Provides an interoperability engine	All Pilots	https://github.com/unparallel-innovation/Service-Connector-Core
Context Extraction Framework	ATB	The Context Extractor allows to monitor and extract the context of the situation under which a product/machine/component is being used, taking into account the human operator. A methodology is guiding the process on how to define a Context Model for extraction of context.	- Allows to easily create a service to connect different clouds, databases, APIs, services, and others	All Pilots	https://github.com/eclipse-opensmartclide/smartclide-context

As Figure 4 shows, according to the information available for the technological partners, all the Background Technologies can be applied, at least, in one Pilot, however, the same Pilot can use more than one of the Background Technologies, standing out Pilot 6 and Pilot 4 with twelve and eleven, respectively.

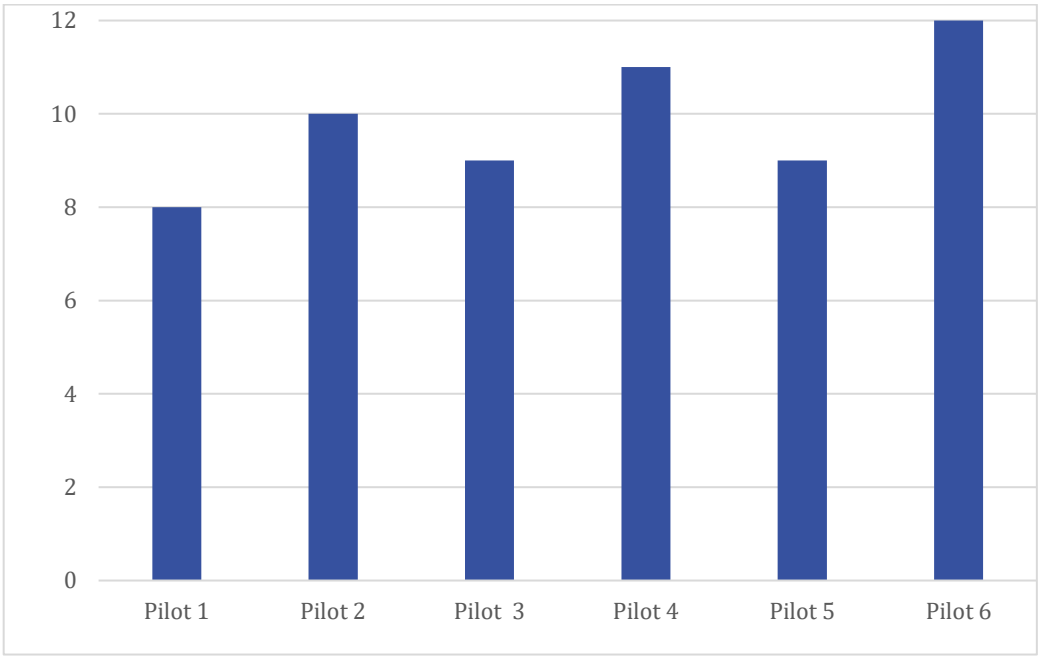


Figure 4: Background Technologies per Pilot

7 CONCLUSIONS

With the aim of Requirements and Reference Scenarios analysis, this deliverable starts with an overview of the six Pilots of the XR5.0 Project:

- Pilot 1 – Rapid Human Centric AI-Enabled Product Design
- Pilot 2 – Human Centred Remote Maintenance and Asset Management
- Pilot 3 – Operator 5.0 Training for Smart Water Pipes based on XR Streaming
- Pilot 4 – Worker Centric Aircraft Maintenance Training
- Pilot 5 – Increased Effectiveness and Safety of Product Assembly and Repair Processes
- Pilot 6 – Human Centric Guidance and Troubleshooting for Customer Service

This overview summarizes and schematically shows the description of each Pilot and its Use Cases.

The next session of the document is dedicated to the User Stories. A User Story is a short, simple description of a feature or functionality told from the perspective of the user or customer who desires that capability. It is designed to create an efficient and effective conversation about the user's needs. The purpose of a User Story is to capture what users need and why, without specifying how the functionality will be implemented. They're meant to foster collaboration and discussion within the team about the best ways to meet the user's needs.

Since this is a public deliverable and the understanding of this approach is easier from a non-technical point of view, the User Story approach was chosen. The Pilots and the Technical Partners validated sixty-nine User Stories from the point of view of ten personas and their needs.

From the User Stories, it was possible to identify nine Reference Scenarios and ten Personas. According to the data collected, all Pilots have, at least, one Reference Scenario standing out of Augmented Information, Step by Step Guidance and Digital Twin Reference Scenarios with more than three Pilots. The nine Reference Scenarios are: Augmented Information, Immersive Training, Navigation Guidance, Personalization, Remote Assistant, Step by Step Guidance, Digital Twin, Generative Ai and Chatbot.

The ten Personas identified are: Business Analyst, Concept Engineer, Customer, Field Technician, Mechanical Responsible, Project Manager, Quality Manager, Robot Programmer, Training Manager and Virtual Commissioner.

Regarding them, the data shows that, at least, one of them is associated with one of the Reference Scenarios, standing out the Customer and the Field Technician, which appears at least in six Scenarios and in more than ten User Stories.

Finally, each one of the eighteen Background Technologies shared by the Technical Partners can be applied, at least, in one Pilot. However, it was possible to identify that the same Pilot can use more than one of the Background Technologies, standing out Pilot 6 and Pilot 4 with twelve and eleven, respectively.

The findings from this deliverable significantly advance the XR5.0 Project's overall objectives by establishing a foundational knowledge base.

ANNEX I. TEMPLATES

ANNEX I.I. Pilot and Use Cases Descriptions Template

Pilot Name	***Pilot name***
Summary	*Short summary of the pilot (with a maximum of 280 char)*
Description	*Extended description of the pilot (text, images, etc.)*
Motivation	*Drivers and motivation for the pilot*
Team Roles	*Roles of the Pilot's team*

Entity Name	***Name of the leader entity of the pilot***
Logo	*Logo (image + weblink) of the local contact organisation*
Role	*Role of the local contact organisation*
Address	*Address of the organisation*
Website	*Website of the local contact organisation*
Contact(s)	*Name and email of the contact person(s)*
Entity Type	*Type of organisation: Higher or secondary education establishment; International Organisation; Non-governmental organization; Private for-profit organisation; Public organisation; Research organisation; Small or medium-size enterprise; Other*

Use Case Name	***Name of the Use Case***
Summary	*Short summary (with a maximum of 280 char) of the Use Case*
Description	*Extended description of the Use Case (text, images, etc.)*
Value Proposition(s)	*Bullet list with value proposition(s) of the Use Case:* - *«Value Proposition #1 in the form ["Verb"] "direct object"»* - *«Value Proposition #2 in the form ["Verb"] "direct object"»* - *«Value Proposition #3 in the form ["Verb"] "direct object"»*

	- *…* *Examples:* - *[Increase] Yield* - *[Reduce] Pesticide Use* - *[Improve] Water Quality* - *[Reduce] Scrap parts*
KPIs	*Three key points to identify:* - *The value intends to achieve* - *The current value* - *The capacity to measure the value that wants to be reached*
XR5.0 Technologies Requirements	*Requirements technology used in project*
Expected Functionalities	*Functionalities expected from the project*
Deploy Characterization Place	*Description of the characteristics of the site where the technology will be applied*
Documentation	*Assorted documentation related to the Use Case*
Image(s)	*Photo gallery of the Use Case*
Website	*The website of the Use Case*
Keywords	*Set of keywords/tags that characterise the Use Case*

ANNEX I.II. Background Technologies Template

Name	***Name of the Background Technology***

Summary	*Short summary (with a maximum of 280 char) of the Background Technology*
Description	*Extended description of the Background Technology (text, images, etc.)*
Website	*The website of the Background Technology*
Manufacturer/Provider	*Name of Component's manufacturer or provider entity*
Contact	*Name and email of the contact(s) person*
Type	*Indicate the type of the Component type. E.g., Component: Platform, Sensor, Gateway, Dataset, Machine Learning Model, Library, Extension, As a Service or Other Software*
Features/Capabilities	*The Features focuses on the asset's abilities, i.e., what the component is able to do.* *Description, in the form [«action verb»] «direct object (the "what" that was acted upon)», examples: "[Measure] wind speed", "[Measure] air temperature", "[Measure] wind direction" for a Weather Station*
Standards	*List of Standards supported by the Component*
License	*If Open source specify the license (e.g., Apache-2.0, MIT, etc.)*
Reference	*Provide useful documentation referred to the component:* *- Documentation: such as instructions manuals, datasheets, publications, API information related to the component, and so on.* *- Repository: Gitlab, GitHub URL and so on*
Linked Components	*List the components and their relationship (e.g., uses, based on, composed by). E.g., Atos' Smart Fleet Framework based on FIWARE*
Media Gallery	*Media gallery of the Background Technology*
Applied in Pilot #	*Pilot in which the technology will or could be used*

ANNEX II. PILOTS

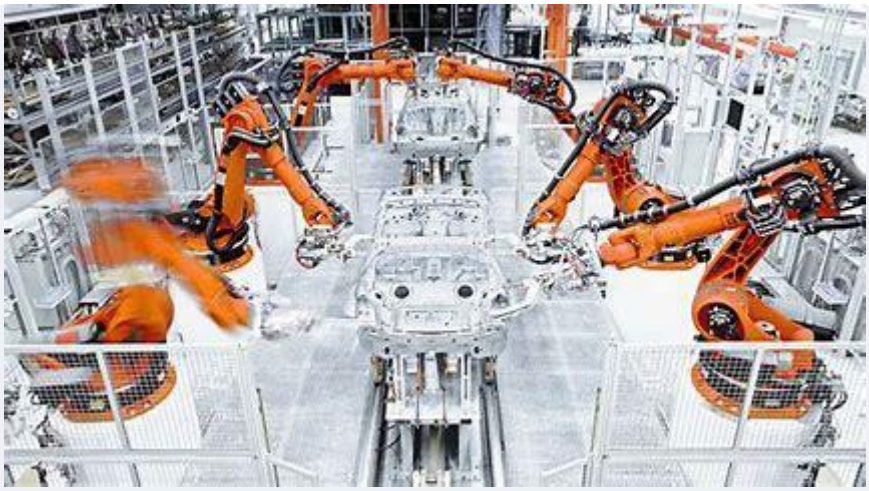
ANNEX II.I. Pilot 1 – Rapid Human Centric AI-Enabled Product Design

Pilot Name	**Rapid Human Centric AI-Enabled Product Design**
Summary	KUKA, a leader in powertrain assembly, embraces XR5.0 for human-centric, AI-powered solutions. XR applications enhance training, reduce downtimes, and offer real-time feedback, addressing labour market changes. Adopting XR boosts KUKA's productivity, efficiency, sustainability, and competitiveness, fostering a more human-centric approach.
Description	 KUKA is a leading provider of systems for the assembly and testing of vehicle powertrain components, as well as the robot-automated assembly of prefabricated building elements. KUKA needs to ensure that it can minimise downtimes while also avoiding the shortage of skilled workers. Moreover, social change, such as the willingness to travel, part-time work, and work-life balance, has implications for the labour market. KUKA can leverage XR5.0's human-centric and AI-powered digital solutions to overcome these challenges. XR applications can provide immersive and interactive training experiences for workers, enabling them to learn new skills more quickly and efficiently. Additionally, XR can assist in maintenance, optimisation, and changes to the plants by reducing the complexity of the line and enabling real- time feedback on production quality. Overall, by adopting XR technologies, KUKA can improve its productivity, efficiency, sustainability, and competitiveness in the market, while also providing a more human-centric approach to its operations.
Motivation	In today's business landscape, companies are constantly seeking ways to improve their competitiveness, productivity, efficiency, sustainability, and resilience while keeping a human-centric approach. One motivation to adopt XR in Industry 5.0 technologies is to bridge the gap between physical and digital spaces, enabling better communication, collaboration, and decision making. Furthermore, the complexity of assembly lines and the infinite number of product variations create challenges in manufacturing, such as high levels of rejected parts and low part availability. To the rescue, XR5.0 technologies can reduce complexity, optimise operations, and create a sustainable and human-centric future.
Team Roles	KUKA (industry & pilot owner); SUPSI (Human DT Provider); ATB (Industrial Solution Integrator).

Entity Name	**KUKA ASSEMBLY & TEST GMBH**
Logo	
Role	Industrial end-user of the pilot
Address	Uhthoffstrasse 1, Bremen 28757, Germany
Website	https://www.kuka.com/
Contact(s)	georgios.karantinakis@kuka.com; christian.behrens@kuka.com
Entity Type	International Organisation

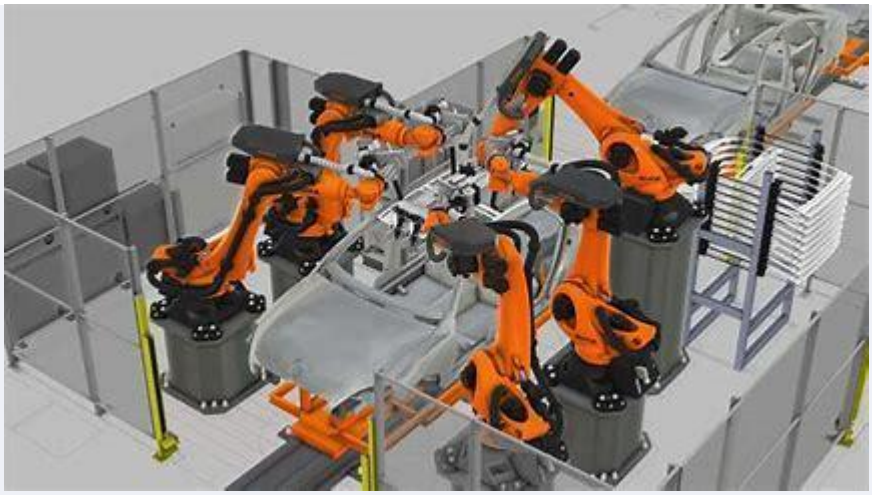
Use Case Name	**Virtual Commissioning and Generative AI in Robotics**
Summary	This XR5.0 Use Case employs integrated results to simplify assembly lines and detect faults early. Digital embedding of products in the plant reduces trial parts, enabling real-time fault detection and personalized feedback. XR5.0 enhances human-machine interaction, helping KUKA optimize assembly lines for efficiency and sustainability.
Description	This UC will adopt various integrated XR5.0 results to reduce the complexity of the assembly lines and enable early detection of possible faults directly on the production line. The solution involves digitally embedding the products to be manufactured and test parts in the real plant, allowing employees to see how the product fits into the machine/plant and how it behaves. This reduces the need for trial parts and enables early detection of possible faults directly on the production line through the project's active and generative learning models. Human DT technology will be utilised to provide real-time personalised feedback on production quality. This UC will leverage the XR5.0's HMIs to optimise the human machine interaction and communication. XR5.0 will enable KUKA to reduce the complexity of assembly lines, improve production efficiency, and provide a more sustainable approach to operations.
Value Proposition(s)	- Reduce complexity of assembly lines - Improve production efficiency - Improve production quality

	- Reduce production faults - Reduce trial parts - Increase troubleshooting - Increase sustainability
KPIs	- >30% reduction on physical testing; - >25% reduction on consumption of test parts/waste; - >50% faster troubleshooting.
XR5.0 Technologies Requirements	- AI & XAI models for fault detection, computer vision, and recommendations; - Generative AI and Active Learning for human-machine interactions; XR Visualisation and AI Explanations.
Expected Functionalities	- Recognition of technical components - Digital embedding and Visualization - Real-time fault detection - Personalized feedback - Optimized Human-Machine Interaction
Deploy Characterization Place	The system will be installed and configured on servers intended to run it on end-user devices. The Site is an industrial indoor environment with clean vision.
Documentation	- Technical Datasheets - CAD-Project - PLC-Code - Robotprogram

Image(s)	
Website	https://www.kuka.com/de-de
Keywords	- Fault detection - Human-Machine Interaction - Personalized AI

Use Case Name	**Personalised XR in Assembly Line Production**
Summary	XR5.0's Use Case tackles challenges in robot-automated assembly by using AI and XAI to address complexity and the need for skilled workers. It employs generative AI for product variants, XR visualization, and virtual commissioning to enhance efficiency, mitigate worker shortages, and promote sustainability.
Description	This UC will tackle the challenges in robot-automated assembly, including the complexity of the assembly process and the need for skilled workers. XR5.0's AI and XAI solutions will detect and recognise the influence that different product variants have on the plant, providing direct information via the XR environment to employees on which parts of the complex systems are relevant and uncritical. To this direction, generative AI technology will be employed to produce product variants and their cyber-representations for visualisation in the XR space. Moreover, virtual commissioning and augmented reality technology will be utilised to improve the efficiency and productivity of the assembly process, concluding to mitigate the shortage of skilled workers, reduce the consumption of test parts and waste, and provide a more sustainable approach to operations.

Value Proposition(s)	- Improve efficiency - Improve productivity - Mitigate the shortage of skilled workers - Reduce test parts - Reduce waste - Increase troubleshooting - Increase sustainability
KPIs	- >30% reduction on physical testing; - >25% reduction on consumption of test parts/waste; - >50% faster troubleshooting.
XR5.0 Technologies Requirements	- AI & XAI models for fault detection, computer vision, and recommendations; - Generative AI and Active Learning for human-machine interactions; - XR Visualisation and AI Explanations.
Expected Functionalities	- Product Variant Detection and Visualization - Virtual commissioning and augmented reality - Automated testing campaigns - Computer Vision - Explainable AI
Deploy Characterization Place	The system will be installed and configured on servers intended to run it on end-user devices. The Site is an industrial indoor environment with clean vision.
Documentation	- Technical Datasheets - CAD-Project - PLC-Code - Robotprogram

Image(s)	
Website	https://www.kuka.com/de-de
Keywords	- Virtual Commissioning - Mixed reality - Automated testing - Explainable AI

ANNEX II.II. Pilot 2 – Human Centred Remote Maintenance and Asset Management

Pilot Name	**Human Centred Remote Maintenance and Asset Management**
Summary	Established in 1864, SH, a leading supplier, leverages XR5.0 for personalized AR solutions, optimizing service in over 80 countries. OCU's SHARE software integrates maintenance workflows, offering visual assistance enriched with AI content from human-AI collaboration, including neurosymbolic learning and XAI, along with GenAI algorithms. This enhances personalization and safety in remote maintenance applications.
Description	SH, established in 1864, is one of the leading suppliers in its field with its polarimeters, refractometers, laboratory and online analytics, and automation solutions for optical-electronic measurement technology. The measuring instruments are used in various industries (e.g., agriculture, automotive, aviation, chemical, pharmaceuticals) in over 80 countries, making their service expensive and complex. This pilot will allow SH to optimise its service, offering personalised and rich AR solutions that enable the solution of complex problems remotely. The pilot will integrate specific maintenance workflows into OCU's SHARE software offering visual assistance. Moreover, SHARE will be

	extended to provide AI content produced by the human-AI collaboration (e.g., neurosymbolic learning, XAI) and by GenAI algorithms. The latter will foster increased personalisation and safety in remote maintenance applications. 
Motivation	Remote maintenance of laboratory instruments is essential for the smooth operation of industrial processes. Industrial environments use complex instruments that require regular maintenance and calibration to avoid downtime and production delays. To this end, many industrial enterprises are already using XR technologies for more efficient and cost-effective remote maintenance through virtual access to instruments in remote or hard-to-reach areas. State of the art XR technologies enable technicians to diagnose and resolve issues remotely, in ways that reduce downtime and save time and money. Nevertheless, as instruments grow in complexity, XR applications must improve in terms of the richness and specialisation of information that they provide to their end-users. To this direction, XR5.0 could improve the personalisation, relevance, and accuracy of the XR environments, based on its AI-driven functionalities (e.g., explanations about human maintenance processes) and their human centric DTs.
Team Roles	SH as business owner of the pilot will define the requirements including data sovereignty requirements for company-specific information, provide guidance and evaluate the developed solutions. Moreover, SH will provide the required data and inputs to be rendered by the XR systems. OCU will bring its SHAPE software to project that will integrate with AI visualisations and recommendations of XR5.0 (development of required APIs). UPRC will contribute and integrate the AI models including generative AI, XAI and neurosymbolic learning.

Entity Name	**FRANZ SCHMIDT & HAENSCH GMBH & CO**
Logo	
Role	Business owner of the Pilot
Address	Waldstrasse 80-81, Berlin 13403, Germany
Website	https://schmidt-haensch.com/

Contact(s)	j.barbian@schmidt-haensch.de
Entity Type	Type of organisation: International Organisation; Private for-profit organisation.

Use Case Name	**Expert Maintenance as a Service**
Summary	This XR5.0 Use Case utilizes OCU's SHARE virtual assistance software for remote inspection and maintenance of lab instruments via XR. Enhanced with project AI visualizations, it efficiently harnesses technicians' expertise, reducing on-site work and enhancing resilience in SH's instrument industries.
Description	This UC will leverage OCU's SHARE virtual assistance software to enable remote inspection and maintenance of laboratory instruments through an XR environment. The latter will be enhanced with the project's AI visualisations (i.e., visualisations of AI explanations) that will be integrated into SHARE software. This UC will enable SH to use the service technicians' expert knowledge efficiently and reduce the amount of on-site service work while increasing resilience in the industries using SH's instruments.
Value Proposition(s)	- Improve efficiency - Reduce on-site service - Increase resilience - Increase efficiency
KPIs	- Reduce of on-site maintenances >=50%; - Time to complete the tasks <=25% increase; - 5-scale rating of site technicians' satisfaction (i.e., excellent social performance).
XR5.0 Technologies Requirements	- XR-enabled Generative AI; - Visualisation of AI Explanations; - Neurosymbolic Learning.
Expected Functionalities	- Adaptive Learning - Real-time Sensor Data Visualization - Predictive Maintenance Insights - AI-powered Troubleshooting - Virtual Maintenance Assistance

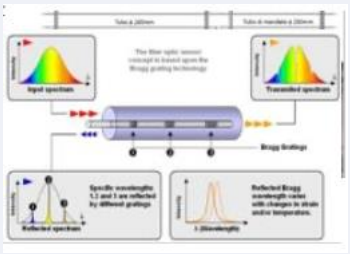
Deploy Characterization Place	- Industrial Facilities - Remote or Hazardous Environments - Specialized Equipment and Machinery The site is characterized by the presence of specialized equipment, machinery, and systems tailored to specific industrial processes.
Documentation	N/A
Image(s)	N/A
Website	N/A
Keywords	- Machine Learning - Neurosymbolic Learning - XR - AI - Virtual Maintenance Training - Remote Support

Use Case Name	**Immersive Retrofitting**
Summary	This XR5.0 Use Case utilizes OCU's SHARE virtual assistance software for remote inspection and maintenance of lab instruments via XR. Enhanced with project AI visualizations, it efficiently harnesses technicians' expertise, reducing on-site work and enhancing resilience in SH's instrument industries.
Description	This UC will allow SH to provide remote guidance to site technicians for performing retrofitting tasks such as electrical component upgrade, equipment reconfiguration, replacement, or refurbishment. XR5.0's AI models will provide real time signals in cases that the safety of the technicians or the equipment are compromised. SHARE software will facilitate the XR rendering.
Value Proposition(s)	- Increase guidance - Improve efficiency

	- Reduce on-site service - Increase security
KPIs	- Reduce of on-site maintenances >=50%; - Time to complete the tasks <=25% increase; - 5-scale rating of site technicians' satisfaction (i.e., excellent social performance).
XR5.0 Technologies Requirements	- XR-enabled Generative AI; - Visualisation of AI Explanations; - Neurosymbolic Learning.
Expected Functionalities	- Adaptive Learning - Real-time Sensor Data Visualization - Predictive Maintenance Insights - AI-powered Troubleshooting - Virtual Maintenance Assistance
Deploy Characterization Place	- Industrial Facilities - Remote or Hazardous Environments - Specialized Equipment and Machinery The site is characterized by the presence of specialized equipment, machinery, and systems tailored to specific industrial processes.
Documentation	N/A
Image(s)	N/A
Website	N/A
Keywords	- Machine Learning - Neurosymbolic Learning - XR - AI - Virtual Maintenance Training - Remote Support

ANNEX II.III. Pilot 3 – Operator 5.0 Training for Smart Water Pipes based on XR Streaming

Pilot Name	**Operator 5.0 Training for Smart Water Pipes based on XR Streaming**
Summary	EKSO's XR5.0 pilot transforms smart pipes maintenance. Using embedded sensors, it monitors operativity and integrity of a pipe during its lifetime. EKSO aims to enhance worker training and operations by leveraging HOLO's XR training application hosted on HOLO's platform and streamed to the AR glasses by HOLO's XR streaming technology, providing hands-on experience without physical equipment. The training will be enhanced by INNOV's AI technology to interpret and utilise the sensor data for efficient and personalized activities and training. This fosters efficient, flexible, and scalable operation execution and training for Operator 5.0, emphasizing creativity and innovation in inspecting and servicing advanced pipes while minimizing costs and risks.
Description	EKSO has recently invested in the digital transformation of its smart pipes manufacturing processes, within their trenchless relining activities for pipes rehabilitation, based on the deployment of embedded detection/measurement devices from the production stage of its smart pipes. Various types of distributed sensors, based on different technologies are investigated (electric, Optic fiber, accelerometers, etc...). By combining signals coming from the pipe "sensors" set along the pipe, the pipes operativity as well as continuity/integrity are monitored. This is achieved by creating a periodic signal measurement sized by each sensor representing a particular condition, or phenomenon related to the pipe (see side figure). The process generates data that the company uses to implement intelligent Condition-Based Monitoring (CBM) processes (including predictive maintenance). The implementation of such data-driven processes is carried out in the company's laboratory as part R&D activities (e.g., recent projects like HORIZON Evenflow and H2020 AI4PublicPolicy). EKSO is therefore considering the provision of personalised trainings and operations for its workers (e.g., maintenance technicians). In this context, this pilot will provide a more efficient way for maintenance operators and for supporting repairing and servicing processes for smart pipes based on the XR5.0 training platform. Specifically, the pilot will use HOLO's XR training application, XR streaming technology as well as HOLO's XR platform to provide operators/trainees with hands-on experience and feedback, without the need for physical equipment or in- person training towards avoiding access to confined spaces. This will reduce the costs and risks associated with traditional operating/training methods, while also enabling more flexible and scalable operating/training programs. The operating/training program to be developed will include personalised and AI-based XR content to enable the customisation of the operating/training process to the knowledge and skills for the work. The

	philosophy of the pilot is to demonstrate operating/training for Operator 5.0, a smart and skilled operator able to use its creativity, ingenuity and innovation aided by information and technology to inspect and service advanced water/sewer/process pipes. 
Motivation	Water networks require regular maintenance to provide safe and reliable water to communities. Therefore, the maintenance of water network can greatly benefit from Condition-Based Maintenance (CBM) practices such as Predictive Maintenance. To benefits from such maintenance models and practices, maintenance workers (e.g., technicians) need to acquire new skills that would allow them to access and interpret analytical outcomes (e.g., ML-based Remaining Useful Life (RUL) calculations, AI-driven detection of defects). XR environments provide perfect playgrounds for training workers on such new skills in cost-effective, yet realistic and safe ways. To exploit the full potential of data-driven maintenance practices, such trainings should be tailored to the varying levels of the workers' digital literacy and skills.
Team Roles	EKSO will be the industrial end-user of the pilot. It will contribute the training content. HOLO will provide the training infrastructure using cloud-based XR streaming, and leverage INNOV's AI data analytics to optimise the learning experience. INNOV will implement the Chat-GPT generative AI interface for the Operator 5.0.

Entity Name	**EKSO SRL**
Logo	
Role	Industrial end-user of the pilot
Address	Zona Industriale C. da Tabuna, Ragusa RG 97100, Italy
Website	https://www.ekso.it/
Contact(s)	Karim Sergio Ladjeri k.ladjeri@ekso.it
Entity Type	Type of organisation: International Organisation; Private for-profit organisation.

Use Case Name	XR-Based Training on Condition Based Maintenance
Summary	This XR5.0 Use Case expands XR streaming to CBM. Utilizing HOLO's ISAR and AI algorithms, live training sessions offer realistic scenarios. A generative AI interface enhances Operator 5.0's interactions, using OpenAI platform with tailored data for effective XR engagement.
Description	This UC will utilize XR streaming to conduct live training sessions for CBM, allowing trainers to remotely guide trainees through simulated scenarios in real-time. Hololight Space application will be streamed to the trainee's mobile AR device using Hololight Stream which will facilitate high-quality 3D content streaming, optimizing computational efficiency via cloud/edge workflows. The streamed content will be enriched with information from INNOV's AI models and algorithms, enabling trainees to experience realistic scenarios and learn advanced technologies and tools in a safe environment on the Hololight Space training application. Additionally, a generative AI interface, akin to ChatGPT, will be provided to Operator 5.0 to enhance interactions with XR representations, utilizing the OpenAI platform extended with tailored data.
Value Proposition(s)	- Improve maintenance - Increase expertise - Reduce on-site service - Improve efficiency - Increase quality control - Reduce failure - Reduce training time
KPIs	- Industrial Process to be supported in terms of training>=3; - XR streaming objects latency<1s; - Average reduction of training time & costs>30%; - 5-scale rating of site technicians' satisfaction from the training (i.e., excellent social performance).
XR5.0 Technologies Requirements	- Personalised Operator 5.0 Training platform based on HOLO's technologies; - XR-enabled Generative AI interfaces; Visualisation of AI Explanations.

Expected Functionalities	- Realistic 3D replica of the targeted equipment - Realistic 3D replica of the targeted infrastructure - Step-by-step instructions display of the maintenance procedure - Real-time error feedback and correction - Performance tracking and assessment features
Deploy Characterization Place	No particular requirement considering the controlled environment for base training activity.
Documentation	Corporate Operations manuals
Image(s)	N/A
Website	www.ekso.it
Keywords	- Extended Reality - Virtual Training - Simulation-based Learning - Real-time feedback system

Use Case Name	**XR-AI based CCTV Inspection and Anomaly Detection**
Summary	EKSO's XR5.0 Use Case revolutionises CCTV pipes inspection training. Deployers use XR devices for immersive experiences with HOLO's XR technologies which include the XR training application, XR streaming plugin and the XR hosting platform. The training application overlays real-time data, offering visual guidance and AI-driven anomaly detection. This accelerates issue identification, reduces maintenance intervention failure risk, and enhances overall equipment efficiency.
Description	This Use Case aims to develop an AI based process to carry over a digital examination of CCTV images/videos using extended reality (XR) technology. Workers from EKSO and its customer network will conduct virtual inspection of a pipe in an XR environment through XR glasses (ex: HoloLens 2). HOLO's centralised XR platform (Hololight Hub; formerly known as XRnow) will host a training application (Hololight Space; formerly known as AR 3S Pro – Augmented Reality for Engineering Space) which will enable the user to overlay data along with visual guidance supporting pipe condition inspection. Hololight

	Space application will be streamed from the server to the client device (ex: HoloLens 2) through Hololight Stream (formerly known as ISAR – Interactive Streaming for Augmented Reality). The streaming technology surpasses the limitations of Hololens 2 by using the computational resources of the server avoiding delays and low-quality visuals. Additionally, INNOV's AI-driven computer vision system will analyse live video feeds to detect anomalies such as corrosion, leaks, or cracks, promptly alerting workers to potential issues on the Hololight Space application during the training. This approach enables swift identification and resolution of quality control issues, ultimately reducing infrastructure maintenance activity failure risks.
Value Proposition(s)	- Increase expertise - Increase quality control - Reduce failure - Improve efficiency - Reduce training cost
KPIs	- Industrial Process to be supported in terms of training>=1; - XR streaming objects latency<3s; - Average reduction of training time & costs>30%; - 5-scale rating of site technicians' satisfaction from the training (i.e., excellent social performance).
XR5.0 Technologies Requirements	- Personalised Operator 5.0 Training platform based on HOLO's technologies; - XR-enabled Generative AI interfaces; - Visualisation of AI Explanations.
Expected Functionalities	- Realistic 3D replica of the targeted pipe - Step-by-step instructions display of the maintenance intervention - Real-time error feedback and correction - Performance tracking and assessment features
Deploy Characterization Place	No particular requirement considering the controlled environment for desktop activity.
Documentation	- Pipes Monitoring images/videos - Infrastructure Blueprints - Infrastructure features

	- Infrastructure operating characteristics
Image(s)	N/A
Website	www.ekso.it
Keywords	- Extended Reality - Virtual Training - Simulation-based Learning - Real-time feedback system

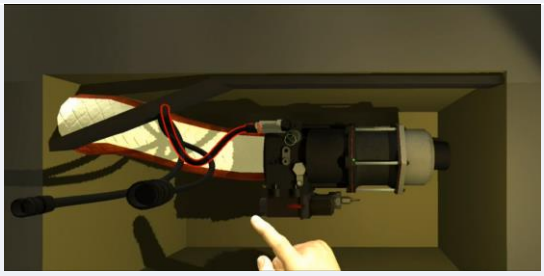
ANNEX II.IV. Pilot 4 – Worker Centric Aircraft Maintenance Training

Pilot Name	**Worker Centric Aircraft Maintenance Training**
Summary	This XR5.0 pilot enhances WAIV maintenance for TAP's junior engineers. AI tools and XR environments, integrated into IML's VR platform, simulate skilled AMTs. The success enables human-centric XR applications in aviation, boosting safety, reliability, and benefiting passengers and airlines.
Description	 The pilot will improve the efficiency and accuracy of the WAIV maintenance procedure while reducing the risk of maloperation. This will be achieved through the development of AI tools and XR environments that will train and support TAP's junior engineers in performing this critical maintenance procedure. To this end, the pilot will expand IML's VR platform with the project's AI and human DTs solutions providing immersive simulations based on the most skilled AMTs. The successful implementation of the pilot will allow the integration of various human-centric XR applications in the aviation industry, enhancing the safety and reliability of the aircraft fleet and benefiting both passengers and airlines.
Motivation	Proper maintenance of airplanes is critical to ensure the safety of passengers and crew members. One of the essential components that must be in working order is the Wing Anti-Ice Valve (WAIV). Should this component fails, the aircraft cannot be operated in most scenarios, and maintenance technicians must quickly repair it to minimise the grounding time. The process of repairing the WAIV is not only time-sensitive but also subject to maloperation, which can lead to costly consequences. All certified Aircraft Maintenance Technicians (AMTs) are required to perform this maintenance procedure, and they face

	harsh stress conditions during the process. XR5.0 technologies can be used to improve the efficiency and safety of such training processes.
Team Roles	TAP will provide domain knowledge, context definition, as well as maintenance, training, technical orders, and technicians data and will evaluate the pilot's results. IML will extend its XR platform (SLB) to support human- robot training in the maintenance of the WAIV. SUPSI will be responsible for the development of the Human DT.

Entity Name	**TRANSPORTES AEREOS PORTUGUESES SA**
Logo	
Role	Provide domain knowledge, context definition, as well as maintenance, training, technical orders, and technicians data and will evaluate the pilot's results.
Address	Edifício 25 do Aeroporto de Lisboa, Lisboa 1700 008, Portugal
Website	https://www.flytap.com/
Contact(s)	Luís Oliveira lmvoliveira@tap.pt
Entity Type	Type of organisation: International Organisation; Private for-profit organisation.

Use Case Name	**Virtual Training**
Summary	This XR5.0 Use Case enhances WAIV maintenance for AMTs using IML's SLB platform. AI in XR environments improves efficiency, accuracy, and safety, ensuring a reliable aircraft fleet for the benefit of passengers and airlines.
Description	This UC will leverage the project's AI tools in an XR environment to support and train AMTs in this critical maintenance procedure. Specifically, IML's Systemic Lisbon Battery (SLB) platform will be expanded to provide XR environments for human-robot training in the replacement of the WAIV. Using AI in a properly designed XR environment (including XAI explanations) the UC will improve the efficiency and accuracy of the maintenance procedure while reducing

	the risk of maloperation. This will result in a safer and more reliable fleet of airplanes, which will benefit both passengers and airlines.
Value Proposition(s)	- Increase expertise - Improve the maintenance - Improve efficiency - Improve accuracy - Increase quality control - Reduce maloperation - Improve safety
KPIs	- Stress index: The less stress the human faces increase the probability of the successful operation, it will be measured with physiological sensors, the baseline will be the resting person and will be compared with the skilled worker's performance; - Performance: Precision and faults of the execution by comparing with the learning digital twin taking as baseline the skilled worker operation. It will use time and adherence to the digital twin measurements.
XR5.0 Technologies Requirements	- Generative AI (for the presentation of the human operator avatar); - Human-aware DTs used in UC 4.2; - Active Learning to enable feedback from the trainee.
Expected Functionalities	- Realistic 3D replica of the targeted equipment - Step-by-step instructions display of the maintenance procedure - Real-time error feedback and correction - Performance tracking and assessment features
Deploy Characterization Place	This technology requires deployment in clear and uncluttered areas that allow freedom of movement, with reduced noise for accurate voice recognition and adequate lighting for reliable hand tracking.
Documentation	N/A
Image(s)	
Website	https://youtu.be/lSY-J8A-1kA

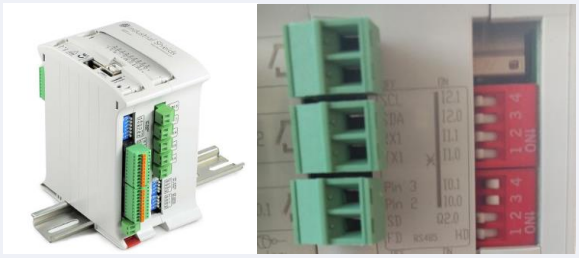
Keywords	- Extended Reality - Virtual Maintenance Training - Simulation-based Learning - Real-time feedback system

Use Case Name	**AMT Digital Twin**
Summary	This XR5.0 Use Case creates a Human DT emulating skilled AMTs, constantly improving through learning from failures. Utilizing XR5.0 visualization and AI-generated instructions, the DT guides and provides feedback to train new maintenance technicians, ensuring precise execution and preventing deviations.
Description	This UC will develop a Human DT simulating the most skilled Aircraft Maintenance Technicians (AMTs) and continuously improve its skills and knowledge. By learning from failures and avoiding them in the future, the DT will be a valuable asset in training new maintenance technicians. The DT will use the XR5.0 visualisation and AI-generated voice instructions to guide the technician through the maintenance process. It will also provide feedback about the movements to execute and warn if the execution deviates from the plan proposed by the AI through the DT.
Value Proposition(s)	- Increase expertise - Improve the maintenance - Improve efficiency - Improve accuracy - Increase quality control - Reduce failure - Improve safety
KPIs	- Stress index: The less stress the human faces increase the probability of the successful operation, it will be measured with physiological sensors, the baseline will be the resting person and will be compared with the skilled worker's performance; - Performance: Precision and faults of the execution by comparing with the learning digital twin taking as baseline the skilled worker operation. It will use time and adherence to the digital twin measurements.

XR5.0 Technologies Requirements	- Generative AI (for the presentation of the human operator avatar); - Human-aware DTs used in UC 4.2; - Active Learning to enable feedback from the trainee.
Expected Functionalities	- Human Digital Twin of skilled AMTs. - Optimal movements display of maintenance execution. - Real-time error feedback and correction. - Performance tracking and assessment features.
Deploy Characterization Place	This technology requires deployment in industrial settings with reduced noise for accurate voice recognition and adequate lighting for reliable hand tracking and environment recognition.
Documentation	N/A
Image(s)	N/A
Website	N/A
Keywords	- Extended Reality - Virtual Maintenance Training - Simulation-based Learning - Real-time feedback system

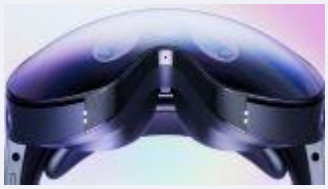
ANNEX II.V. Pilot 5 – Increased Effectiveness and Safety of Product Assembly and Repair Processes

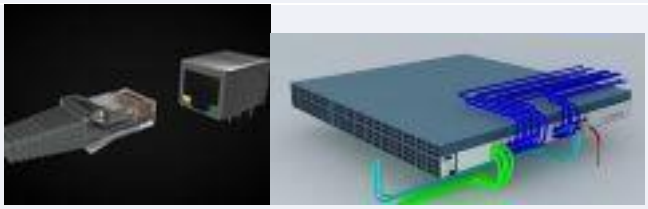
Pilot Name	**Increased Effectiveness and Safety of Product Assembly and Repair Processes**
Summary	This XR5.0 pilot showcases solutions for SPACE's worker training and support in edge device assembly. Emphasizing personalized instructions for different skill levels proves the effectiveness of tailored guidance in assembly and repairs, enhancing worker proficiency.
Description	In this pilot project, the primary focus will be to implement and showcase Extended Reality (XR) technologies specifically designed to train and assist the workers at SPACE in the assembly, deployment, and maintenance of edge devices. A critical aspect of this initiative is to demonstrate the value and effectiveness of providing personalized instructional content that caters to varying skill levels of the workforce, particularly targeting beginners and intermediate-level workers. To achieve these objectives, the project will develop tailored content and

	establish specific workflows, organized into two distinct use cases (UCs). These personalized workflows are expected to improve the proficiency of workers in handling complex tasks and enhance the overall safety and quality of the work processes. Regarding the control application of ALPHA watches, the device to be used is MDUINO 19R type with integrated Ethernet Interface, USB port, SD card, digital inputs, relay, RTC (Real Time Clock) μSD Socket (using SPI port, chip select D53 pins). 100x75x115mm DIN Rail mounting, 12/24V power supply.  The communication for the activation of the controller relays is done through MQTT protocol commands that open the relays of the controller for 5 seconds, which in turn lower or raise the store's blinds. The notification to the Control Center for the raising or lowering of the rolls is done by opening/closing digital magnetic contacts, or changing the state of which is sent to the Control Center via MQTT.
Motivation	As part of its security solutions portfolio, SPACE assembles and configures tailored edge devices with sensors and actuators mainly focused on physical security applications. These devices feature an LTE (Long Term Evolution Model) modem, analog and digital I/O set, and a lightweight compute node hosting the IoT edge logic. SPACE develops a bespoke agent for these devices, which connects to the GuardianTM 2.0 PSIM platform for integrated surveillance rule-based incident response (e.g., triggering alarms, locking doors and safes, lighting control, etc.). Such devices have been installed and operate in several enterprise customers of SPACE (e.g., in the banking sector). After uploading the application, it will be necessary to check the functions of the relays and digital inputs. It can be done either directly over the network by connecting the MDUINO to the local LAN network or locally on the computer where a classic USB to Ethernet adapter is used for convenience through which the network connection is made. In this case we will need to check the settings of the adapter to ensure that we "see" (ping) the controller. Knowing the IP of the device and

	having connected the device to the ETH interface of the USB/ETH adapter, using an MQTT broker we can control the relays using the activation commands. However, their assembly and support are quite challenging, given the variety of components and configurations they entail. SPACE is seeking solutions to assist its engineers in carrying out the assembly process in less time and with increased quality and safety. In this direction, XR solutions (including VR/AR cyber-representations) could greatly benefit SPACE through safe and effective training of engineers in the assembly process and remote support to field workers in maintenance and repair tasks.
Team Roles	SPACE will be the pilot's business owner, offering access to edge devices and engaging technicians in the experimentation. SYN will be the integrator of the personalized XR solutions for training and repairs. UBI and INNOV will participate in providing the personalized AI/XAI models.

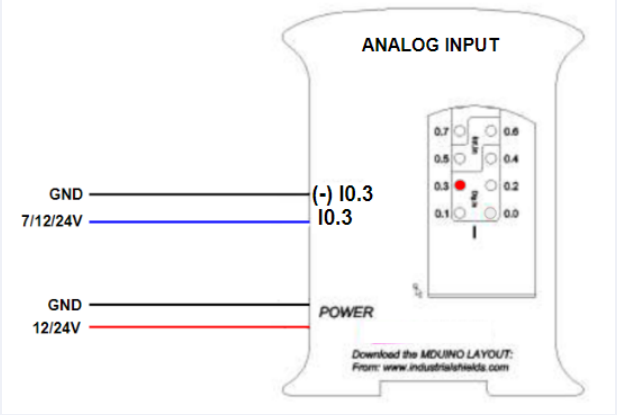
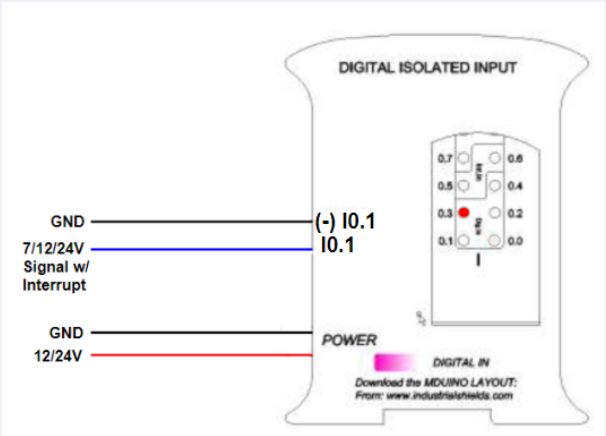
Entity Name	**SPACE HELLAS ANONYMI ETAIREIA SYSTIMATA KAI YPIRESIES TILEPIKOINONIONPLIROFORIKIS ASFALEIAS - IDIOTIKI EPICHEIRISI PAROCHIS YPERISION ASFA**
Logo	SPACE
Role	Business owner of the pilot
Address	Messogion Ave 312, Agia Paraskevi, Athina 153 41, Greece
Website	https://www.space.gr/
Contact(s)	Dr. Nikos Papadakis npap@space.gr Nikolaos Zafeiropoulos nzafeiropoulos@space.gr
Entity Type	System Integrator and Value Added Solutions Provider

Use Case Name	**Personalized Training for Edge Devices Assembly**
Summary	This XR5.0 Use case will develop custom VR/AR training sessions tailored for assembling SPACE's edge devices, targeting different learner profiles. It utilizes SYN's Unity-based XR solutions and META Quest VR glasses to deliver personalized, AI-driven scenarios through immersive 3D visualizations.
Description	This UC will develop personalized VR/AR training for the assembly of SPACE's edge devices. Several variations of XR content and training workflows will be developed for different trainee profiles. To this end, the trainees will be guided in the process of assembling/repairing the edge devices. Different training scenarios based on the trainee's knowledge level will be selected by the personalised AI models and rendered through a VR application. The implementation will be based on SYN's Unity-based XR training solutions, using META Quest VR glasses. The XR application will integrate 3D visualizations and content created for SPACE's edge device and will interface with the AI models developed in WP4, providing information about the trainee skill level and type of training to be performed and retrieving personalized training workflows that will be rendered in the glasses. Due to the limited computing power of the glasses themselves, the communication between the XR app and AI models will happen over a lightweight REST API. 
Value Proposition(s)	- Enhance Learning Efficiency - Boost Training Engagement - Minimize Assembly Errors - Expand Technical Expertise - Optimize Training Processes - Increase Procedural Accuracy - Lower Training Costs
KPIs	- Average reduction to the time needed to assemble an edge device>=20%;

	- Increased engagement of lower-skilled technicians in the process>=50%; - Average Reduction of the Cost of the Assembly and Repair Processes>20%.
XR5.0 Technologies Requirements	- Personalized XR5.0 Training platform; - XR-enabled Generative AI interfaces; - Visualisation of AI Explanations; - 3D rendering of device assembly procedures.
Expected Functionalities	- Realistic 3D replica of SPACE's edge device - Generative AI able to produce training workflows - Ability to render training workflows in a VR environment
Deploy Characterization Place	There are no specific requirements
Documentation	N/A
Image(s)	
Website	N/A
Keywords	- Personalized Training - XR Technology - Skill Enhancement

Use Case Name	**Remote Instructions for Repairs**
Summary	This XR5.0 Use Case crafts personalized AR content for technicians to identify and fix defects. AI-driven, tailored guidance offers detailed help for novices and concise solutions for experts, enhancing repair efficiency and accuracy.
Description	This UC will concentrate on creating personalized AR content specifically designed to guide technicians through the identification and repair of defective edge devices. The personalization of the content will be tailored to match the expertise level of each technician, utilizing AI-based

	analytics that offer detailed explanations and recommendations about potential device failures and malfunctions. Technicians with lower skill levels will receive comprehensive, step-by-step instructions enriched with detailed content to help them thoroughly understand and address the issues. Conversely, more experienced technicians will benefit from succinct and focused guidance, enabling them to quickly pinpoint defects and efficiently utilize repair instructions. This approach not only enhances learning and operational efficiency but also optimizes the repair process according to the individual's skill level.
Value Proposition(s)	- Enhanced Operational Efficiency - Improved Production Quality - Reduced Production Faults - Increased Technician Expertise - Greater Accuracy - Reduced Operational Costs
KPIs	- Average reduction to the time needed to assemble an edge device>=20%; - Increased engagement of lower-skilled technicians in the process>=50%; - Average Reduction of the Cost of the Assembly and Repair Processes>20%.
XR5.0 Technologies Requirements	- Personalized XR-enabled Generative AI interfaces; - Visualization of AI Explanations; - AI/XAI models for detecting defects, explaining defect causality, and providing repair recommendations.
Expected Functionalities	- AI augmented models able to recognize defects - Ability to visualize the instructions of the maintenance procedure
Deploy Characterization Place	Environments in which SPACE's edge devices are installed. Wireless Internet access.
Documentation	N/A
Image(s)	TYPICAL CONNECTION

	 
Website	N/A
Keywords	- Personalization - Efficiency - Accuracy

ANNEX II.VI. Pilot 6 – Human Centric Guidance and Troubleshooting for Customer Service

Pilot Name	**Human Centric Guidance and Troubleshooting for Customer Service**
Summary	This XR5.0 pilot showcases AI-driven solutions addressing the challenge of "limited personalization" in XR environments. Tailored guidance for maintenance and troubleshooting adapts to individuals' experience, preferred interaction, and stress levels, utilizing ALMER's AR glasses and software alongside LNS bar feeder technology.

Description	This pilot will illustrate how XR5.0 addresses the "limited personalisation" challenge through AI-driven functionalities that improve the personalisation, relevance, and accuracy of XR environments, including guidance for maintenance and troubleshooting. In this pilot, this guidance will be tailored to the needs of individuals e.g., to their level of experience, preferred interaction mode, and stress levels. The UCs will be based on ALMER's AR glasses and software, as well as on the LNS bar feeder (see side figure). 
Motivation	Maintenance and troubleshooting are critical to ensure smooth operations and avoid downtime. However, current maintenance and troubleshooting XR instructions are often not personalised, making it overwhelming for beginners and unnecessarily time-consuming for experienced personnel who need to sift through irrelevant information and steps. Additionally, troubleshooting can be stressful, especially when equipment is down. While XR glasses are used in the industry, personalisation is often lacking as creating personalised instructions is time-consuming.
Team Roles	ALMER is the AR/XR solution provider, while LNS the business owner contributing to design, deployment, and evaluation. SSF will have a role in training planning and pilot systems validation activities in its testbed.

Entity Name	**LNS Management Sàrl**
Logo	
Role	Business Owner
Address	Route de Frinvillier 2534 Orvin, Switzerland
Website	https://lns-europe.com/
Contact(s)	douhaddou@lns-group.com psaurer@lns-group.com
Entity Type	Type of organisation: International Organisation; Private for-profit organisation.

Use Case Name	**Human Centred Preventive Maintenance guidance**
Summary	This XR5.0 pilot enhances predictive maintenance. AI-linked AR glasses guide technicians, offering customized instructions based on expertise. Human DTs detect stress, adjusting guidance. Quality assurance adapts to beginners' confirmation needs and automates documentation for experienced workers, optimizing efficiency and effectiveness.
Description	This pilot will support planned predictive maintenance based on XR5.0 solutions. The service technicians are guided to the machines needing maintenance using AI-linked AR glasses knowing the 3D location of the machines. After verifying the machine, the AR glasses provide customised maintenance instructions based on expertise level: Beginners receiving detailed step by step guidance to experienced workers receiving only necessary information (e.g., replace “filter x”). Based on Human DTs, signs of stress or being overwhelmed are detected, prompting the AI system to adjust the guidance accordingly. This may include simplifying instructions or initiating human remote support if necessary. Finally, the system will adapt the quality assurance and documentation processes to match the employee's needs. For beginners, each step may need to be confirmed to ensure that the job is done correctly. Experienced workers will benefit from automated non-interactive and non-disturbing documentation of their maintenance activities.
Value Proposition(s)	- Improve maintenance - Improve efficiency - Improve quality - Reduce faults - Improve accuracy - Improve personalization - Reduce onboarding time
KPIs	- Time to complete the planned maintenance task reduced by > 35%; - All planned maintenance tasks are automatically documented (for experts); - Human satisfaction increased (measured by 5-scale rating of service technicians); - Reduce onboarding time (new service technicians) by > 30%; - Error rate reduced by 20% (new and medium experienced technicians).

XR5.0 Technologies Requirements	- Human cantered AI adaptive worker guidance; - XR adaptive visualisation of worker guidance; - XR visualised AI path navigation; - Human Digital Twin; - Almer AR glasses with their maintenance software.
Expected Functionalities	XR solution powered by AI to adapt the maintenance tasks to the human worker's stress level, and experience
Deploy Characterization Place	This Technology can be deployed in any industrial place where an internet connection is present. The surrounding noise has to be reasonable that the microphones on the AR glasses can capture the voice of the operator. Additionally, the air humidity should not be on a high level to prevent any damage to the AR glasses.
Documentation	N/A
Image(s)	
Website	N/A
Keywords	- Augmented Reality - Preventive Maintenance - AI assistance

Use Case Name	**Trouble Shooting for Repair**
Summary	Expanding on the first case, this XR5.0 Use Case employs AI for troubleshooting sudden machine malfunctions. Adaptive plans prioritize steps based on data, experience, and stress levels from the Human Digital Twin. XR glasses offer tailored representations and user-controlled data

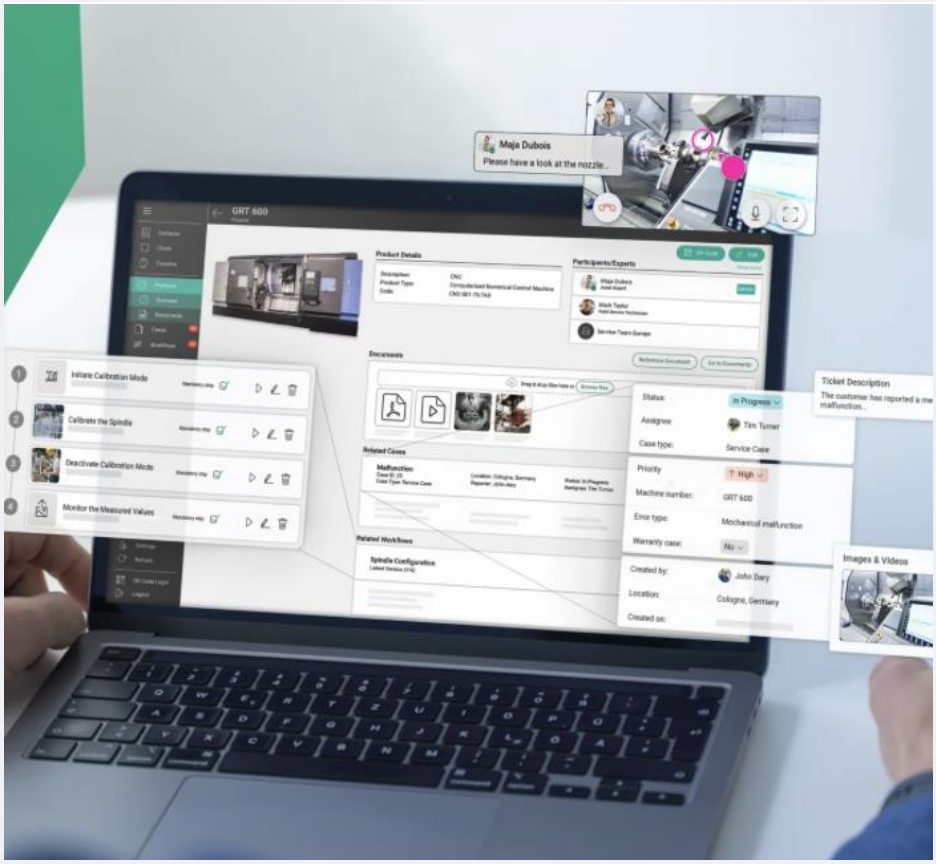
	monitoring, optimizing identification of root causes for efficient repairs and documentation.
Description	This use case builds upon the first one, expanding its capabilities to exploit XR5.0 to perform troubleshooting for sudden malfunctions of machines. In such cases, it's often unclear what's causing the issue, making it necessary to identify the root cause before proceeding with maintenance / repairs (UC1). To efficiently identify potential root causes of sudden malfunctions, an AI system will generate adaptive (step-by-step) plans that prioritise troubleshooting. These plans take multiple factors into account, such as machine data, results from previous steps and the human experience and stress level (from the Human Digital Twin), to tailor the plan to the specific human and situation. Also, the representation on the XR glasses is tailorable to the preferences of the human (such as providing additional video support). The user has control over which personal data is collected and monitored by the AI system. Once the necessary repairs are clearly identified, the user can then proceed with repairs and documentation according to UC1.
Value Proposition(s)	- Improve maintenance - Improve efficiency - Improve quality - Reduce faults - Improve accuracy - Increase troubleshooting - Reduce documentation time - Improve personalization
KPIs	- Troubleshooting time reduced > 35% for new and medium experienced technicians; - Reduction of documentation time for experienced technicians > 50%; - Reduce troubleshooting learning time for new employees by > 20%.
XR5.0 Technologies Requirements	- Human cantered AI adaptive worker guidance; - XR adaptive visualisation of worker guidance; - XR visualised AI path navigation; - Human Digital Twin; - Almer AR glasses with their maintenance software.
Expected Functionalities	XR solution powered by AI to create on the fly the troubleshooting tasks to the human worker’s stress level, and experience

Deploy Characterization Place	This Technology can be deployed in any industrial place where an internet connection is present. The surrounding noise has to be reasonable that the microphones on the AR glasses can capture the voice of the operator. Additionally, the air humidity should not be on a high level to prevent any damage to the AR glasses.
Documentation	N/A
Image(s)	
Website	N/A
Keywords	- Augmented Reality - Preventive Maintenance - AI assistance - Human centred guidance - Stress level adaptive guidance

ANNEX III. BACKGROUND TECHNOLOGIES

ANNEX III.I. Oculavis SHARE Platform

Name	**Oculavis SHARE Platform**
Summary	Remote Maintenance Platform (iOs, Android, Web-App and XR-App)
Description	Oculavis SHARE is a smart service & connected worker platform for machine and equipment manufacturers. From smart services for customer and product support to intelligent tools for maintenance teams – Oculavis SHARE is a device-agnostic solution that connects technicians, experts and users of machinery & equipment around the world. The Oculavis API guarantees seamless integration into daily operations.
Website	www.oculavis.de
Manufacturer/Provider	Oculavis GmbH
Contact	Mathias Horner

Type	SaaS Platform
Features/Capabilities	Workflow (Digital Step-by-Step Instructions), AR and MR Videocall, Asset Management, Ticketing, AR and MR 3D-Viewer
Standards	ISO 27001
License	N/A
Reference	https://oculavis.de/web/en/release-notes-and-support/
Linked Components	N/A
Media Gallery	

	
Applied in Pilot #	#2

ANNEX III.II. Interactive 3D Maintenance Training

Name	**Interactive 3D Maintenance Training (SLB platform)**
Summary	An immersive tool accessible via XR devices that allows technicians to explore and manipulate virtual equipment and practise step-by-step maintenance procedures.
Description	The Interactive 3D Maintenance Training tool of the SLB platform was developed in the scope of the CS2 AIRMES project. It immerses technicians in interactive XR environments for virtual training on maintenance procedures. The app displays step-by-step instructions of selected maintenance procedures, allowing technicians to interact with a realistic 3D replica of the target equipment using virtual projections of their hands.
Website	http://www.airmes-project.eu/
Manufacturer/Provider	Immersive Lives

Contact	Jorge Oliveira jorge.oliveira@immersivelives.pt
Type	Android application
Features/Capabilities	- Display realistic 3D replicas of the targeted equipment - Display step-by-step instruction of the maintenance procedure - React to user hand interactions
Standards	N/A
License	Proprietary
Reference	N/A
Linked Components	N/A
Media Gallery	N/A
Applied in Pilot #	#4

ANNEX III.III. AR Assistant

Name	**AR Assistant**
Summary	AI/XAI explanations and AI recommendations and visualisations in XR environments to be rendered in the target XR device/platform in real-time, ensuring also that the positioning of the XAI visualisations in the XR environment meet the users' needs. The solution comprises interfaces, tools, and algorithms for the integration of human XAI models for industrial applications.
Description	Intelligent AR avatar based on ChatGPT
Website	https://www.cyens.org.cy https://www.cyens.org.cy/en-gb/research/pillars-groups/human-factors-design/extended-experiences/

Manufacturer/Provider	Extended Experiences Research Group CYENS Centre of Excellence
Contact	Prof. Dr. Fotis Liarokapis f.liarokapis@cyens.org.cy
Type	Application (interfaces, tools and algorithms)
Features/Capabilities	- Integration and visualisation of AI/XAI explanations and recommendations in XR environments - Rendering of 3D virtual content to real environments - Positioning of XAI visualisations and 3D content in XR environment - Integration of human-centric XAI models in real-world applications - Right positioning of 3D content in real time
Standards	OpenXR
License	Initially used in XR4ED AR interface. The next steps will be decided at a later stage
Reference	Not yet known
Linked Components	Not yet known
Media Gallery	Initially used in XR4ED marketplace
Applied in Pilot #	All pilots

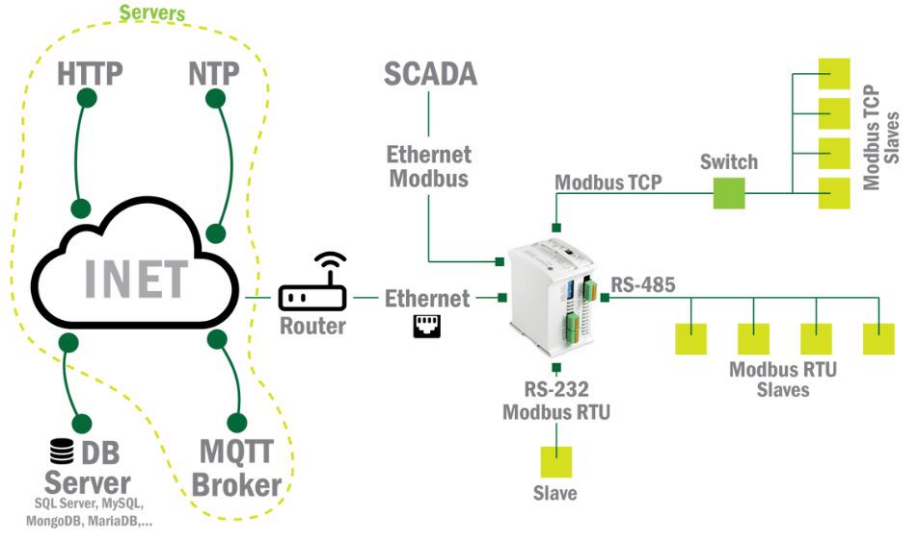
ANNEX III.IV. IoT Edge Devices equipped with LTE connectivity, tailored for surveillance applications

Name	**IoT (Internet of Things) Edge Devices equipped with LTE connectivity, tailored for surveillance applications**
Summary	This XR5.0 Use Case crafts personalized AR content for technicians to identify and fix defects. AI-driven, tailored guidance offers detailed help for novices and concise solutions for experts, enhancing repair efficiency and accuracy.

Description	SPACE is piloting the integration of XR solutions and collaborate with SYN, including VR/AR cyber-representations, to enhance assembly efficiency and provide remote support for maintenance tasks of their tailored edge devices designed for physical security applications.
Website	https://www.space.gr/en
Manufacturer/Provider	SPACE HELLAS
Contact	Nikos Papadakis
Type	- MDUINO 19R+ Industrial controller - Industrial IoT controller - Programmable Arduino compatible - Customizable firmware - Wide range of applications - Many external interfaces - Digital inputs/relays/RS232/I2C/SPI/ETH/SD card /Real time clock/web server - This industrial controller has 17I/Os. It also contains several communication ports which provide more flexibility and control. - The industrial arduino M-DUINO family offers the possibility to expand up to 127 modules through I2C, which means that you can have multiple Inputs / Outputs in Master-Slave connections, additionally to sensors, etc.
Features/Capabilities	VR/AR cyber-representations, LTE modem connectivity, Lightweight compute node hosting IoT edge logic

Standards	- Conformity with Health, Safety, and Environmental Protection (CE):
	  - EN61010-1 | EN61010-2-201 | EN61131-2:2007(Clause 8: Zone A/B EMC and clause 11:LVD) |
	  - EN61000-6-4:2007 + A1 2011 (Emissions) | EN 61000-6-2:2005 (Immunity)
	  - Medical Devices Directive (CE): 93/42/EEC
	- FCC Federal Code of Regulation (CFR) for Electronic Equipment: EMC: FCC Part 15
	- RoHS: Directive 2002/95/EC | Restriction of Hazardous Substances (EEE)

License	- The Open Source Board CPU

	- Single Board Computer (SBC) Microcontroller: Arduino Mega Original Board (ATmega 2560) - Flash Memory (KB): 256 - Flash Memory of which used by bootloader (KB): 8 - SRAM (KB): 8 - EEPROM (KB): 4 - Clock Speed (MHz): 16
Reference	Documentation, connection diagrams, interfaces, programming features are described in the link below: https://www.industrialshields.com/technical-features-industrial-m-duino-plc Typical network Connection diagram of the controller is presented below: 
Linked Components	N/A
Media Gallery	https://www.youtube.com/watch?v=R1VdVLYiMjo
Applied in Pilot #	#5

ANNEX III.V. Hololight Hub

Name	**Hololight Hub**

Summary	Hololight Hub is an easy-to-use orchestration platform for hosting, managing, and streaming AR/VR applications to head-mounted displays (HMDs) and mobile devices – from the cloud or on-premises servers.
Description	Hololight Hub is a scalable enterprise XR streaming platform for centrally hosting, managing, and streaming AR/VR applications to mobile XR devices - in the cloud or from on-premises servers. This ecosystem provides centralized application management and secure access to 3D content from anywhere, on any device. Users can host their own XR applications as well as access a variety of AR/VR solutions from ISVs for training, work instructions, remote support, and product development from a single platform regardless of their location. Employees can even stream VR training in their home offices on various XR devices. Hololight Hub provides enterprise administrators with customizable access permissions and configurations, centralized security, and the flexibility to revoke or reinstate access at any time, ensuring your workflow is both secure and efficient. It is designed for mass adoption, providing an ecosystem for XR apps from all segments and industries. Enterprises benefit from a centralized platform empowering industrial AR/VR use cases that were not scalable or even possible before. Hololight Hub is an enterprise-grade Industrial Metaverse that brings the power of the cloud to mobile XR, enabling high performance, centralized app management and a direct interface between XR applications and content. Hololight Hub combines the powerful performance of Hololight Stream with the management capabilities of a powerful data platform. It is a customizable platform that can, based on requirements, integrate with external systems/services such as PLM, ERP, SAP etc. Users have continuous access to the company's entire XR app portfolio via numerous devices, regardless of their location. Companies can adapt Hololight Hub to their individual hardware, software and security requirements. The Industrial Metaverse can be quickly and easily integrated into any existing IT infrastructure. Because Hololight Hub operates independently of devices, XR

	applications can be scaled across the company without any additional cost. This also accelerates the development of XR applications, because these applications do not have to be optimized for different devices – a single stream operates on any type of hardware.
Website	https://hololight.com/products/hololight-hub-industrial-metaverse-platform/
Manufacturer/Provider	HOLO-Industrie 4.0 Software GmbH (Hololight)
Contact	Harsh Manoj Shah (h.shah@holo-light.com) Leesa Joyce (l.joyce@holo-light.com)
Type	Streaming as a Service - Centralised Streaming Platform
Features/Capabilities	- Unify all XR Apps under one platform allowing multiple AR/VR devices to connect to and utilize a centralized library of managed and distributed applications, ensuring easy access for users. - Stream XR applications on-demand at the highest quality and original complexity, giving users an immersive and engaging XR experience. - Manage and deploy XR applications - Manage resources – users, assets - Maintain high data security standards ensured as data is never stored on the end devices - Seamless 3D data pipeline - Multiple data connectors/services - PLM, ERP, CRM etc - High scalability and flexibility - Enables high XR performance - Global availability and collaboration
Standards	N/A
License	N/A
Reference	N/A
Linked Components	- Hololight Hub resources are running on cloud provider (currently Amazon Web Services)

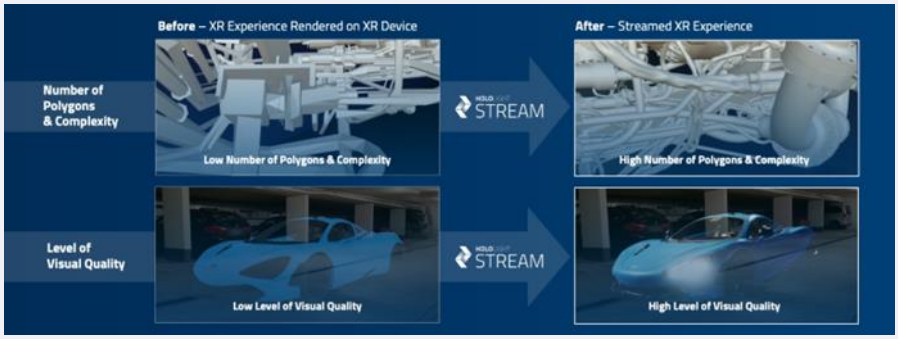
	- Hololight Hub hosts and manages XR applications such as Hololight Space
Media Gallery	Admin level:  User level:

	
Applied in Pilot #	#3 (can be applied to all pilots, need to align and discuss)

ANNEX III.VI. Hololight Stream

Name	**Hololight Stream**
Summary	Hololight Stream is a powerful remote rendering solution designed to stream high-quality XR experiences from local servers or cloud-based infrastructure to AR/VR glasses, smartphones, and tablets.
Description	Hololight Stream SDK enables real time, high-performance streaming of AR/VR applications to all kinds of mobile XR devices through a cross-platform approach. By streaming each application as a whole, Hololight Stream enables visualization and interaction with highly polygonal, data-intensive content such as graphics-intensive 3D objects, 3D CAD models or BIM data by overcoming key challenges such as low-hardware performance,

	data security and cross-platform development. The Hololight Stream SDK can be integrated into any XR application. Once the Hololight Stream SDK is integrated into an XR application, the app no longer needs to be installed on an end device. Instead, the XR app (with the server-side SDK component) is installed on a more powerful local server or in the cloud. Hololight's corresponding client application runs on the XR device and receives the image stream. The user simply connects via the client app on the mobile device to the XR app on the external server. The rendering process shifts from the low-performance XR device to the high-performance server. The client app sends data - sensor data for room tracking, gesture input, SLAM - to the server. After the data is processed on the server, the rendered images are encoded to use less network traffic and sent back to the client app, where they are decoded again. To ensure a high-quality user experience, this process must occur in real time and hence everything in Hololight Stream - down to the socket level - is optimized for low latency.
Website	hololight.com/products/hololight-stream-software-development-kit/
Manufacturer/Provider	HOLO-Industrie 4.0 Software GmbH (Hololight)
Contact	Harsh Manoj Shah (h.shah@holo-light.com) Leesa Joyce (l.joyce@holo-light.com)
Type	Streaming SDK
Features/Capabilities	- Real-time streaming - Streams high polygonal, data-intensive 3D CAD contents to XR applications - Improve data security - Stream your XR applications over networks you control and protect your critical data by never storing it on endpoints - Remote rendering - Device-agnostic, cross-platform approach

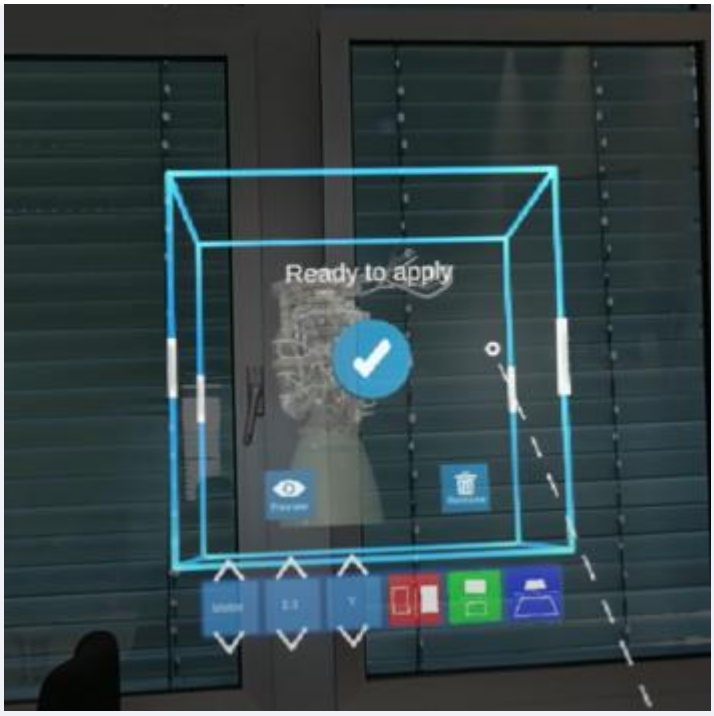
	- Easy integration - Eliminate the need for reduction, simplification, or preparation of data - Simplify and accelerate XR development with a device-agnostic approach, native Unity 3D integration, and rapid application deployment
Standards	OpenXR
License	N/A
Reference	https://support.hololight.com/portal/en/kb/hololight-stream
Linked Components	XR Applications such as Hololight Space are built with Hololight Stream SDK
Media Gallery	XR Streaming using Hololight Stream SDK: 
Applied in Pilot #	#3 (can be applied to all pilots, need to align and discuss)

ANNEX III.VII. Hololight Space

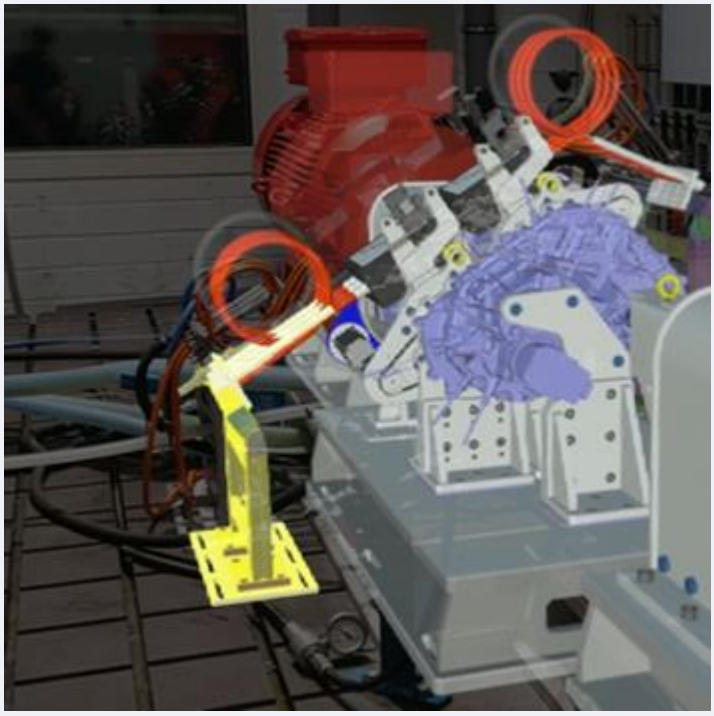
Name	**Hololight Space**
Summary	Hololight Space is the industrial VR and AR visualization software that helps streamline engineering and product development workflows.
Description	Hololight Space is an XR end-user engineering application tailored for augmented reality (AR) and virtual reality (VR) environments, designed to enhance the visualisation, interaction, and collaboration of complex 3D engineering data. The application allows a user to import original 3D CAD data easily without

	requiring any data preparation. Users can visualise and interact with their 3D data in an XR environment and merge physical elements with virtual objects. For an enterprise, Hololight Space i) accelerates the conceptual design phase with a digital product development process, leading to faster time-to-market solutions; ii) allows for efficient testing of virtual prototypes, leading to reduced expenses, waste, and time through a fully digital product development; iii) allows for remote collaboration through multi-user modes on digital prototypes in real-time to reduce the need for physical meetings, travelling, and associated costs while also minimising the firm's carbon footprint and iv) enables quick identification and correction of errors, as well as enhances product quality, through testing full-scale designs in a real-world setting. The key use cases of the application include rapid prototyping, design reviews, product design, factory planning and training. The Hololight Space XR application can be deployed on any type of infrastructure (on-premises/cloud/edge) and is pixel-streamed to the XR mobile device in real-time over WIFI/LTE/5G using Hololight Stream SDK. This allows users to protect sensitive data on the server side and view high quality content with hundreds of millions of polygons in AR/VR.
Website	https://hololight.com/products/hololight-space-enduser-application/
Manufacturer/Provider	HOLO-Industrie 4.0 Software GmbH (Hololight)
Contact	Harsh Manoj Shah (h.shah@holo-light.com) Leesa Joyce (l.joyce@holo-light.com)
Type	XR Application
Features/Capabilities	- Import and manage 3D CAD files - Interact with 3D content using multiple tools – measurement, explosion, annotation etc - Multi-user remote collaboration - Visualise high quality polygonal data - High performance through XR streaming - Device agnostic

	- Real-world referencing using QR codes or object tracking - Perform design review, rapid prototyping, factory planning, risk assessment, quality assurance and product presentation
Standards	Support to standardised file formats such as .jt, .obj, .fbx, etc.
License	N/A
Reference	https://support.hololight.com/portal/en/kb/hololight-space
Linked Components	- Hololight Space application uses Hololight Stream SDK - Hololight Space application is hosted, managed and stream from Hololight Hub
Media Gallery	Space App:  Import 3D files:

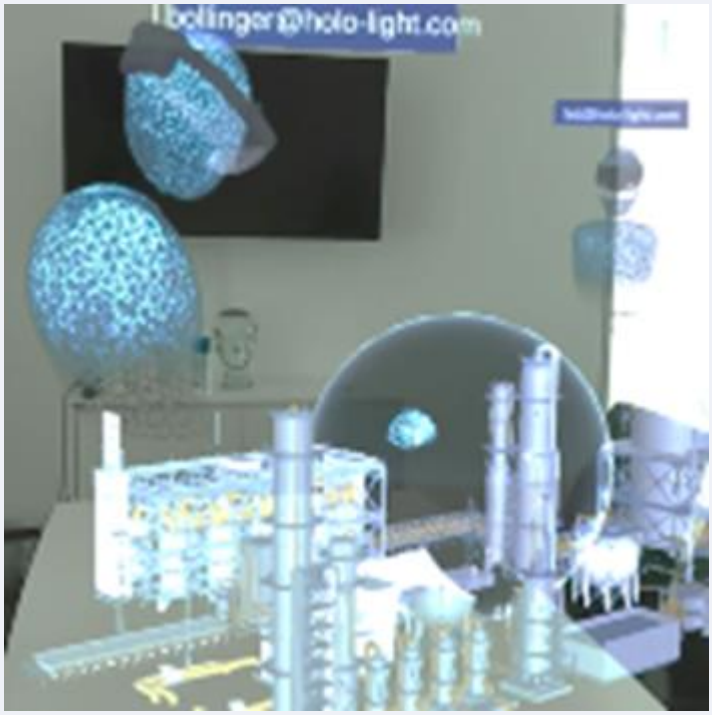


Real-size visualisation:



Explosion view:

Interaction:

	Remote Collaboration: 
Applied in Pilot #	#3

ANNEX III.VIII. Neurosymbolic AI

Name	**Neurosymbolic AI**
Summary	AI system that combines deep learning along with context based features in order to provide explainable solutions for the results of Deep Learning process.
Description	A model that is capable of learning the symbolic concepts of a problem and provide predictions based on these concepts. These allow us to explain why the model reached the prediction it gave us and provide reasoning for the model predictions. It requires the dataset to have some form of concepts / attributes along with the classic "Features"-"Labels" format, in order to be able to provide the symbolic reasoning.

Website	https://ibm.github.io/neuro-symbolic-ai/toolkit/ https://github.com/pietrobarbiero/pytorch_explain
Manufacturer/Provider	UPRC
Contact	Stergios Chairistanidis
Type	Model
Features/Capabilities	Provide predictions along with explainability, able to reach a conclusion based on the concepts of the required problem
Standards	PyTorch
License	- Apache 2.0 - MIT
Reference	N/A
Linked Components	N/A
Media Gallery	N/A
Applied in Pilot #	#2 and possibly #4 and #6

ANNEX III.IX. LeanXcaleDB

Name	**LeanXcaleDB**
Summary	An ultra-scalable relational database with innovative features for big data management and real-time analytics.
Description	The LeanXcaleDB is a relational, full SQL-compliant database that combines the benefits of two worlds: NoSQL for high-rated data ingestion and SQL for advanced analytics, while ensuring database transactional semantics and ACID properties. Due to its novel indexing mechanism, it can support data ingestion at very high-rates, ideally for cases where we need offline batch ingestion of high volume, or support data ingestion coming from streaming

	data at high velocity. Additionally, it provides real-time analytical processing, while data is being ingested at the same time, ensuring database transactions and data consistency. It can be ideal for XR scenarios where data generated from the end-users needs to be stored, while facilitating data exploration with its ability to provide analytical results in real-time, which is also a strong requirement in XR use cases.
Website	https://www.leanxcale.com/
Manufacturer/Provider	LeanXcale SL
Contact	Pavlos Kranas pavlos@leanxcale.com
Type	Database It can be offered as standalone or as DBaaS.
Features/Capabilities	- Ingests data at very high rates - Calculates analytical queries in real time - Supports all data management operations expected in a relational database
Standards	JDBC, ODBC Compliant with popular analytical frameworks such as Apache Spark, Apache Flink, and others
License	Proprietary license of LeanXcale
Reference	https://docs.leanxcale.com/leanxcale/v2.3/index.html
Linked Components	N/A
Media Gallery	N/A
Applied in Pilot #	All pilots

ANNEX III.X. Generative AI

Name	**Generative AI – LLM Chat Engine**
Summary	A FastAPI-based web service offering chat and file upload functionalities integrated with OpenAI API for enhanced interactive capabilities. Supports CORS, modular API routing, and robust context management for efficient data processing and context aware responses.
Description	This service leverages FastAPI to build a scalable and efficient web service providing chat and file upload functionalities. Integrated with OpenAI's API, it offers advanced conversational capabilities. The system features modular routing, secure environment configuration, and comprehensive context management, ensuring robust and flexible operation across various environments. The service includes detailed error handling, structured data processing, and efficient index management for optimal performance. Additionally, it supports Retrieval-Augmented Generation (RAG) operations based on the provided documents, enabling context-aware responses to the user based on proprietary data.
Website	https://github.com/giorgosfatouros/llm-chat-engine
Manufacturer/Provider	Innov-Acts Ltd
Contact	George Fatouros
Type	Software as a Service
Features/Capabilities	- [Handle] chat messages via OpenAI API - [Upload] and process files - [Configure] environment securely - [Manage] CORS policies - [Route] API endpoints modularly - [Create] and manage service context via Embeddings - [Support] Retrieval-Augmented Generation (RAG) operations for context-aware responses
Standards	OpenAPI specification V3
License	Apache-2.0

Reference	https://github.com/giorgosfatouros/llm-chat-engine
Linked Components	N/A
Media Gallery	N/A
Applied in Pilot #	All pilots

ANNEX III.XI. Almer Arc 2

Name	**Almer Arc 2**
Summary	The Almer Arc 2 is the second-generation hardware from Almer Technologies. It is a lightweight AR headset that can be used for a variety of industry use cases, from logistics to remote support. Everything is possible.
Description	The Almer Arc 2 is a sophisticated augmented reality (AR) headset designed for industrial applications, enhancing the efficiency of frontline workers by providing hands-free access to critical information and remote support. Lightweight at just 179 grams, the Arc 2 features a 1080p full HD micro OLED display, offering a clear, immersive visual experience. The 25 MP auto-focus camera captures and streams high-quality 4K video, while the beamforming microphones filter out background noise, ensuring clear communication in noisy environments (Almer AR Industry) (SiliconANGLE). Designed for comfort and adaptability, the Arc 2 supports various safety gear and prescription glasses, making it suitable for diverse work settings. The device is equipped with programmable buttons and voice control, enabling users to operate it without using their hands (Almer AR Industry) (Almer AR Industry). In practical use, the Almer Arc 2 facilitates remote troubleshooting and maintenance. For instance, a technician can connect with a remote expert via live video, allowing the expert to

	see and guide the technician through the repair process in real time. This feature significantly reduces downtime and the need for on-site visits, improving overall productivity (HapaKenya) (TeamViewer). Companies like Cablex have successfully integrated the Arc 2 into their operations, using it to enhance technical installations and maintenance services. This integration has led to increased efficiency, accuracy, and productivity, highlighting the transformative potential of the Almer Arc 2 in industrial applications (Almer AR Industry).
Website	https://almer.com/almer-arc2/
Manufacturer/Provider	Almer
Contact	Timon Binder
Type	Augmented Reality Hardware
Features/Capabilities	AR Headset
Standards	All normal android applications can run on the device
License	It's available as a subscription. For 99CHF/month. It's not open source
Reference	**Technical Specifications** **Display** See through 1080p monocular full HD color micro OLED 16:9 aspect ratio 22° deg diagonal FOV, 0.49 inch diagonal

	3000cd/m^2 50000 : 1 contrast ratio DCI-P3, 95% color accuracy **Computational Unit** Qualcomm 4GB RAM 64GB Internal flash memory Almer OS (Android compatible) 1800 mAh internal battery **Connectivity** USB2.0 with type C connector WiFi 5, 2,4 (802.11ac) Compatible with wireless headphones With USB-C cable unlimited external battery **Camera** 25MP AF 4k at 30fps, 1080p at 60fps Codecs: h264, hevc, mpeg4-sw, vp8, vp9, vc1, div4/5/6-sw, h263-sw, mpeg2 Flash light Privacy light

Audio

Bluetooth and integrated speakers on both side

Bluetooth and 4 integrated microphones (beam forming and noise suppression)

Location

Yes, if the Companion App is connected

Inertial Sensors

3 axis gyro

3 axis accelerometer

Controls

3 interactive and programable buttons

Voice control with speech engine

Almer Companion app on Android and iOS

Mounting options

Weight: 179 gramms

Dimensions: 155 x 68 x 64 mm

Replaceable pad and head band

Supported Eye use: Right

Compatible with:

	Safety and prescription glasses Hard hat Peltor headphone (the headphones can be worn over the Arc) **Environment** Operating temperature: -10°C to 45°C Operating humidity: 10% to 80% non-condensing Storage temperature: 10°C to 40°C Storage humidity: 20% to 60% Cleaning Process: Wet-Towel **Mobile Device Management** Compatibility with Microsoft Intune and Ivanti
Linked Components	See technical description above
Media Gallery	

	
Applied in Pilot #	#6 and maybe others

ANNEX III.XII. Almer OS – Operating System

Name	**Almer OS – Operating System**
Summary	The Almer OS is an Android-based operating system used in AR headsets to enhance ease of use and user-friendliness. It improves UX/UI aspects to make using AR devices effortless. The operating system is also installed on the Almer Arc 2.
Description	Almer OS is a specialized operating system developed by Almer Technologies for their augmented reality (AR) devices, including the Almer Arc series. This OS is an adapted version of Android, designed to leverage the robust ecosystem of Android applications while optimizing them for AR use. **Features and Capabilities:** **Adapted for AR:** Almer OS modifies Android to cater specifically to AR devices, ensuring seamless integration with AR hardware. This includes support for high-resolution displays, advanced camera

functionalities, and precise voice control, which are critical for AR applications.

Intuitive User Experience:

The operating system is designed to be user-friendly, with an intuitive interface that allows for effortless navigation and interaction. Users can control the device through voice commands and programmable buttons, making it easy to operate without using their hands.

Compatibility with Android Applications:

One of the standout features of Almer OS is its compatibility with a vast range of Android applications. This means users can install and run standard Android apps on their AR devices, opening up a world of possibilities for productivity, entertainment, and more. The system ensures these apps run smoothly in an AR environment, providing an enhanced user experience.

Effortless Deployment:

Deploying applications on Almer OS is straightforward. The OS supports easy installation and configuration of new apps, allowing businesses to quickly equip their devices with the necessary tools for various tasks. This capability is particularly beneficial for enterprises looking to integrate AR into their workflows without extensive technical overhead.

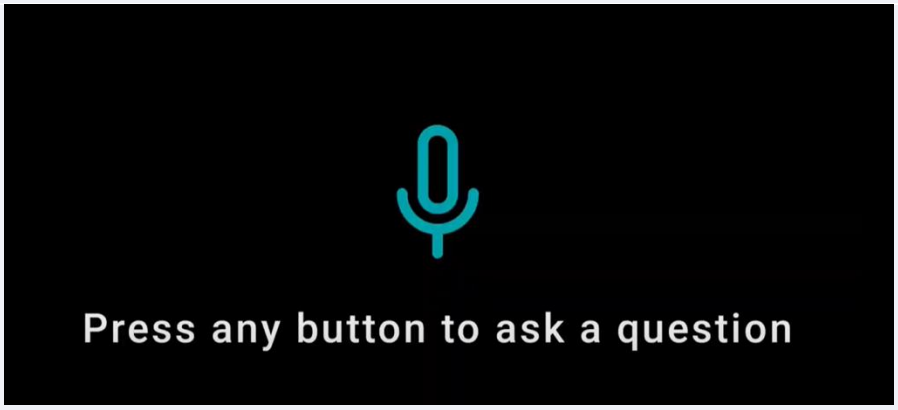
Real-World Applications:

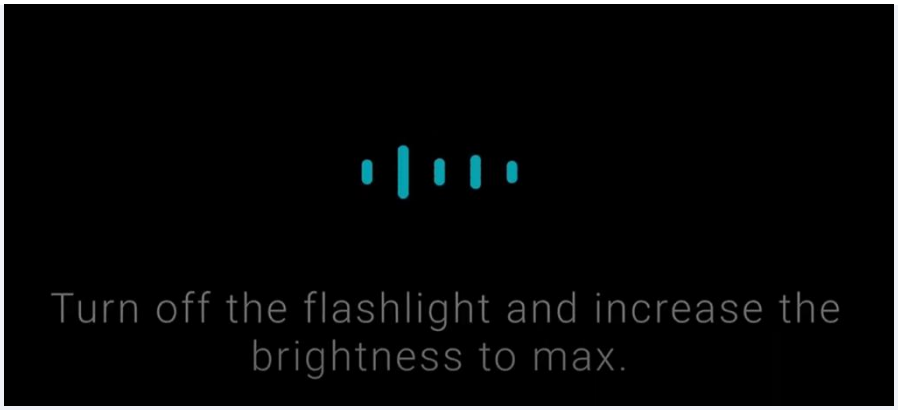
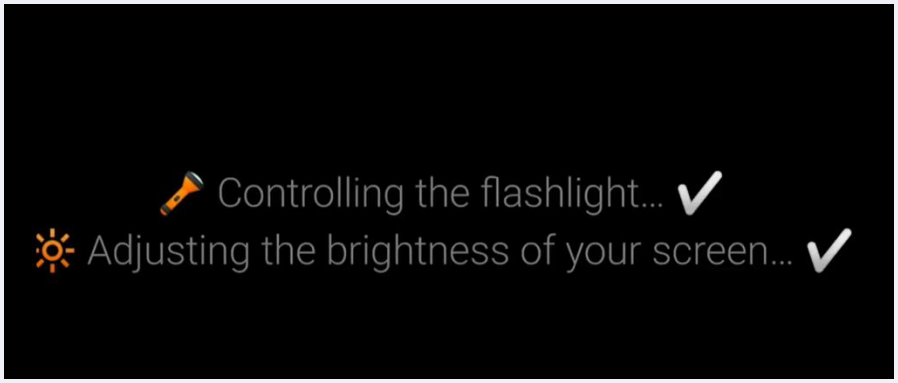
In industrial settings, Almer OS powers devices like the Almer Arc 2, enabling functionalities such as remote assistance, real-time data visualization, and interactive training. For instance, a worker using an Almer Arc 2 can install an Android-based troubleshooting app, which leverages the device's AR capabilities

	to overlay diagnostic information directly onto equipment being serviced.
Website	https://almer.com/almer-arc2/
Manufacturer/Provider	Almer
Contact	Timon Binder
Type	Operating system for AR hardware
Features/Capabilities	AR Operating System
Standards	Based on Android
License	No license required (free). Not open source.
Reference	N/A
Linked Components	N/A
Media Gallery	Not representable by images
Applied in Pilot #	#6 and maybe others

ANNEX III.XIII. Ultron – Smart Assistance

Name	**Ultron – Smart Assistance**
Summary	Ultron is a smart assistant for AR devices and other mobile devices.
Description	Ultron is a smart assistant that is part of the Almer Operating System. Ultron can answer questions, check for information online, and change the hardware state of its system. It can gather information about its environment from the sensors of the AR platform. Ultron can automatically handle tasks, send reminders, and trigger automatic behaviors given a certain situation. It can make calls, send messages, check the weather, take pictures and videos, translate languages, recognize text in images, give directions, switch applications, and operate the device anonymously, among other capabilities. Ultron also has an

	environmental understanding of its surroundings, which contributes to its situational awareness. Additionally, it can detect the state of a user, including their emotions, and so on.
Website	https://almer.com/almer-arc2/
Manufacturer/Provider	Almer
Contact	Timon Binder
Type	It's a smart assistance that can do a vast amount of tasks and problem solving.
Features/Capabilities	Smart Assistance
Standards	No standard. But can integrate to any services over API.
License	Currently no license is required, but the assistance is optimized for the Almer Arc.
Reference	Please contact us on more details.
Linked Components	N/A
Media Gallery	

	 
Applied in Pilot #	#6 and maybe others

ANNEX III.XIV. TeamViewer – Frontline

Name	**TeamViewer – Frontline**
Summary	Teamviewer Frontline is installed by default on the Almer Arc 2. It's a AR software solution tailored for industrial use. It overlays digital information, like instructions and data, onto the real world via smart glasses or mobile devices, enabling hands-free operation. The software features remote assistance, allowing experts to provide live support and guidance from afar. Additionally, it offers step-by-step instructions for training, integrates with enterprise systems such as ERP or CRM, and facilitates data capture for compliance and optimization. Primarily beneficial in manufacturing, logistics, and maintenance,

	TeamViewer Frontline enhances worker efficiency and productivity through advanced AR tools.
Description	TeamViewer Frontline is an advanced augmented reality (AR) application developed by TeamViewer. It is designed to enhance productivity and efficiency for frontline workers across various industries by providing them with hands-free, real-time access to critical information and remote expert assistance. **Key Features and Capabilities:** **1. Remote Assistance:** TeamViewer Frontline enables frontline workers to connect with remote experts via live video calls. This feature allows experts to see exactly what the worker sees, providing real-time guidance and support. This capability is particularly useful for troubleshooting, maintenance, and complex task execution, reducing downtime and improving problem resolution speed. **2. Hands-Free Operation:** The application is optimized for hands-free use, which is crucial for tasks that require manual dexterity. Workers can interact with the application through voice commands and gesture controls, ensuring they can maintain productivity while using the system. **3. Augmented Reality Overlay:** TeamViewer Frontline utilizes AR to overlay digital information onto the physical world. This includes displaying instructions, highlighting objects, and providing real-time annotations. This visual aid helps workers understand tasks better and perform them more accurately.

4. Integration with Wearable Devices:

The application is compatible with various AR-enabled wearable devices, such as smart glasses and headsets. This integration allows workers to keep their hands free while accessing essential information directly in their field of vision.

5. Task Management and Guidance:

TeamViewer Frontline offers features for task management, including step-by-step instructions and checklists. Workers can follow guided workflows, ensuring consistency and accuracy in task execution. This is particularly beneficial for training new employees and standardizing procedures across the workforce.

6. Data Capture and Documentation:

The application allows for real-time data capture and documentation. Workers can record their actions, capture images, and document issues directly through the AR device, ensuring accurate and timely reporting.

7. Scalability and Customization:

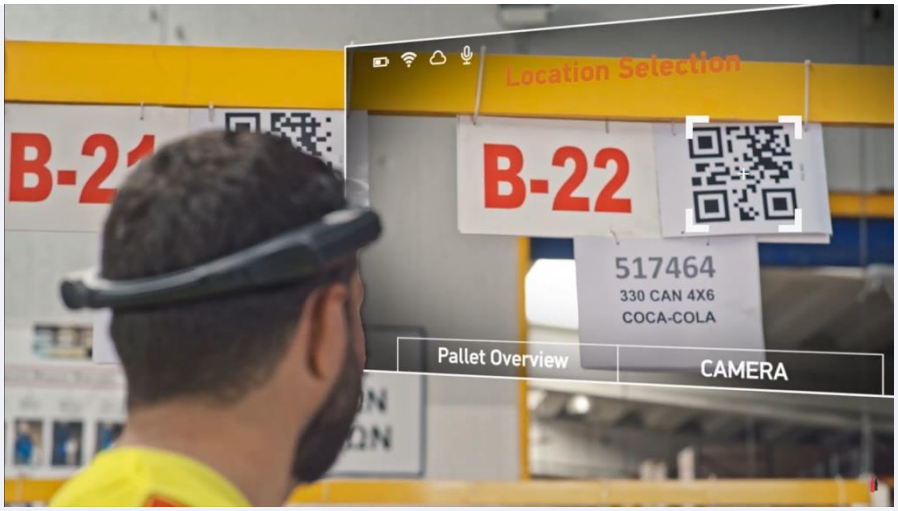
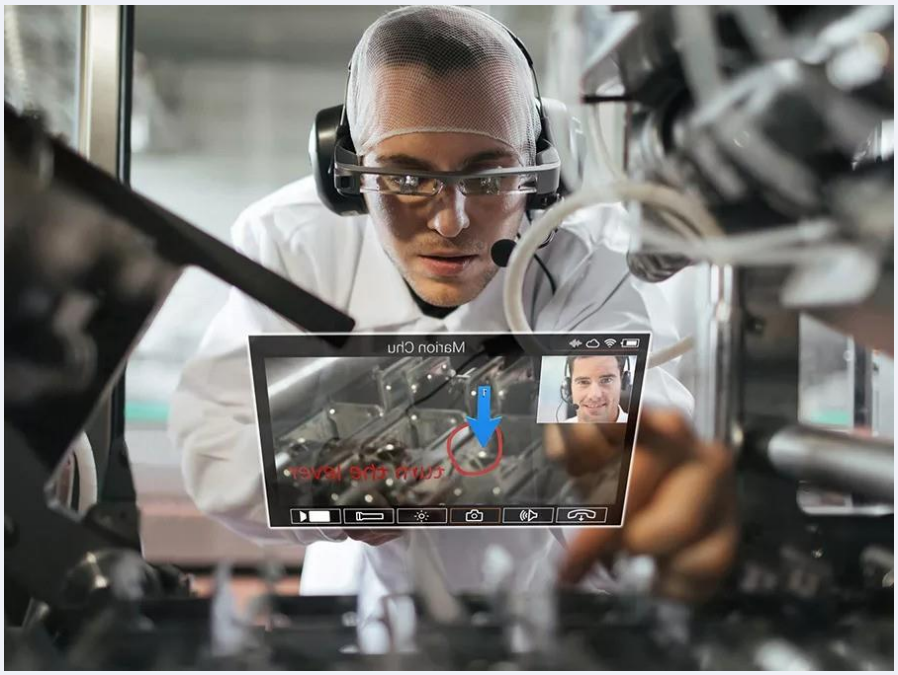
TeamViewer Frontline is scalable and customizable to meet the specific needs of different industries and businesses. Companies can tailor the application to fit their unique workflows and operational requirements, ensuring maximum relevance and efficiency.

Use Cases:

TeamViewer Frontline is used in various sectors, including manufacturing, logistics, healthcare, and field service. For

	example, in manufacturing, it helps in equipment maintenance and quality inspections by providing remote expert support and real-time guidance. In logistics, it assists with inventory management and order picking by overlaying relevant information on the physical items. **Conclusion:** TeamViewer Frontline revolutionizes how frontline workers perform their tasks by integrating AR technology into their daily operations. It enhances productivity, reduces errors, and enables real-time support and guidance, making it an invaluable tool for modern enterprises looking to leverage AR for operational excellence.
Website	https://www.teamviewer.com/en-us/products/frontline/
Manufacturer/Provider	Almer
Contact	Timon Binder
Type	It's an AR device software that can be installed on the Almer Arc
Features/Capabilities	Workflow, Videocall, Products and AR Viewer
Standards	Works on almost all Android devices
License	49-149 EURO / month
Reference	https://www.teamviewer.com/de/products/frontline/?utm_source=google&utm_medium=cpc&utm_campaign=de%7Cb%7Cpr%7C23%7Caug%7CFrontline%7Ct0%7C0&utm_content=Frontline&utm_term=teamviewer+frontline&gad_source=1&gclid=CjwKCAjwps-zBhAiEiwALwsVYVCV9BeN2M2lmsodLJXmfDEt7zsLtWmT-FjqqC-MF2Uf5_FlOT924RoCvVUQAvD_BwE
Linked Components	N/A

Media Gallery

	 
Applied in Pilot #	#6 and maybe others

ANNEX III.XV. Clawdite

Name	**Clawdite**
Summary	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.
Description	Clawdite is an extensible and flexible IIoT - industrial internet of things – based platform with a twofold benefit: on the one hand, to support the creation of customised data representations of production systems and their entities including humans; on the other hand, to provide a modular infrastructure, along with its interchangeable components, for easy digital twin instantiation and ramp-up.
Website	https://gitlab-core.supsi.ch/dti-isteps/spslab/public/clawdite
Manufacturer/Provider	SUPSI
Contact	Elias Montini
Type	Platform
Features/Capabilities	N/A
Standards	N/A
License	N/A
Reference	Paper: An IIoT Platform For Human-Aware Factory Digital Twins Gitlab: https://gitlab-core.supsi.ch/dti-isteps/spslab/public/clawdite
Linked Components	N/A
Media Gallery	N/A
Applied in Pilot #	All pilots

ANNEX III.XVI. Wearable OS – Operating System

Name	**Wearable OS – Operating System**
Summary	Wearable OS is an operating system used by the PineTime SmartWatch. It is based on the InfiniTime OS and can run in low

	powered devices, allowing not only the collection of relevant measurements, but also enabling the execution of small-factor algorithms.
Description	The PineTime is a free and open source smartwatch capable of running custom-built open operating systems. Some of the notable features include a heart rate monitor, a week-long battery, and a capacitive touch IPS display that is legible in direct sunlight. It is a fully community driven side-project which anyone can contribute to, allowing you to keep control of your device.
Website	https://pine64.org/devices/pinetime/
Manufacturer/Provider	Pine64
Contact	Pine64 info@pine64.org
Type	Wearable Sensor Platform
Features/Capabilities	- Accelerometer - PPG Heart Rate Sensor
Standards	Bluetooth GATT
License	This project is released under the GNU General Public License version 3 or, at your option, any later version. It integrates the following projects: - RTOS: **FreeRTOS** under the MIT license - UI: **LittleVGL/LVGL** under the MIT license - BLE stack: **NimBLE** under the Apache 2.0 license - Font: **Jetbrains Mono** under the Apache 2.0 license
Reference	https://github.com/InfiniTimeOrg/InfiniTime/
Linked Components	N/A

Media Gallery	
Applied in Pilot #	#4

ANNEX III.XVII. Service Connector Core

Name	**Service Connector Core**
Summary	The Sensor Platform allows the users to easily create a service to connect different clouds, databases, APIs, services, and others.
Description	The Sensor Platform uses a simple structure of providers, parsers and consumers to connect different services. The service connector has a list of connectors. Each one has one provider, one parser and one or several consumers. Each connector can also have specific options passed as arguments to the providers, parsers and consumers.
Website	https://github.com/unparallel-innovation/Service-Connector-Core
Manufacturer/Provider	Unparallel Innovation
Contact	Bruno Almeida

	bruno.almeida@unparallel.pt
Type	Interoperability Middleware
Features/Capabilities	- Provides parsers to any data format - Transforms data from one format to another - Provides an interoperability engine
Standards	N/A
License	This software is free and is distributed under the MIT License
Reference	GitHub: https://github.com/unparallel-innovation/Service-Connector-Core
Linked Components	N/A
Media Gallery	N/A
Applied in Pilot #	All pilots

ANNEX III.XVIII. Context Extraction Framework

Name	**Context Extraction**
Summary	The Context Extractor allows to monitor and extract the context of the situation under which a product/machine/component is being used, taking into account the human operator. A methodology is guiding the process on how to define a Context Model for extraction of context.
Description	These core services are used for extraction of context during daily product/machine/component use operation, and to provide the extracted context to the downstream services. The services to extract the context could be extended to include the observation of the human operator behaviour, i.e. to take his activities into account when identifying current context.

	Baseline for identifying current context is the context model. The context model describes circumstances under which a product/machine/component is currently used, and by this allows adjustments to dynamically meet specific needs of the users of the products/machines/components. The context model is set of concepts and their relations which describe circumstances under which the product is currently used.
Website	https://github.com/eclipse-opensmartclide/smartclide-context
Manufacturer/Provider	ATB
Contact	Sebastian Scholze scholze@atb-bremen.de
Type	Background Service
Features/Capabilities	Allows to easily create a service to connect different clouds, databases, APIs, services, and others
Standards	N/A
License	EPL-2.0
Reference	https://github.com/eclipse-opensmartclide/smartclide-context/blob/main/docs/index.md
Linked Components	N/A
Media Gallery	N/A
Applied in Pilot #	All pilots