



# MOTIVATEXR

Maintenance, Support & Operation Training using Immersive Virtual and Augmented Technology for Efficiency with XR

## **D3.4 INDUSTRIAL USER REQUIREMENTS AND USE-CASE SCENARIOS V2**

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## D3.4 INDUSTRIAL USER REQUIREMENTS AND USE-CASE SCENARIOS

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Authors	Luca Rizzi, Sarah De Cristofaro, Antonio Zingarofalo (CETMA) MAG, CS, SOP, F6S, YBQ, D3, 2F, CET, UPM, TUD, TEC, HGE, AV, AAA, BIR, DED, AA
Reviewers	Iñaki Martínez-Sarriegui (TEC), Alexandra Malouta (MAG)
Abstract	This Deliverable presents an updated and consolidated analysis of User Needs, User Requirements, and Use-Case Scenarios for the MOTIVATE XR platform following the Beta testing phase and the maturation of industrial pilots. Building on real user interaction and continuous partner feedback, the document revises, refines, introduces, or removes requirements to ensure alignment with consolidated operational contexts. A clear distinction between authoring and experiencing requirements is maintained, improving clarity across the XR content lifecycle.
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17	DIACHEIRISTIS ELLINIKOU DIKTYOU DIANOMIS ELEKTRIKIS ENERGEIAS AE	HEDNO	EL
18	AEROCAMPUS AQUITAINE	AC	FR

## EXECUTIVE SUMMARY

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This deliverable focuses on the analysis, revision, and consolidation of the **User Requirements (URs)** and related **Use-Case Scenarios**, building upon the updated set of **User Needs (UNs)** defined for the different project pilots. The work represents an advanced step following the first release of the deliverable and is grounded in a structured and iterative exchange with the Pilot partners, carried out after a more detailed definition of the application scenarios and real operational conditions.

Based on the feedback collected during analysis and testing activities, including beta release validation, the previously identified User Needs were systematically reviewed. This process resulted in the introduction of new needs, the rephrasing of existing ones to improve clarity and contextual relevance, and the removal of those no longer considered useful or coherent with the finalised pilot scenarios. Particular attention was given to **usability, perceptual quality, XR session management, sustainability of use, and operational support**, in line with the key SEL objectives analysed within Task 3.1.

Following these updates, the entire list of User Requirements was revised to ensure full alignment and traceability with the updated User Needs. This led to the modification, introduction, or removal of both functional and non-functional requirements, with the aim of providing a clearer, more consistent, and implementation-oriented set of URs. Each requirement has been associated with a corresponding **verification method**, supporting the validation of the requested functionalities, and classified according to the type of user involved (authoring, experiencing, or both).

Overall, the deliverable presents a consolidated and updated overview of the user requirements for each pilot, strengthening the coherence between needs, requirements, and use-case scenarios. This work establishes a robust foundation for the subsequent development, integration, and validation phases of the XR solutions, ensuring that future implementations are closely aligned with real end-user needs and the intended operational contexts.

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## ABBREVIATIONS

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AAA	Architectural Aluminium Academy
AI	Artificial Intelligence
AR	Augmented Reality
KPI	Key Performance Indicator
MoSCoW	Must, Should, Could, Wish nomenclature
MR	Mixed Reality
MRO	Maintenance and Repair Operations
SEL	Social, Ethical and Legal analysis
SPL	Spare Part List
SSH	Social Sciences and Humanities framework
UN	User Needs
UR	User Requirements
UX	User Experience
VR	Virtual Reality
WP	Work Package
XR	Extended Reality
YT	YouTube

## INTRODUCTION

---

This Deliverable “*D3.4 Industrial User Requirements and Use-Case Scenarios (Second Release)*”, is part of the activities carried out within WP3, which focuses on the definition of the socio-technical and industrial framework of the MOTIVATE XR project through a user-centred and pilot-driven approach. The overall objective of WP3 is to ensure that the design and development of the MOTIVATE XR platform are firmly grounded in real industrial needs, operational constraints, and user practices across heterogeneous application domains. This report is the second release of report “*D3.3 Industrial User Requirements and Use-Case Scenarios*” [1].

Within this context, D3.4 represents a key transitional deliverable. While earlier WP3 outputs were primarily concerned with the identification of initial user needs and high-level system assumptions, this second release reflects the increased maturity of the project, both from a technological and methodological perspective. The deliverable builds upon the availability of a Beta version of the MOTIVATE XR tools and leverages experimental evidence collected through hands-on testing in real pilot environments.

The primary focus of this document is the refinement and consolidation of Industrial User Needs and User Requirements, derived from direct interaction with the MOTIVATE XR framework by pilot owners, tool owners, and end users. Rather than introducing new conceptual frameworks, D3.4 applies the established methodology in a more informed and evidence-based manner, allowing latent needs, previously hidden constraints, and usability-related aspects to emerge clearly.

By explicitly addressing the evolution of user needs and requirements after Beta testing, this deliverable plays a strategic role in aligning user-centred analysis with downstream technical activities. In particular, D3.4 provides the necessary foundation for the definition of Functional Specifications (Task 3.3, Deliverable D3.6) and supports future validation and assessment activities foreseen in WP6 and WP7. As such, it acts as a conceptual and methodological bridge between early requirement elicitation, system implementation, and large-scale industrial validation.

## STRUCTURE OF THE DOCUMENT

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The document is structured to guide the reader progressively from the methodological context to the detailed pilot-specific results.

Section 1 (MATERIALS AND METHODS ) describes the methodological framework adopted for this second release. It clarifies the continuity with the approach defined in previous deliverables, the data sources used to update User Needs and User Requirements, and the rationale behind key methodological choices, such as the distinction between authoring and experiencing users, the handling of latent needs, and the prioritisation and verification strategies.

Section 2 (PILOTS ANALYSIS) presents the application of the methodology across the five industrial pilots involved in the project. For each pilot, the chapter includes an updated description of the use-case scenario, the final set of User Needs, and the corresponding User Requirements. The chapter

also highlights the main changes introduced during this iteration, explaining eliminations, reformulations, and newly identified needs in relation to real usage evidence.

### Section 3(

## CONCLUSIONS

CONCLUSIONS) summarises the main outcomes of the deliverable, reflecting on the methodological value of the second iteration and its contribution to the overall project roadmap, particularly in relation to functional specification, validation, and exploitation activities.

## 1 MATERIALS AND METHODS

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This chapter describes the methodological approach adopted to update and refine User Needs and User Requirements within M4-M19 period. The section explains how the original user-centred methodology defined in previous project phases has been applied at a more advanced stage of development, integrating empirical evidence collected during the Beta testing of the MOTIVATE XR platform. The Materials and Methods chapter therefore provides the conceptual and procedural framework underpinning the changes presented in this deliverable, clarifying data sources, decision criteria, and validation logic before introducing the pilot-specific results discussed in the following sections.

### 1.1 METHODOLOGICAL CONTINUITY AND SECOND ITERATION

---

The methodological approach adopted in Deliverable D3.4 is firmly rooted in the user-centred and pilot-driven framework previously defined and validated in Deliverable D3.3 [1]. That methodology, which structured the identification, analysis, and prioritisation of User Needs and their translation into requirements, is considered mature and fully applicable to the objectives of the MOTIVATE XR project. For this reason, the methodological foundations are not redefined in the present document, but explicitly referenced as the baseline upon which the current work is built. For a detailed description of the methodology, please refer to [1] and Appendix A of the same report.

However, D3.4 represents a deliberate refinement of scope rather than a simple repetition of the previous exercise. Following the availability and testing of the Beta Version of the MOTIVATE XR platform, the consortium reached a level of technological and operational maturity that made the redefinition of generic System Requirements no longer appropriate or useful at this stage. In the first iteration, System Requirements were necessarily formulated at a high level, as the platform architecture, interaction paradigms, and user roles were still partially conceptual. After the Beta phase, these elements have been sufficiently clarified through direct experimentation.

For this reason, Deliverable D3.4 intentionally focuses exclusively on User Needs (UN) and User Requirements (UR). The refinement of these two layers is considered the most effective way to consolidate user-driven knowledge gained through Beta testing and to prepare the ground for the definition of Functional Specifications. These specifications are explicitly addressed in *Task 3.3 Functional Specification and Cybersecure Architecture* and will be formalised in Deliverable D3.6 at M20 by CS. In this sense, **D3.4 acts as a methodological hinge between early requirement elicitation and detailed functional design**, ensuring continuity while avoiding redundancy.

The decision to exclude a new definition of System Requirements is therefore not a simplification, but a methodological choice driven by project maturity. It reflects the transition from a phase

dominated by abstraction and anticipation to one grounded in validated usage patterns, where user needs and user requirements can be articulated with greater precision and directly inform functional implementation.

## 1.2 AUTHORING AND EXPERIENCING PERSPECTIVES

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A central methodological choice in this second iteration of the report is the **explicit distinction between authoring-oriented and experiencing-oriented user perspectives**. This distinction builds directly on the User Personas identified through the UX co-design activities described in Deliverable D3.7 [2][2], where different user profiles were characterised according to their roles, responsibilities, skills, and interaction patterns within the MOTIVATE XR ecosystem.

During the Beta phase, this distinction proved to be not only conceptually relevant, but also operationally necessary. Through a series of structured interviews, feedback sessions, and iterative discussions with Pilot Owners, it became evident that users interacting with the platform as content creators face needs, constraints, and decision-making processes that differ substantially from those of users consuming XR content in training or operational contexts. As a result, User Needs and User Requirements were analysed and refined by explicitly considering whether they refer to authoring activities, experiencing activities, or to both dimensions.

**Authoring users** are primarily involved in the **creation**, configuration, and management of XR experiences. Their interaction with the platform extends beyond XR visualisation tools and includes desktop-based interfaces, content repositories, asset management, workflow configuration, and integration with existing company data and procedures. Feedback collected from Pilot Owners highlighted that many critical needs emerge at this level, such as the ability to structure procedures, reuse and adapt existing content, manage updates, and ensure consistency between training and maintenance materials. These needs could not be fully captured in the first iteration of the analysis, as they only became evident once users were able to work concretely with the Beta version of the tools.

**Experiencing users**, on the other hand, **interact** with the MOTIVATE XR platform primarily through immersive or mixed-reality interfaces during training, maintenance, or operational tasks. Their needs are closely linked to usability, clarity of instructions, cognitive load, comfort, and contextual access to information. Interviews with Pilot Owners confirmed that several experiencing-related needs only emerged after repeated usage of XR devices in realistic scenarios, where factors such as session duration, information density, and interaction flow directly affected task performance and user acceptance.

Importantly, the distinction between authoring and experiencing perspectives does not imply a separation between tools and platform components. On the contrary, the analysis intentionally considers the MOTIVATE XR platform as a unified system, where authoring and experiencing activities are interconnected. Decisions made during the authoring phase have direct consequences on the quality and effectiveness of the experiencing phase, and vice versa. For this reason, User Needs and User Requirements defined in this deliverable do not focus exclusively on

the creation of XR experiences within specific tools, but encompass the broader platform functionalities supporting the full lifecycle of XR content.

The explicit reference to authoring and experiencing perspectives also supported a more precise interpretation of feedback collected from the pilots. Pilot Owners were encouraged to reflect not only on what users explicitly requested, but also on how different user roles interact with the system at different stages of the workflow. This approach enabled a more accurate refinement of User Needs and reduced ambiguities that were present in earlier formulations, where distinct interaction contexts were implicitly merged.

Overall, the adoption of this dual perspective represents a methodological consolidation step for *Task 3.2 Industrial User Requirements and Use-Case scenarios*. It strengthens the traceability between User Needs, User Requirements, and subsequent Functional Specifications by anchoring them to clearly identified user roles, while maintaining a holistic view of the MOTIVATE XR platform as an integrated socio-technical system.

### 1.3 ADDRESSING LATENT USER NEEDS THROUGH SEL ANALYSIS

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In addition to the User Needs explicitly expressed by end users during interviews and testing activities, the methodological approach adopted here deliberately integrates a set of latent User Needs derived from the Social, Ethical and Legal (SEL) analysis carried out in Task 3.1 and reported in Deliverable D3.2 [3][3].

These needs do not correspond to classical technical requirements, but rather to operational, organisational, and human-centred considerations that significantly influence the safe, effective, and acceptable use of XR technologies in industrial contexts.

The SEL analysis provides a structured and evidence-based overview of potential risks and impacts related to health and well-being, safety, cognitive load, accessibility, organisational readiness, and legal accountability. While these aspects are often not articulated by end users as direct functional requests, they emerge clearly when observing real usage conditions, prolonged exposure scenarios, and the interaction between XR tools and existing work practices. For this reason, they represent an essential **complementary input to the definition of User Needs and User Requirements**.

Within this report, recommended SEL measures were not translated into additional technical functionalities by default. Instead, they were explicitly considered and discussed with both Pilot Owners and Tool Owners as part of the requirements refinement process. This discussion aimed to ensure that such recommendations are taken into account in the design of XR experiences, in the preparation of content, and in the definition of usage guidelines, rather than through the introduction of new monitoring or control mechanisms that fall outside the scope of the project.

A clear example concerns issues related to discomfort, fatigue, cybersickness, and reduced situational awareness. As highlighted during internal discussions and confirmed by tool owners, the MOTIVATE XR tools are not designed to directly monitor physiological or psychological conditions

such as user malaise. Consequently, the project does not aim to implement dedicated sensing or tracking functionalities for these aspects. Instead, the SEL analysis informed the definition of guidelines for correct use, including recommendations on session duration, task segmentation, onboarding procedures, and gradual exposure, which can be embedded into training content and operational practices.

By integrating SEL-derived insights at the level of User Needs and User Requirements, the work reported here ensures that these considerations are not treated as external constraints or post-hoc checks, but as design-relevant inputs that shape how XR experiences are authored, deployed, and used across pilots. This approach preserves a clear separation between technical requirements and socio-technical guidance, while at the same time ensuring that the latter is explicitly acknowledged, shared with relevant stakeholders, and carried forward into subsequent phases of content development and validation.

Overall, the integration of latent User Needs through SEL analysis strengthens the robustness of the user-centred design process and supports the development of XR solutions that are not only functionally effective, but also responsible, usable, and aligned with real industrial conditions.

#### 1.4 USER REQUIREMENTS CONSOLIDATION AND VERIFICATION METHOD

---

Following the refinement and consolidation of User Needs, the subsequent methodological step focused on the definition and structuring of User Requirements (URs). In this phase, User Requirements were intentionally formulated at a relatively high level of abstraction, in order to preserve flexibility across pilots while ensuring robustness and traceability toward later design and validation stages.

This choice reflects a deliberate methodological decision. At the current maturity level of the MOTIVATE XR platform, overly granular User Requirements would risk duplicating or constraining the work foreseen in the definition of Functional Specifications. Instead, each User Requirement has been designed to respond to multiple User Needs, potentially of different nature (authoring-related, experiencing-related, or mixed), while remaining sufficiently precise to guide subsequent functional design choices.

A key element introduced in this iteration is the verification-oriented structuring of User Requirements. For each UR, an additional column has been **included to explicitly indicate the verification approach** that will be used to assess its fulfilment. This information serves multiple purposes. First, it strengthens the traceability between requirements and validation activities, supporting the monitoring of the associated project KPI. Second, it clarifies whether a given User Requirement primarily concerns authoring activities, experiencing activities, or both, thus reinforcing alignment with the user personas defined in Deliverable D3.7 [2]. Third, it anticipates the validation logic that will be applied in later work packages, without prematurely defining detailed test protocols.

Verification approaches are intentionally expressed using concise and standardized formulations (e.g. verification through testing, demo exercise, demo maintenance), rather than detailed procedural descriptions. This ensures consistency across pilots, improves readability of the tables, and avoids redundancy with validation methodologies that will be further elaborated in WP6 and WP7. At this stage, the objective is not to validate the system, but to ensure that each User Requirement is explicitly associated with a verifiable outcome.

The consolidation process also aimed to limit the proliferation of User Requirements. Given that each User Requirement typically leads to the definition of multiple Functional Specifications in *Task 3.3 Functional Specification and Cybersecure Architecture* (Deliverable D3.6), introducing an excessive number of URs would result in unnecessary complexity downstream. Instead, broader User Requirements were preferred, provided that they could be clearly traced back to distinct User Needs and verified through appropriate validation activities.

Overall, this structuring approach positions User Requirements as a stable and meaningful interface between user-centred analysis and system design. By explicitly linking User Requirements to verification logic and KPIs, this report establishes a solid methodological foundation for the definition of Functional Specifications and for the subsequent validation of the MOTIVATE XR platform in real pilot contexts.

## 1.5 USER REQUIREMENTS PRIORITISATION AND ALIGNMENT WITH FUNCTIONAL SPECIFICATIONS

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The prioritisation of User Requirements in this report represents a deliberate methodological shift compared to the previous phase of the project. In earlier iterations, prioritisation activities were primarily focused on System Requirements, using a MoSCoW-based scoring to manage technical uncertainty in an early design stage [4]. At the current stage of development, this approach has been revised to reflect the increased maturity of the MOTIVATE XR platform and the availability of empirical evidence from Beta testing.

In the present document, prioritisation is applied directly at the level of User Requirements. The MoSCoW nomenclature (Must, Should, Could, Wish) has been retained to ensure continuity and readability across deliverables, but its role has evolved. Rather than supporting abstract system-level decisions, the prioritisation of User Requirements is now explicitly intended to guide the definition and sequencing of Functional Specifications developed within *Task 3.3 Functional Specification and Cybersecure Architecture* and reported in Deliverable D3.6.

The priority assigned to each User Requirement is derived from the importance and criticality of the associated User Needs, considering both authoring and experiencing perspectives. This ensures that prioritisation reflects actual user impact rather than purely technical considerations. As a result, User Requirements that address safety, usability, learning effectiveness, or operational continuity, particularly those emerging from Beta testing, are typically classified at higher priority levels.

Importantly, the prioritisation exercise does not introduce a rebalancing of the overall requirement landscape. The priority matrix defined in earlier phases has not been recalculated, as no substantial shifts in relative importance emerged during the second iteration. Instead, the methodology confirms the robustness of the initial prioritisation while enabling a more precise operational use of priorities in downstream design activities.

This approach also acknowledges a key structural consideration: each User Requirement generally maps to multiple Functional Specifications. Over-fragmentation of User Requirements would therefore lead to unnecessary complexity and reduced traceability. By maintaining User Requirements at an appropriate level of abstraction and prioritising them coherently, the project ensures that Functional Specifications can be derived in a structured and scalable manner, while still addressing diverse User Needs across pilots.

Overall, the prioritisation strategy adopted here establishes a clear and transparent link between user-centred evidence, requirement consolidation, and functional design. It positions this deliverable as the final decision-making layer before detailed functional specification and validation, ensuring alignment between Beta testing outcomes, *Task 3.3 Functional Specification and Cybersecure Architecture* implementation activities, and future verification and validation phases.

## 2 PILOTS ANALYSIS

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This section is focused on the definition of Use-Case Scenarios and on the results obtained from the application of the previously described methodology to consolidate User Needs and User Requirements. For simplicity one sub-section per Pilot has been created using the following nomenclature:

- Pilot 1 - Aerospace Industry.
- Pilot 2 - Home appliance Industry.
- Pilot 3 - Aluminium Industry.
- Pilot 4 - Electric Distribution Industry.
- Pilot 5 - Robot-human hybrid manufacturing.

To improve readability, traceability, and cross-analysis of User Needs and User Requirements, a colour-coding scheme has been systematically applied to the tables presented in this report. The use of colours is intended as a visual support tool, helping the reader to immediately identify the nature of each need or requirement and its role within the MOTIVATE XR ecosystem.

With respect to User Needs, colours are used to distinguish the primary dimension to which each need belongs:

- Light Orange highlights technical and functional needs, directly related to the behaviour, performance, and capabilities of the XR tools and platform components.



- Turquoise identifies manufacturing-related needs, including aspects linked to content production, configurability, process structuring, and cost-related constraints associated with the creation and maintenance of XR experiences.



- Indigo is used for safety-related needs, encompassing physical safety, operational risk mitigation, user well-being, and the prevention of hazardous or uncomfortable usage conditions.



- Lime marks aesthetic, recognisability, and usability-related needs, addressing aspects such as clarity, visual coherence, user orientation, and the overall recognisability of content and experiences.



This categorisation does not imply rigid separation, as some User Needs may span multiple dimensions. However, the colour indicates the dominant perspective through which the need has been analysed and discussed.

For User Requirements, colours are instead used to clarify the user perspective involved:

- Aqua identifies User Requirements primarily associated with Authoring activities, such as content creation, configuration, structuring of procedures, and management of XR experiences within the platform.



- Purple identifies User Requirements primarily associated with Experiencing activities, referring to the end-user interaction with XR content during training, maintenance, or operational execution.



This visual distinction supports the methodological separation between authoring and experiencing perspectives introduced in this deliverable and aligned with the User Personas defined in Deliverable D3.7 [2]. It also helps to clarify cases where a single User Requirement responds to multiple User Needs of different nature, reinforcing the rationale behind maintaining User Requirements at an intentionally broad level of abstraction.

Overall, the colour-coding system serves as a navigation and interpretation aid, facilitating comparison across pilots, improving consistency among tables, and strengthening the link between User Needs, User Requirements, and subsequent Functional Specifications developed in *Task 3.3 Functional Specification and Cybersecure Architecture* (Deliverable D3.6).

## 2.1 PILOT 1 – AEROSPACE INDUSTRY

**The aerospace industry** faces a critical challenge: a shortage of qualified maintenance operators. As aircraft systems grow more complex and fleets expand, the demand for skilled professionals who can ensure safety, reliability, and regulatory compliance has never been greater.

To meet this challenge, training must scale efficiently, safely, and cost-effectively. **Extended Reality (XR)** offers a transformative solution.

XR-based training delivers:

- Immersive, hands-on simulations of real-world maintenance tasks.
- Scalable learning environments adaptable to multiple sites and diverse aircraft models.
- AI-driven feedback for continuous skill improvement and higher training quality.

The **MOTIVATE XR Pilot1** aims to demonstrate how XR can revolutionise aircraft maintenance training by making it more engaging, effective, and aligned with the industry’s evolving needs.

### 2.1.1 SCENARIO DESCRIPTION

The objective of the Aerospace Pilot is to validate how AI and XR technologies can automate the conversion of aircraft technical documentation into an XR training application, exploiting an Aircraft Digital Mock-Up and extensive technical manuals.

Pilot1 brings together key aerospace industry partners to deliver an XR-based maintenance training solution dedicated to the **MRO profession (Maintenance, Repair, and Overhaul)**.



FIGURE 1: ACTUAL TRAINING CLASSROOM



FIGURE 2: AIRPLANE DIGITAL TWIN

The MOTIVATE XR Pilot1 solution offers significant benefits for the aerospace industry:

- **Reducing time and costs** to produce XR maintenance training systems.
- **Making training more engaging** and addressing the shortage of maintenance technicians.

- **Improving training quality** while minimizing the need to immobilize real aircraft.

**Reducing errors** in interpreting documentation and modelling procedures through AI-driven conversion tools.

The pilot case scenario replicates a real-world aeronautical maintenance operation, developed in collaboration with Liebherr Aerospace.

Its purpose is to evaluate the effectiveness and usability of the **MOTIVATE XR platform** for training maintenance technicians in aircraft system inspections. The focus is on the **Airbus A320 air conditioning pack**, manufactured by Liebherr Aerospace. In alignment with Liebherr Aerospace, the beta scenario centres on a specific maintenance procedure: **Primary Heat Exchanger (PHX) Inspection** within the air conditioning pack.

The inspection process includes:

- Disassembly
- Visual checks
- Reassembly

To ensure authenticity, the scenario integrates **realistic interactions** and **error management mechanisms**.

This procedure was chosen for its **frequent operational use** and **technical complexity**, offering rich data for performance evaluation.

### 2.1.2 USER NEEDS

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The set of User Needs previously collected from Pilot 1 partners was systematically reviewed and refined in close collaboration with them. This revision was informed by a more mature and operational definition of the pilot scenario, including clearer assumptions on the training context, the selected XR modality, and the expected user interactions.

Starting from the preliminary User Needs collected in the early phase of the project, the refinement process led to the consolidation, rephrasing, or removal of those needs that, in light of the evolved pilot definition, were no longer fully aligned with the actual operational requirements and expectations of the end users. At the same time, additional User Needs were introduced where gaps were identified or where new requirements emerged as a result of the progressive validation of use cases and training workflows.

The revised and removed User Needs are detailed in the following. For each change, a specific rationale is provided to clearly justify the evolution from the initial formulation in D3.3 [1] to the updated and consolidated set of User Needs presented in D3.4, ensuring transparency, traceability, and consistency across project phases.

Here below a list of reviewed and deleted UNs:

- **UN-0500-P1:** XR System must be able to allow request for support from an experienced operator

This UN has been **removed** following a clarification of the Pilot 1 training context and operational setup. Pilot 1 is explicitly focused on structured training activities, which are always conducted under the supervision and in the physical presence of an expert. Within this training framework, the attention and support of an expert are continuously available and can be requested directly, without the need for mediation through the XR system. As a result, the implementation of a dedicated XR-based support request functionality was deemed unnecessary and outside the actual needs of the pilot, thus UN-0500-P1 no longer aligns with operational requirements from Pilot 1.

- **UN-0700-P1:** XR System must display procedures in a highly visible way

This UN has been **rephrased** and reformulated to reflect the updated requirements of the end user. In particular, the original intent of the need has been clarified and more precisely expressed in the revised user need *UN-0710-P1 - XR System must present contents in a way that ensures clear visibility and high perceptual quality*, which is highlighted in the table below.

- **UN-0800-P1:** XR System must guide the trainee at times coherent with the exercise (animations speed, screwing speed, etc.)

This UN has been **rephrased** and reformulated to reflect the updated requirements of the end user. In particular, it has been rewritten in a clearer and more explicit manner to specify that the XR experience must accurately reflect the timings and operational methodologies of the real exercise. The revised user need is identified as *UN-0810-P1 - XR System must guide the trainee at times consistent with the exercise*, and is highlighted in the table below.

- **UN-0900-P1:** XR System must show the correct ways to handle the tools needed for the operation

This User Need has been **removed** following a deeper consolidation of the Pilot 1 training objectives and scope. Given the extensive variety of specialised tools used in the aeronautical domain, providing detailed instructions on tool manipulation or handling techniques would be impractical and would significantly increase the complexity of the XR content without delivering proportional training value.

Moreover, the primary objective of the XR training is not to teach fine-grained tool-handling or specific grasping procedures, but rather to support the trainee in the execution of complex maintenance tasks. This includes guiding the user in identifying and selecting the correct tool among multiple available options and applying it within the correct procedural context.

Within the authoring environment, each tool is already associated with a predefined and standardised set of actions, which can be easily applied when building the XR training scenario. As a result, no additional level of detail related to tool handling needs to be authored or experienced by the trainee.

- **UN-1300-P1:** XR System must have a non-prohibitive cost

This UN has been **rephrased** and reformulated to reflect the updated requirements of the end user. In particular, it has been rewritten to provide a more precise reference to the economic

sustainability of use, shifting from a generic or estimated cost value to the specification that the XR experience should be accessible through mid-range hardware devices. The revised user need is identified as *UN-1310-P1 - XR System should operate on affordable devices (mid-range XR headsets)* and is highlighted in the table below.

- **UN-1400-P1:** XR System must allow the user to be able to run an entire process without restricting the user's hands

This User Need has been **removed** following the confirmation that the Pilot 1 training will be implemented in a Virtual Reality environment. In the VR configuration, trainees do not handle real tools but interact exclusively through VR controllers. As a result, hands-free interaction or gesture-based control is not required to perform the training tasks.

This need had originally been introduced since hands-free operation was considered potentially relevant for an Augmented Reality scenario involving real tools. Given the confirmed VR-based design and interaction paradigm, this User Need no longer aligns with the operational scope of the pilot.

- **UN-2900-P1:** XR System must make searching for information in the manual intuitive, quick and accurate

This User Need has been rephrased to better reflect the technical characteristics and limitations of AI-based information retrieval mechanisms. The updated wording adopts the term “*sufficiently precise*” to more realistically describe the expected performance of AI-based systems. The revised user need is identified as *UN-2910-P1 - XR System must make searching for information in the manual intuitive, quick and sufficiently precise*, and is highlighted in the table below.

For the newly introduced User Needs, a detailed justification is also provided, clearly outlining the motivations and considerations that led to their identification and inclusion in the updated requirements set. These were not included in the first release, as they emerged from further analyses and additional discussions with the Pilot partners, and were also informed by the SEL analysis performed within Task 3.1.

Here below a list of newly added UNs:

- **UN-1710-P1:** XR System must prevent overexposure

This UN has been **introduced** to address one of the “*quick wins*” mitigation measures identified within the SEL analysis carried out in Task T3.1, specifically the recommendation to limit session durations and reduce the risk of user overexposure. In particular, it highlights the need to avoid excessively prolonged XR sessions, which could negatively affect user comfort and overall user experience. The inclusion of this user need aims to ensure that XR usage actively supports overexposure prevention with relatively low effort solutions such as automated break prompts for the experiencing users.

- **UN-1720-P1:** XR System must allow to finish the XR session at any time through an easily accessible and unambiguous action

This UN has been **introduced** to address one of the “*quick wins*” mitigation measures identified within the SEL analysis carried out in Task T3.1, specifically the recommendation to monitor users for signs of discomfort (e.g., dizziness, nausea, irregular movements) and to allow or trigger session termination when necessary. Since the implementation of automated solutions for detecting user discomfort falls outside the scope of the project, this requirement focuses on ensuring that users remain in full control of the XR experience and can independently decide to terminate the session whenever increasing discomfort is perceived. In this context, the User Need emphasises the importance of providing a clearly identifiable and always accessible “exit” or “end session” action, enabling a safe, intuitive, and stress-free interruption of the ongoing XR experience.

- **UN-2510-P1:** XR System must allow the segmentation of procedures to create short duration session

This User Need has been introduced to address one of the “*quick wins*” mitigation measures identified within the SEL analysis carried out in Task T3.1, specifically the recommendation to limit session durations and reduce the risk of user overexposure. In this context, allowing the segmentation of training procedures into shorter sessions represents a practical and effective way to operationalise such mitigation measures within the XR training environment.

By enabling content creators to divide complex procedures into shorter, self-contained segments, the system supports the definition of task-specific maximum durations and the introduction of checkpoint-based breaks between sessions. This approach facilitates safer and more manageable training experiences, while preserving the overall instructional coherence of the procedure.

- **UN-3500-P1:** XR System must provide a repository for already available XR assets

This UN has been **introduced** to support the XR scene creation process by ensuring the availability of assets already accessible to the user at the authoring stage. In particular, it highlights the need for a repository where XR assets are preloaded, stored, and ready for use, allowing the user to quickly select and integrate existing assets into XR scenes that will subsequently be experienced by the operator.

- **UN-3600-P1:** XR System must allow the possibility to a seamless creation of new XR assets

This UN has been **introduced** to support the XR content creation workflow by ensuring that new XR assets created ad hoc can be easily hosted within the system repository. In particular, it highlights the need for a repository that can accommodate newly created assets and enable their smooth integration into XR scenes during the authoring phase, ensuring continuity and efficiency in the overall content preparation process.

The changes described above, together with the updated list of User Needs, are reported below. The table highlights (with bold characters) the User Needs that have been newly introduced, as well as those resulting from the rephrasing of previously identified ones. In addition, it explicitly shows the

relationship between each User Need and the type of user primarily involved, distinguishing between authoring users, experiencing users, or both.

UN ID	USER NEEDS	AUTHORING	EXPERIENCING
UN-0100-P1	XR System must enable the transmission of basic knowledge about the airplane model		X
UN-0200-P1	XR System must be able to suggest the intervention points for maintenance operations		X
UN-0300-P1	XR System must provide guidance on required tools		X
UN-0400-P1	XR System must provide guidance on the equipment to be used in the training course		X
UN-0600-P1	XR System must show the steps of the process operations step by step	X	X
UN 0710-P1	<b>XR System must present contents in a way that ensures clear visibility and high perceptual quality</b>		X
UN-0810-P1	<b>XR System must guide the trainee at times consistent with the exercise</b>		X
UN-1000-P1	XR System must show the correct ways to perform the operations		X
UN-1100-P1	XR System must be able to provide access to view manuals and/or other documentation useful to the process		X
UN-1200-P1	XR System must be able to provide the guidance in different languages	X	X
UN 1310-P1	<b>XR System should operate on affordable devices (mid-range XR headsets)</b>		X
UN-1500-P1	XR System must allow stable and secure wearability		X
UN-1600-P1	XR System must allow adaptable wearability for different users		X
UN-1700-P1	XR System must offer a comfortable user experience	X	X
UN-1710-P1	<b>XR System must prevent user overexposure</b>		X
UN-1720-P1	<b>XR System must allow to finish the XR session at any time through an easily accessible and unambiguous action</b>		X
UN-1800-P1	XR System must have a distinctive layout	X	X
UN-1900-P1	XR System must have a clear and defined layout	X	X
UN-2000-P1	XR System must allow for well-defined element visibility	X	X

<b>UN-2100-P1</b>	XR System must make searching for information in the trouble shooting manual and maintenance manual	X	
<b>UN-2200-P1</b>	XR System must enable well-defined visibility of elements in indoor environment	X	X
<b>UN-2300-P1</b>	XR System must provide a runtime of at least 4 hours		X
<b>UN-2400-P1</b>	XR System must provide audio feedback (equipment sounds)	X	X
<b>UN-2500-P1</b>	XR System must allow saving of executed steps and steps not yet executed	X	
<b>UN-2510-P1</b>	<b>XR System must allow the segmentation of procedures to create short duration session</b>	X	
<b>UN-2600-P1</b>	XR system should guarantee an easy desktop preview of the built exercise	X	X
<b>UN-2700-P1</b>	XR System must allow the identification of a safety work area		X
<b>UN-2800-P1</b>	XR System must provide feedback on the use of correct tools		X
<b>UN-2910-P1</b>	<b>XR System must make searching for information on the manual intuitive, quick and sufficiently precise</b>	X	
<b>UN-3000-P1</b>	XR System must offer the possibility to let more than one trainee to work at the same time in the same environment		X
<b>UN-3100-P1</b>	XR System could be used offline or on a local network (intranet) for confidentiality and security reasons	X	X
<b>UN-3200-P1</b>	XR System must guarantee an easy creation/modification of the scenario	X	
<b>UN-3300-P1</b>	XR system must guarantee an easy reviewing on exercise execution		X
<b>UN-3400-P1</b>	XR System must provide virtual storage to manage removed and spare parts		X
<b>UN-3500-P1</b>	<b>XR System must provide a repository for already available XR assets</b>	X	
<b>UN-3600-P1</b>	<b>XR System must allow the possibility to a seamless creation of new XR assets</b>	X	

TABLE 1: PILOT 1 USER NEEDS.

### 2.1.3 USER REQUIREMENTS

Following the update and consolidation of the User Needs presented in the previous section, the corresponding set of User Requirements has been systematically reviewed and realigned. This

activity aimed to ensure full consistency between the updated User Needs and functional and non-functional User Requirements derived from them.

In particular the refinement of User Requirements has been conducted to appropriately reflect the specific perspective, responsibilities, and interaction patterns of the user persona from which the associated User Need originates (e.g. authoring users versus experiencing users).

This approach allows the User Requirements to more accurately capture the multifaceted nature of the XR system usage, clarifying how the same User Requirement may satisfy different User Needs depending on the role of the end user. The resulting set of User Requirements thus provides a clearer, more structured, and persona-aware foundation for subsequent Functional Specifications refinement foreseen in *Task 3.3 Functional Specification and Cybersecure Architecture*.

Here below a list of the URs reviewed or deleted:

- **UR-NFUN-1300-P1:** Battery

This UR has been **rephrased** and reformulated as *UR-NFUN-1310-P1 – Operational autonomy*, to provide a clearer definition of device battery autonomy management, in alignment with the XR experiences foreseen within the pilot scenario. The revision ensures that battery-related constraints are explicitly considered in relation to the expected duration and usage patterns of the XR sessions.

- **UR-NFUN-1400-P1:** Price

This UR has been **rephrased** and reformulated as *UR-NFUN-1410-P1 – Compatibility*, in alignment with the updates introduced in the related User Needs. The revision provides a clearer and more consistent linkage between this requirement and the need to enable the fruition of XR experiences on mid-range devices, ensuring that the overall solution remains economically accessible and non-prohibitive for the end user.

- **UR-FUNC-2200-P1:** Gesture Controls

This UR has been **deleted** to maintain consistency with the deletion of the corresponding User Need (UN-1400-P1), which was deemed no longer relevant to the pilot scenario, as detailed in the corresponding justification section.

Here following a list of the newly added User Requirements:

- **UR-FUNC-0410-P1:** XR predefined assets

This UR has been **introduced** to align the traced User Needs with concrete implementation strategies, specifically addressing the definition of a repository of predefined XR assets. The inclusion of this requirement supports the implementation of a structured assets repository capable of effectively responding to the identified user needs and facilitating the preparation of XR scenes during the authoring phase.

- **UR-FUNC-0420-P1:** XR assets creation

This UR has been **introduced** to trace the user needs related to the creation of new XR assets, ensuring that such assets can be developed and subsequently integrated into a shared repository. The inclusion of this requirement supports the definition of implementation strategies that enable the availability, management, and reuse of newly created assets within the common XR asset repository.

- **UR-FUNC-2800-P1:** Quick exit mode

This UR has been **introduced** to align with the newly added User Needs related to the ability to easily quit the XR experience at any time. The inclusion of this requirement ensures that the system provides a quick, easily accessible and unambiguous exit mechanism, allowing users to safely leave the XR experience whenever needed.

Following the updates introduced with respect to the first release of the User Requirements list, the revised table is presented below. It reports the updated User Requirements together with their associated verification methods, which are essential for validating the correct implementation of the requested functionalities. The Table 2 also distinguishes the User Requirements according to the type of user involved in the verification process, differentiating between experiencing users and authoring users.

UR ID	UR NAME	DESCRIPTION	UN REF	VERIFICATION METHOD	PRIORITY
<b>UR-FUNC-0100-P1</b>	XR process	Guided visualization of the process steps	UN-0200-P1 UN-0600-P1 UN-1000-P1	To test the created exercise for visual guidance and highlights of intervention points	M
			UN-0600-P1	To test the possibility to create detailed process steps	
<b>UR-FUNC-0200-P1</b>	XR textual information	Virtual spaces containing useful written details	UN-0100-P1 UN-0600-P1 UN-2800-P1 UN-3300-P1	To test the possibility to read contents in the scene of the created exercise	M
			UN-0600-P1 UN-2100-P1	To test the possibility to create textual contents	

<b>UR-FUNC-0300-P1</b>	3D models	Visualisation of 3D elements useful for the exercise fruition	UN-2000-P1 UN-3400-P1	To test the presence of 3D contents in the scene of the created exercise	M
			UN-2000-P1	To test the possibility to insert 3D contents	
<b>UR-FUNC-0400-P1</b>	2D/3D animations	Guided process through the presence of virtual elements	UN-0200-P1 UN-0600-P1 UN-0810-P1 UN-1000-P1 UN-2800-P1	To test the proper run of animations in the created exercise	M
			UN-0600-P1	To test the possibility to create 2D/3D animations	
<b>UR-FUNC-0410-P1</b>	<b>XR predefined assets</b>	<b>Repository with a predefined set of XR assets already available for authoring</b>	<b>UN-3500-P1</b>	<b>To test the possibility to use 2D/3D assets already available in a common repository</b>	<b>M</b>
<b>UR-FUNC-0420-P1</b>	<b>XR assets creation</b>	<b>Intuitive creation of new XR assets</b>	<b>UN-3600-P1</b>	<b>To test the possibility to create and save XR assets in a common repository</b>	<b>M</b>
<b>UR-NFUN-0500-P1</b>	Easy to use	The system needs to be usable by non-experts	UN-1200-P1 UN-1700-P1 UN-1720-P1 UN-1900-P1 UN-3300-P1	To be verified by usability test foreseen in WP7	M
			UN-1200-P1 UN-1700-P1 UN-1900-P1 UN-2910-P1 UN-3200-P1 UN-3500-P1 UN-3600-P1	To be verified by usability test foreseen in WP7	
<b>UR-FUNC-0600-P1</b>	Back/Forward instructions	Process step execution flow aligned with actual operator progress	UN-0600-P1 UN-0810-P1 UN-1900-P1 UN-3300-P1	To test the possibility to move back and forward between scenes	M

			UN-0600-P1 UN-1900-P1 UN-2510-P1 UN-3200-P1	To test the possibility to implement back and forward action to allow the user to move among scenes	
<b>UR-FUNC-0700-P1</b>	Homepage	Possibility to return to homepage at any time	UN-1700-P1 UN-1900-P1	To test the possibility to jump to the homepage anytime	M
			UN-1700-P1 UN-1900-P1	To test the possibility to implement the homepage link button in every scene	
<b>UR-FUNC-0800-P1</b>	Intranet connection	XR device local networking	UN-3100-P1	To test if the XR experience can be implemented as standalone trainings on a device isolated from the network	M
			UN-3100-P1	To test the possibility to run the XR System on intranet	
<b>UR-FUNC-0900-P1</b>	Data storage	Local/Offline storage of instruction manuals, videos or other documentation	UN-3500-P1	To test the possibility to access data stored locally	M
<b>UR-FUNC-1000-P1</b>	Data Input/Output	Audio instruction	UN-2400-P1	To test the XR experience for audio-based hints to the user	C
			UN-2400-P1	To test the possibility to add audio files to provide hints in the procedures and help the user to perform the entire process	

<b>UR-NFUN-1100-P1</b>	Wearability	Comfortable and adjustable wearability for all different types of users	UN-1500-P1 UN-1600-P1	To test the possibility to adapt the headset on different users and guarantee a stable wearability	W
<b>UR-FUNC-1200-P1</b>	Instructions language	Opportunity to see instructions in different languages	UN-1200-P1	To test the possibility to experience different languages	C
			UN-1200-P1	To test the possibility to change language in the authoring UI	
<b>UR-NFUN-1310-P1</b>	<b>Operational autonomy</b>	<b>Ensure sufficient operational autonomy for the intended application</b>	<b>UN-2300-P1</b>	<b>To test the possibility to complete the selected training with battery power or to plug the headset if longer sessions are expected</b>	<b>W</b>
<b>UR-FUNC-1410-P1</b>	<b>Compatibility</b>	<b>Able to run also on affordable devices (mid-range XR headsets)</b>	<b>UN-1310-P1</b>	<b>To test the possibility to run the experience on mid-range headsets (Meta Quest 3 - medium price range device)</b>	<b>S</b>
<b>UR-FUNC-1500-P1</b>	Saving steps	Opportunity to continue the process at different times since the last save of the executed operations	UN-2500-P1	To test the possibility to save unfinished XR experience creation	C
<b>UR-FUNC-1600-P1</b>	Quality of virtual elements	Visibility of instructions and virtual elements present in	UN-0710-P1 UN-1700-P1 UN-2000-P1 UN-2200-P1	To test the user's capability to properly recognise	M

		process instructions		contents in the scenes	
			UN-1700-P1 UN-2000-P1 UN-2200-P1	To test the possibility to use high quality XR contents and to properly set the visual quality parameters based on the intended use	
<b>UR-FUNC-1700-P1</b>	Recognizable layout	Identification of an effective element display system and distinctive elements	UN-1700-P1 UN-1800-P1	To test the UI for consistency and recognizability	M
			UN-1700-P1 UN-1800-P1	Not applicable, already tested in UR-FUNC-2400-P1	
<b>UR-FUNC-1800-P1</b>	Spare parts storage	Management of removed and replacement components	UN-3400-P1	To test the availability of a virtual spare parts inventory	C
<b>UR-FUNC-1900-P1</b>	Remote viewing	Desktop preview of the completed exercise	UN-2600-P1	To test the possibility to preview the XR experience on desktop	S
			UN-2600-P1	To test the possibility to preview the created XR experience without wearing the headset	
<b>UR-FUNC-2000-P1</b>	Safety information	Provide the operator safety instruction (i.e. Recommend which PPE should be used for the selected process)	UN-0400-P1 UN-1710-P1	To test the presence of safety-related messages (i.e. forced breaks; PPE; warning on tools, etc.)	S
			UN-2510-P1	To test the possibility to split a complete training in smaller procedures to	

				reduce the duration of the training session	
<b>UR-FUNC-2100-P1</b>	Tools information	Illustration of the equipment needed for the process	UN-0300-P1 UN-2800-P1	To test the presence of tools details to guide in the proper tool selection and in their correct use	S
<b>UR-FUNC-2300-P1</b>	Searching info system	Quick search mode for files and words contained in documents	UN-2100-P1 UN-2910-P1	To test the possibility to use a desktop chatbot to help in the creation of XR content consistent with manual instructions	C
<b>UR-FUNC-2400-P1</b>	Customizable panels	Textures, specific images or background colours to text panels or buttons	UN-1800-P1 UN-1900-P1	Not applicable, already tested in UR-FUNC-1700-P1	M
			UN-1800-P1 UN-1900-P1	To test the possibility to use specific palette colour, icon sets etc. to create the experience in a consistent and recognizable way	
<b>UR-FUNC-2500-P1</b>	Exercise review	Easy review of the steps conducted by the trainee during the exercise	UN-3300-P1	To test the possibility to use the Instructor View in classroom	S
<b>UR-FUNC-2600-P1</b>	Working area	Visualisation of the boundary at the working area	UN-2700-P1	To test the possibility to set the boundaries of the working areas on the headset	C
<b>UR-FUNC-2700-P1</b>	Multi player	The system needs to be used	UN-3000-P1	To test the possibility to	S

		by more than one trainee sharing the same training environment and time		have a multiplayer experience on desktop mode	
<b>UR-FUNC-2800-P1</b>	<b>Quick exit mode</b>	<b>The system needs to provide users with an easy self-termination option so they can exit sessions quickly if discomfort intensifies</b>	<b>UN-1720-P1</b>	<b>To the possibility to exit the XR experience anytime in an easy and unambiguous way</b>	<b>M</b>

TABLE 2: PILOT 1 USER REQUIREMENTS.

## 2.2 PILOT 2 – HOME APPLIANCE INDUSTRY

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The Home Appliance Industry Pilot will be focused on Training activities of technicians and assistance during maintenance operations onsite. Actually, maintenance of whitegoods is performed by trained technicians. Maintenance interventions are typically pre-planned, indeed specific spare parts are ordered in advance, and manuals are consulted by reviewing exactly the procedures relating to the specific product that will be the object of the maintenance.

Onsite troubleshooting and access to technical documentation is essential to correctly perform the task. MOTIVATE XR tools could provide simplification and significant improvement with respect to the access to technical documentation. A simplified scenario will also include the use of MOTIVATE XR tools for direct intervention executed by untrained customers.

### 2.2.1 SCENARIO DESCRIPTION

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The Gorenje company has a strong presence in the European market for home appliances, where it sells a range of household appliances such as washing machines, tumble dryers, ovens, hobs, hoods, refrigerators, freezers, dishwashers, etc. The company in total produces 3.5 million large home appliances per year.

As already outlined, the Home Appliance Pilot focuses on technician training for maintenance operations and on-field support delivered through Augmented Reality solutions primarily accessed via tablets or smartphones. While the use of see-through headsets could represent a potential added value, it is not currently applicable within this use case and is therefore not translated into specific User Needs. The actual procedure for training activities and maintenance tasks has been provided by Gorenje during the in-depth interviews reported in Deliverable D3.3 [1] and synthesised below.

In real maintenance tasks, the technician follows a sort of preparation protocol before actually going to the customer: first of all, the Call for maintenance is checked, and spare parts that are expected to be changed are ordered from the Spare Part List (SPL) where 2D drawings of the part can be consulted. This procedure is usually performed on a tablet, mobile phone or a desktop PC (almost 10 minutes in duration). Once finished, the technician reviews maintenance procedures from the manuals that are relevant for the specific product being maintained. Most of Gorenje's service manuals are provided in soft and hard copy, but are also available on a mobile application and the official website. Two different kinds of manuals are accessible for technicians (using personal credentials) and one for final users with free guest access. In some cases, manuals are also in the form of video, provided through a YouTube (YT) channel with limited access to certified technicians and service managers.

In this Pilot the application of MOTIVATE XR tools should simplify all maintenance procedures. The already existing workflow and materials would be followed, while new features would be added such

as spare parts identification, visualisation, interaction and the fruition of advanced information (such as videos of replacement procedure which includes complex workflows of troubleshooting).

Such an advancement requires not only the integration of the MOTIVATE XR tools, but also the availability of digital assets that are traditionally managed through the existing Spare Parts List (SPL). In industrial practice, the SPL represents a key reference for identifying components, understanding their relationships, and accessing technical information. In this context, XR technologies can support the visualisation of parts and assemblies through interactive 3D representations (e.g. rotation, isolation, exploded views, zooming), provided that such assets are made available by external systems or content preparation workflows.

However, it is important to clarify that the evolution, management, and operational use of the SPL itself (including spare parts ordering, lifecycle management, and transactional processes) are outside the scope of the MOTIVATE XR platform. These activities, as well as the addition of items to the shopping cart, are carried out entirely through existing company systems and are therefore not traced as User Needs within the MOTIVATE XR framework.

The creation of advanced manuals using XR tools is fostered. The tool will help technical support to speed-up/simplify education and or training process of service managers and technicians. At the same time, the tool could also be beneficial for everyday use of service technicians, to update their knowledge (repair, refurbishment). In order to comply with existing and upcoming EU Ecodesign and Right to Repair regulatory frameworks, manufacturers of household appliances are required to ensure that users and repairers have access to clear and adequate product information supporting correct use, maintenance and repair. For certain product categories, such as dishwashers and washing machines, sector-specific Ecodesign regulations [5] already require the availability of user-facing instructions and repair-related information, while the EU Right to Repair Directive [6] further strengthens transparency and access to repair information from 2026 onwards.



FIGURE 3: WASHING MACHINE MAINTENANCE



FIGURE 4: VIDEO GUIDE ON YT PRIVATE LINK

## 2.2.2 USER NEEDS

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The set of User Needs previously collected from Pilot 2 partners was systematically reviewed and refined in close collaboration with them. This revision was informed by a more mature and operational definition of the pilot scenario, including clearer assumptions on the training and maintenance context, the selected XR modality, and the expected user interactions.

Starting from the preliminary User Needs collected in the early phase of the project, the refinement process led to the consolidation, rephrasing, or removal of those needs that, in light of the evolved pilot definition, were no longer fully aligned with expectations of the end users. At the same time, additional User Needs were introduced where gaps were identified or where new requirements emerged as a result of the progressive validation of use cases and training workflows.

The revised and removed User Needs are detailed in the following list. For each change, a specific rationale is provided to clearly justify the evolution from the initial formulation in D3.3 [1] to the updated and consolidated set of User Needs presented in D3.4, ensuring transparency, traceability, and consistency across project phases:

Here below a list of the UNs modified and deleted:

- **UN-0700-P2:** XR System must display procedures in a highly visible way

This UN has been **rephrased** and reformulated to reflect the updated requirements of the end user. In particular, the original intent of the need has been clarified and more precisely expressed in the revised user need *UN-0710-P2 - XR System must present contents in a way that ensures clear visibility and high perceptual quality*, which is highlighted in the table below.

- **UN-0800-P2:** XR System must guide the trainee at times coherent with the exercise (animations speed, screwing speed, etc.)

This UN has been **rephrased** and reformulated to reflect the updated requirements of the end user. In particular, it has been rewritten in a clearer and more explicit manner to specify that the XR experience must accurately reflect the timings and operational methodologies of the real exercise. The revised user need is identified as *UN-0810-P2 - XR System must guide the trainee at times consistent with the exercise* and is highlighted in the table below.

- **UN-1300-P2:** XR System must have a non - prohibitive cost

This UN has been **rephrased** and reformulated to reflect the updated requirements of the end user. In particular, it has been rewritten to provide a more precise reference to the economic sustainability of use, shifting from a generic or estimated cost value to the specification that the XR experience should be accessible through mid-range hardware devices. The revised user need is identified as *UN-1310-P2 - XR System should operate on affordable devices (mid-range XR headsets, tablets, smartphones)* and is highlighted in the table below.

- **UN-2700-P2:** XR System needs to display 3D elements of the spare part list

This User Need has been **removed** following the refinement of the Pilot 2 use case scenario. As clarified during this phase, access to the spare parts list is not required within the XR experience,

as maintenance activities are planned and prepared in advance and the operator is already provided with all the necessary spare parts before the intervention.

Given that the spare parts selection and verification processes are performed upstream of the training or on-field activities, the display of 3D elements of the spare part list within the XR system does not provide additional value for the pilot. Moreover, once the relevant information has been explored within the XR environment, the technician can proceed with the spare parts ordering process through the internal Gorenje ordering system. This activity, including the addition of items to the shopping cart, is carried out entirely outside the MOTIVATE XR platform and tools and therefore falls outside the scope of the project.

For the newly introduced User Needs, a detailed justification is also provided, clearly outlining the motivations and considerations that led to their identification and inclusion in the updated requirements set. These were not included in the first release, as they emerged from further analyses and additional discussions with the Pilot partners, and were also informed by the SEL analysis performed within Task 3.1.

Here following a list of new UNs:

- **UN-1710-P2:** XR System must prevent overexposure

This UN has been **introduced** to address one of the “quick wins” mitigation measures identified within the SEL analysis carried out in Task T3.1, specifically the recommendation to limit session durations and reduce the risk of user overexposure. In particular, it highlights the need to avoid excessively prolonged XR sessions, which could negatively affect user comfort and overall user experience. The inclusion of this user need aims to ensure that XR usage actively supports overexposure prevention with relatively low effort solutions such as automated break prompts for the experiencing users.

- **UN-1720-P2:** XR System must allow to finish the XR session at any time through an easily accessible and unambiguous action

This UN has been **introduced** to address one of the “quick wins” mitigation measures identified within the SEL analysis carried out in Task T3.1, specifically the recommendation to monitor users for signs of discomfort (e.g., dizziness, nausea, irregular movements) and to allow or trigger session termination when necessary. Since the implementation of automated solutions for detecting user discomfort falls outside the scope of the project, this requirement focuses on ensuring that users remain in full control of the XR experience and can independently decide to terminate the session whenever increasing discomfort is perceived. In this context, the User Need emphasises the importance of providing a clearly identifiable and always accessible “exit” or “end session” action, enabling a safe, intuitive, and stress-free interruption of the ongoing XR experience.

- **UN-3010-P2:** XR System must allow the segmentation of procedures to create short duration session

This User Need has been **introduced** to address one of the “quick wins” mitigation measures identified within the SEL analysis carried out in Task T3.1, specifically the recommendation to limit session durations and reduce the risk of user overexposure. In this context, allowing the segmentation of training procedures into shorter sessions represents a practical and effective way to operationalise such mitigation measures within the XR training environment.

By enabling content creators to divide complex procedures into shorter, self-contained segments, the system supports the definition of task-specific maximum durations and the introduction of checkpoint-based breaks between sessions. This approach facilitates safer and more manageable training experiences, while preserving the overall instructional coherence of the procedure.

- **UN-3100-P2:** XR System must provide a repository for already available XR assets

This UN has been **introduced** to support the XR scene creation process by ensuring the availability of assets already accessible to the user at the authoring stage. In particular, it highlights the need for a repository where XR assets are preloaded, stored, and ready for use, allowing the user to quickly select and integrate existing assets into XR scenes that will subsequently be experienced by the operator.

- **UN-3200-P2:** XR System must allow the possibility to a seamless creation of new XR assets

This UN has been **introduced** to support the XR content creation workflow by ensuring that new XR assets created ad hoc can be easily hosted within the system repository. In particular, it highlights the need for a repository that can accommodate newly created assets and enable their smooth integration into XR scenes during the authoring phase, ensuring continuity and efficiency in the overall content preparation process.

- **UN-3300-P2:** XR System should allow an agile update or upgrade of XR experience for multi-language purposes

This User Need has been **introduced** to address the requirement of supporting multilingual training and operational content with reduced effort. In particular, it responds to the need to create and maintain manuals and instructional content in multiple languages without requiring extensive reworking of the XR experience.

By enabling agile updates or upgrades of language-dependent elements, the XR system can facilitate the efficient adaptation of existing content to different linguistic contexts, improving scalability and reducing time and cost associated with content localisation. The introduction of this User Need therefore supports broader accessibility of the XR experience and aligns with the practical needs of pilots operating in multilingual environments.

- **UN-3400-P2:** XR System should allow the repeat/replay function

This User Need has been **introduced** to support the effective use of AR content during both training activities and on-site support scenarios. In particular, it enhances flexibility and usability of the XR experience, ensuring that content can be consumed iteratively and on

demand depending on individual learning pace or operational needs, in alignment with real operational workflows of Pilot 2.

The changes described above, together with the updated list of User Needs, are reported below. The table highlights the User Needs that have been newly introduced as well as those resulting from the rephrasing of previously identified ones. In addition, it explicitly shows the relationship between each User Need and the type of user primarily involved, distinguishing between authoring users, experiencing users, or both.

UN ID	USER NEEDS	AUTHORING	EXPERIENCING
UN-0100-P2	XR System must enable the transmission of basic knowledge about the machines models		X
UN-0200-P2	XR System must be able to suggest the intervention points for maintenance operations		X
UN-0300-P2	XR System must guide the operator to use the necessary tools		X
UN-0400-P2	XR System must provide guidance on required PPE		X
UN-0500-P2	XR System must be able to allow request for support from an experienced operator	X	X
UN-0600-P2	XR System must show the steps of the process operations step by step	X	X
UN-0710-P2	<b>XR System must present contents in a way that ensures clear visibility and high perceptual quality</b>		X
UN-0810-P2	<b>XR System must guide the user at times consistent with process steps</b>		X
UN-0900-P2	XR System must show the correct ways to handle the tools needed for the operation		X
UN-1000-P2	XR System must provide access with credentials	X	X
UN-1100-P2	XR System must be able to provide offline access to view manuals and/or video useful to the process	X	X
UN-1200-P2	XR System must be able to provide the guidance in different languages	X	X
UN 1310-P2	<b>XR System should operate on affordable devices (mid-range XR headsets, tablets, smartphones)</b>		X
UN-1400-P2	XR System must allow the user to be able to run an entire process without restricting the user's hands		X
UN-1500-P2	XR System must allow stable and secure wearability		X
UN-1600-P2	XR System must allow adaptable wearability for different users		X

UN-1700-P2	XR System must offer a comfortable user experience	X	X
UN-1710-P2	<b>XR System must prevent overexposure</b>		X
UN-1720-P2	<b>XR System must allow to finish the XR session at any time through an easily accessible and unambiguous action</b>		X
UN-1800-P2	XR System must have a distinctive layout	X	X
UN-1900-P2	XR System must have a clear and defined layout	X	X
UN-2000-P2	XR System must allow for well-defined element visibility	X	X
UN-2100-P2	XR System must make searching for information on the manual intuitive, quick and accurate	X	X
UN-2200-P2	XR System must enable well-defined visibility of elements in indoor environment	X	X
UN-2300-P2	XR System must provide a runtime of at least 2 hours	X	X
UN-2400-P2	XR System must be able to provide audio indications		X
UN-2500-P2	XR System must be able to show product codes		X
UN-2600-P2	XR System must provide the operator the safety conditions		X
UN-2800-P2	XR System must have a stable internet connection	X	X
UN-2900-P2	XR System must be able to manage the display of elements in "exploded" mode		X
UN-3000-P2	XR System must allow saving of executed interventions	X	
UN-3010-P2	<b>XR System must allow the segmentation of procedures to create short duration session</b>	X	
UN-3100-P2	<b>XR System must provide a repository for already available XR assets</b>	X	
UN-3200-P2	<b>XR System must allow the possibility to a seamless creation of new XR assets</b>	X	
UN-3300-P2	<b>XR System should allow an agile update or upgrade of XR experience for multi language purposes</b>	X	
UN-3400-P2	<b>XR System should allow the repeat/replay function</b>		X

TABLE 3: PILOT2 USER NEEDS.

### 2.2.3 USER REQUIREMENTS

Following the update and consolidation of the User Needs presented in the previous section, the corresponding set of User Requirements has been systematically reviewed and realigned to ensure full consistency between the updated User Needs and functional and non-functional User Requirements derived from them.

In particular, the refinement of User Requirements has been conducted to appropriately reflect the specific perspective, responsibilities, and interaction patterns of the user persona from which the associated User Need originates (e.g. authoring users versus experiencing users).

The resulting set of User Requirements thus provides a clearer, more structured, and persona-aware foundation for subsequent Functional Specifications refinement foreseen in task *Task 3.3 Functional Specification and Cybersecure Architecture*.

Here below a list of the URs reviewed or deleted:

- **UR-NFUN-1300-P2:** Battery

This UR has been **rephrased** and reformulated as *UR-NFUN-1310-P2 – Operational autonomy*, to provide a clearer definition of device battery autonomy management, in alignment with the XR experiences foreseen within the pilot scenario. The revision ensures that battery-related constraints are explicitly considered in relation to the expected duration and usage patterns of the XR sessions.

- **UR-NFUN-1400-P2:** Price

This UR has been **rephrased** and reformulated as *UR-NFUN-1410-P2 – Compatibility*, in alignment with the updates introduced in the related User Needs. The revision provides a clearer and more consistent linkage between this requirement and the need to enable the fruition of XR experiences on mid-range devices, ensuring that the overall solution remains economically accessible and non-prohibitive for the end user.

- **UR-FUNC-1800-P2:** Spare parts storage

This UR has been **deleted** to maintain consistency with the deletion of the corresponding User Need (UN-2700-P2). As clarified during the refinement of the Pilot 2 use case scenario, spare parts management activities such as selection, verification, ordering, and storage are performed outside the XR environment and are handled through the internal Gorenje systems, not the MOTIVATE XR platform. For these reasons, this UR was deemed no longer relevant to the pilot scenario, as further detailed in the corresponding justification section.

- **UR-FUNC-2200-P2:** Gesture Controls

This UR has been **deleted** to maintain consistency with the selection of tablets and smartphones as selected devices to experience the training and the on-site support.

- **UR-FUNC-2600-P2:** Voice recognition

This UR has been **rephrased** and reformulated as *UR-NFUN-2610-P2 – Remote Call* in alignment with clarifications provided by Pilot 2 partners in the related User Needs. The revised formulation

establishes a clearer and more consistent link to the requirement of enabling communication with an experienced technician during on-site maintenance activities in the event of unforeseen issues that may prevent the completion of the task, rather than to the previously misinterpreted functionality related to voice command recognition for scene navigation. The inclusion of this requirement ensures that the system offers a quick, easily accessible, and unambiguous way to contact an expert whenever necessary.

The newly introduced User Requirements are listed below:

- **UR-FUNC-0410-P2:** XR predefined assets

This UR has been **introduced** to align the traced User Needs with concrete implementation strategies, specifically addressing the definition of a repository of predefined XR assets. The inclusion of this requirement supports the implementation of a structured assets repository capable of effectively responding to the identified user needs and facilitating the preparation of XR scenes during the authoring phase.

- **UR-FUNC-0420-P2:** XR assets creation

This UR has been **introduced** to trace the user needs related to the creation of new XR assets, ensuring that such assets can be developed and subsequently integrated into a shared repository. The inclusion of this requirement supports the definition of implementation strategies that enable the availability, management, and reuse of newly created assets within the common XR asset repository.

- **UR-FUNC-2700-P2:** Quick exit mode

This UR has been **introduced** to align with the newly added User Needs related to the ability to easily quit the XR experience at any time. The inclusion of this requirement ensures that the system provides a quick, easily accessible and unambiguous exit mechanism, allowing users to safely leave the XR experience whenever needed.

Following the updates introduced with respect to the first release of the User Requirements list, the revised table is presented below. It reports the updated User Requirements together with their associated verification methods, which are essential for validating the correct implementation of the requested functionalities. The Table 4 also distinguishes the User Requirements according to the type of user involved in the verification process, differentiating between experiencing users and authoring users.

UR ID	UR NAME	DESCRIPTION	UN REF	VERIFICATION METHOD	PRIORITY
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<b>UR-FUNC-0100-P2</b>	XR process	Guided visualization of the process steps	UN-0200-P2 UN-0300-P2 UN-0600-P2 UN-0900-P2	To test the created maintenance procedure for visual guidance and highlights of intervention points	M
			UN-0300-P2 UN-0600-P2	To be verified by testing the creation of detailed process steps	
<b>UR-FUNC-0200-P2</b>	XR textual information	Virtual spaces containing useful written details	UN-0100-P2 UN-0600-P2 UN-2500-P2	To test the possibility to read contents in the scene of the created exercise	M
			UN-0600-P2	To test the possibility to create textual contents	
<b>UR-FUNC-0300-P2</b>	3D models	Visualisation of 3D elements useful for the exercise fruition	UN-2000-P2 UN-2900-P2	To test the presence of 3D contents in the scene of the created exercise	M
			UN-2000-P2 UN-2900-P2	To test the possibility to insert 3D contents	
<b>UR-FUNC-0400-P2</b>	2D/3D animations	Guided process through the presence of virtual elements	UN-0200-P2 UN-0600-P2 UN-0810-P2 UN-0900-P2	To test the proper run of animations in the created maintenance procedure	M
			UN-0600-P2	To test the possibility to create 2D/3D animations	
<b>UR-FUNC-0410-P2</b>	<b>XR predefined assets</b>	<b>Repository with a predefined set of XR assets already available for authoring</b>	<b>UN-3100-P2</b>	<b>To test the possibility to use 2D/3D assets already available in a</b>	<b>M</b>

				<b>common repository</b>	
<b>UR-FUNC-0420-P2</b>	<b>XR assets creation</b>	<b>Intuitive creation of new XR assets</b>	<b>UN-3200-P2</b>	<b>To test the possibility to create and save XR assets in a common repository</b>	<b>M</b>
<b>UR-NFUN-0500-P2</b>	Easy to use	The system needs to be usable by non-experts	UN-1200-P2 UN-1700-P2 UN-1720-P2 UN-1900-P2 UN-2100-P2 UN-3100-P2 UN-3200-P2 UN-3300-P2 UN-3400-P2	To be verified by usability test foreseen in WP7	W
			UN-1200-P2 UN-1700-P2 UN-1900-P2 UN-2100-P2 UN-3100-P2 UN-3200-P2 UN-3300-P2	To be verified by usability test foreseen in WP7	
<b>UR-FUNC-0600-P2</b>	Back/Forward instructions	Process step execution flow aligned with actual operator progress	UN-0600-P2 UN-0810-P2 UN-1900-P2 UN-3000-P2 UN-3010-P2 UN-3400-P2	To test the possibility to move back and forward between scenes	M
			UN-0600-P2 UN-1900-P2 UN-3000-P2 UN-3010-P2 UN-3400-P2	To test the possibility to implement back and forward action buttons to allow the user to move among scenes	
<b>UR-FUNC-0700-P2</b>	Homepage	Possibility to return to homepage at any time	UN-1700-P2 UN-1900-P2	To test the possibility to jump to the homepage anytime	M
			UN-1700-P2 UN-1900-P2	To test the possibility to implement the homepage link button in every scene	

<b>UR-FUNC-0800-P2</b>	Wi-fi connection	XR device networking	UN-0500-P2 UN-2800-P2	To test the possibility to run the experience smoothly and to have a remote assistant call	M
			UN-0500-P2 UN-2800-P2	To test the possibility to access and create smoothly a new maintenance experience	
<b>UR-FUNC-0900-P2</b>	Data storage	Local/Offline storage of instruction manuals, videos or other documentation (flag)	UN-0100-P2 UN-1100-P2	To test the possibility to run a video or read a PDF within the maintenance process	M
			UN-0100-P2 UN-1100-P2 UN-3100-P2 UN-3300-P2	To test the possibility to access data stored locally and load them as assets	
<b>UR-FUNC-1000-P2</b>	Data Input/Output	Audio instruction and remote interaction with experienced users (through audio, images, video streaming)	UN-0500-P2 UN-2400-P2	To test the XR experience for audio-based hints to the user	M
			UN-0500-P2	To test the possibility to add audio files to provide hints in the procedures and help the user to perform the entire process, to test the possibility to add a Remote Call action in every scene	
<b>UR-NFUN-1100-P2</b>	Wearability	Comfortable and adjustable wearability for all different types of users	UN-1500-P2 UN-1600-P2	To test the possibility to adapt the headset on different users and guarantee a	W

				stable wearability	
<b>UR-FUNC-1200-P2</b>	Instructions language	Opportunity to see instructions in different languages	UN-1200-P2	To test if icons/functionalities languages are coherent with the XR maintenance procedure language	C
			UN-1200-P2 UN-3300-P2	To test the possibility to select the language of the UI among those available	
<b>UR-NFUN-1310-P2</b>	<b>Operational autonomy</b>	<b>Ensure sufficient operational autonomy for the intended application</b>	<b>UN-2300-P2</b>	<b>To test the possibility to complete the selected XR experience with battery power or to plug the device if longer sessions are expected</b>	<b>W</b>
<b>UR-FUNC-1410-P2</b>	<b>Compatibility</b>	<b>Able to run also on affordable devices (mid-range XR headsets)</b>	<b>UN-1310-P2</b>	<b>To test the possibility to run the experience on mid-range devices (Meta Quest 3 or Youbiquo headset, tablets, smartphones)</b>	<b>W</b>
<b>UR-FUNC-1500-P2</b>	Saving steps	Opportunity to continue the process at different times since the last save of the executed operations	UN-3000-P2	To test the possibility to save unfinished XR experience creation	S
<b>UR-FUNC-1600-P2</b>	Quality of virtual elements	Visibility of instructions and virtual elements present in	UN-0710-P2 UN-1700-P2 UN-2000-P2 UN-2200-P2	To test the user's capability to properly recognize	M

		process instructions		contents in the scenes	
			UN-1700-P2 UN-2000-P2 UN-2200-P2	To test the possibility to use high quality XR contents and to properly set the visual quality parameters based on the intended use	
<b>UR-FUNC-1700-P2</b>	Recognizable layout	Identification of an effective element display system and distinctive elements	UN-1700-P2 UN-1800-P2	To test the UI for consistency and recognizability	M
			UN-1700-P2 UN-1800-P2	Not applicable, already tested in UR-FUNC-2400-P2	
<b>UR-FUNC-1900-P2</b>	See-through system	AR visualisation of virtual elements in the scene	UN-0200-P2 UN-1400-P2 UN-2200-P2 UN-2600-P2	To be tested by visualising virtual elements in the XR experience	M
			UN-2200-P2	To be verified by testing the possibility to set visualisation features of virtual elements according to the intended use	
<b>UR-FUNC-2000-P2</b>	Safety information	Provide the operator safety instruction (i.e. Recommend which PPE should be used for the selected process)	UN-0400-P2 UN-1710-P2 UN-2500-P2 UN-2600-P2	To test the presence of safety-related messages (i.e. force breaks; PPE; warning on tools, etc.)	M
			UN-3010-P2	To test the possibility to split a long maintenance procedure in micro-steps to reduce the duration of each and avoid	

				discomfort and overexposure	
<b>UR-FUNC-2100-P2</b>	Tools information	Illustration of the equipment needed for the process	UN-0300-P2 UN-0900-P2	To test the presence in the XR maintenance procedure of hints to select the proper tool or to use it correctly	C
<b>UR-FUNC-2300-P2</b>	Searching info system	Quick search mode for files and words contained in documents	UN-2100-P2	To test the possibility to easily search among assets	C
<b>UR-FUNC-2400-P2</b>	Customizable panels	Textures, specific images or background colours to text panels or buttons	UN-1800-P2 UN-1900-P2	Not applicable, already tested in UR-FUNC-1700-P2	S
			UN-1800-P2 UN-1900-P2	To test the possibility to use specific palette colour, icon sets etc. to create the experience in a recognizable way	
<b>UR-FUNC-2500-P2</b>	Login/Logout	Credential access	UN-1000-P2	To be verified by testing a login	M
			UN-1000-P2	To be verified by testing a login and the access to private repositories and contents	
<b>UR-FUNC-2610-P2</b>	Remote call	Remote call with an expert	UN-0500-P2	To test the possibility to call remotely an experienced operator	M
			UN-0500-P2	To test the possibility to	

				<b>add a remote call action</b>	
<b>UR-FUNC-2700-P2</b>	<b>Quick exit mode</b>	<b>The system needs to provide users with an easy self-termination option so they can exit sessions quickly if discomfort intensifies</b>	<b>UN-1720-P2</b>	<b>To test the possibility to exit the XR experience anytime in an easy and recognisable way</b>	<b>M</b>

TABLE 4: PILOT 2 USER REQUIREMENTS.

## 2.3 PILOT 3 – ALUMINUM INDUSTRY

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The Aluminium Industry Pilot will be focused on Training activities and simulated onsite assistance. Architectural Aluminium Academy typically provides different levels of training, guidance and remote support. Training is usually performed through classroom sessions, practical hands-on workshops, and demonstrations by experienced trainers within the Academy. Simulated onsite assistance is performed through assembly guidance that includes access to step-by-step instructions and remote support from supervisors or senior technicians of the Academy. MOTIVATE XR tools could be used in order to simplify training activities, but also while performing simulated onsite assembling to improve access to technical documentation.

### 2.3.1 SCENARIO DESCRIPTION

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Architectural Aluminium Academy(AAA) is an Innovation and Skills Development Centre in the sector of Architectural Aluminium Systems, with premises in Athens and Thessaloniki. It was created on the initiative of ALUMIL and the partnership with two of the greatest universities in the country (Aristotle University of Thessaloniki & University of Macedonia). AAA fosters the advancement of the construction industry by prioritizing the continual training and development of its professionals, using XR technologies.

AAA training activities are performed using traditional methods as detailed hereafter.

- Training is conducted through classroom sessions, practical hands-on workshops, and demonstrations by experienced trainers. The training sessions cover various aspects of aluminium architecture, including material handling, cutting, assembly, and installation techniques. This process is typically time-consuming and requires the involvement of a specific number of participants to ensure that everyone can follow the session and become proficient in hands-on tasks. In some cases, training can also be conducted in the factory.
- Assembly Guidance refers to the support required after training and during the assembly process. Fabricators and technicians rely on detailed manuals and printed guides that provide step-by-step instructions for various tasks. During assembly, fabricators often require remote support from supervisors or senior technicians of the Academy.
- Remote Support is provided via phone calls and video conferencing tools. Expert fabricators guide the on-site personnel through various tasks by sharing screens and providing verbal instructions.



FIGURE 5: TYPICAL TRAINING SESSION.



FIGURE 6: ASSEMBLING PROCEDURE.

The working environment at the Architectural Aluminium Academy includes wide areas equipped with all necessary tools and machinery for handling, cutting, assembling, and installing aluminium structures. Workstations are organised to facilitate efficient workflow and safety. There are also storage areas with designated zones for storing raw materials, tools, and finished products, managed through inventory systems to ensure proper organisation and access.

Within the academy there are also dedicated spaces for classroom training sessions, equipped with projectors, whiteboards, and seating arrangements for trainees.

### 2.3.2 USER NEEDS

Within this activity, all User Needs previously collected from the Pilot partners were analysed and jointly reviewed with them after a more in-depth definition of the pilot scenario. Building on the User Needs already identified in the first release, this process led to the integration, refinement, or removal of those needs that, for various reasons, were not fully aligned with the actual expectations and requirements of the end users.

The User Needs that have been revised or removed, as outlined, are listed below. For each change, the underlying rationale is also provided to clearly explain the motivations behind the revision or deletion.

Here following a list of the UNs modified and removed:

- **UN-0700-P3:** XR System must display procedures in a highly visible way

This UN has been **rephrased** and reformulated to reflect the updated requirements of the end user. In particular, the original intent of the need has been clarified and more precisely expressed in the revised user need *UN-0710-P3 - XR System must present contents in a way that ensures clear visibility and high perceptual quality*, which is highlighted in the table below.

- **UN-0800-P3:** XR System must guide the trainee at times coherent with the exercise (animations speed, screwing speed, etc.)

This UN has been **rephrased** and reformulated to reflect the updated requirements of the end user. In particular, it has been rewritten in a clearer and more explicit way to specify that the XR experience must accurately reflect the timings and operational methodologies of the real exercise. The revised user need is identified as *UN-0810-P3 - XR System must guide the trainee at times consistent with the exercise* and is highlighted in the table below.

- **UN-1300-P3:** XR System must have a non-prohibitive cost

This UN has been **rephrased** and reformulated to reflect the updated requirements of the end user. In particular, it has been rewritten to provide a more precise reference to the economic sustainability of use, shifting from a generic or estimated cost value to the specification that the XR experience should be accessible through mid-range hardware devices. The revised user need is identified as *UN-1310-P3 - XR System should operate on affordable devices (mid-range XR headsets)*, and is highlighted in the table below.

- **UN-2300-P3:** XR System must provide a runtime of at least 1 hour

This UN has been **rephrased** to explicitly include an estimated runtime of at least one hour. The revision was introduced based on the results of the beta release testing, which demonstrated that a duration of one hour is sufficient to complete the exercise while also helping to prevent user overexposure. The updated formulation therefore ensures an appropriate balance between operational effectiveness and user comfort within the pilot scenario.

- **UN-2700-P3:** XR System must allow the identification of a safety work area

This UN has been **removed** following the finalisation of the Pilot 3 use case definition and the selection of HoloLens 2 as the XR headset. With the consolidation of the see-through AR approach, it became clear that the identification and enforcement of virtual safety work area boundaries are not required within this pilot context. In the selected configuration, users maintain full awareness of the real environment while interacting with digital content, and the operational setup does not introduce conditions that would require the definition of virtual safety zones. As a result, implementing specific functionalities for identifying a safety work area would not provide additional value for the pilot activities.

- **UN-2900-P3:** XR System must make searching for information in the manual intuitive, quick and accurate

This UN has been **rephrased** to better reflect the technical characteristics and limitations of AI-based information retrieval mechanisms. The updated wording adopts the term “*sufficiently precise*” to more realistically describe the expected performance of AI-based systems. The

revised user need is identified as *UN-2910-P3 - XR System must make searching for information in the manual intuitive, quick and sufficiently precise* and is highlighted in the table below.

In addition, a set of new User Needs is reported below. These were not included in the first release, as they emerged from further analyses and additional discussions with the Pilot partners, and were also informed by the key SEL objectives examined within Task 3.1.

Here below a list of new UNs:

- **UN-1710-P3:** XR System must prevent overexposure

This UN has been **introduced** to address one of the “quick wins” mitigation measures identified within the SEL analysis carried out in Task T3.1, specifically the recommendation to limit session durations and reduce the risk of user overexposure. In particular, it highlights the need to avoid excessively prolonged XR sessions, which could negatively affect user comfort and overall user experience. The inclusion of this user need aims to ensure that XR usage actively supports overexposure prevention with relatively low effort solutions such as automated break prompts for the experiencing users.

- **UN-1720-P3:** XR System must allow to finish the XR session at any time through an easily accessible and unambiguous action

This UN has been **introduced** to address one of the “quick wins” mitigation measures identified within the SEL analysis carried out in Task T3.1, specifically the recommendation to monitor users for signs of discomfort (e.g., dizziness, nausea, irregular movements) and to allow or trigger session termination when necessary. Since the implementation of automated solutions for detecting user discomfort falls outside the scope of the project, this requirement focuses on ensuring that users remain in full control of the XR experience and can independently decide to terminate the session whenever increasing discomfort is perceived. In this context, the User Need emphasises the importance of providing a clearly identifiable and always accessible “exit” or “end session” action, enabling a safe, intuitive, and stress-free interruption of the ongoing XR experience.

In this context, the User Need emphasises the importance of providing a clearly identifiable and always accessible “exit” or “end session” action, enabling a safe, intuitive, and stress-free interruption of the ongoing XR experience.

- **UN-2510-P3:** XR System must allow the segmentation of procedures to create short duration session

This UN has been **introduced** to address one of the “quick wins” mitigation measures identified within the SEL analysis carried out in Task T3.1, specifically the recommendation to limit session durations and reduce the risk of user overexposure. In this context, allowing the segmentation of training procedures into shorter sessions represents a practical and effective way to operationalise such mitigation measures within the XR training environment. By enabling content creators to divide complex procedures into shorter, self-contained segments, the system supports the definition of task-specific maximum durations and the introduction of

checkpoint-based breaks between sessions. This approach facilitates safer and more manageable training experiences, while preserving the overall instructional coherence of the procedure.

- **UN-3000-P3:** XR System must guarantee an easy creation/modification of the scenario

This UN has been **introduced** to address the necessity of simplifying and streamlining the creation and modification of XR scenarios. By minimising the effort required to modify existing scenarios or create new ones, the XR system can better support content creators and reduce the time and resources needed to maintain and update XR experiences. The introduction of this User Need therefore aims to enhance flexibility, scalability, and sustainability of the XR content creation process

- **UN-3100-P3:** XR System must have a progress indication of the scenario

This UN has been **introduced** to enhance the overall user experience by providing clear and continuous feedback. Providing information related to the training progress helps reduce the sense of uncertainty or overwhelm that may arise when users are not aware of the expected length of the XR experience. By offering clear progress cues, the system supports better cognitive orientation, increases user confidence, and contributes to a more comfortable and manageable training experience.

- **UN-3200-P3:** XR System must support voice commands for basic functions (Play/Stop, Next/Previous)

This UN has been **introduced** to enhance usability and improve the overall user experience during XR sessions. Enabling voice commands for basic control functions, such as play, stop, and step navigation, allows users to interact with the system in a more natural and intuitive manner, reducing reliance on manual controls or complex interaction gestures, which have proven to be challenging for the group of trainees involved in the Beta Release testing.

- **UN-3300-P3:** XR System can reset the position of the elements to their starting position

This UN has been **introduced** to support the user's need to return specific virtual elements to their initial position within defined XR scenes. This capability is essential to allow users to repeat or correctly perform the operations integrated into the XR-based manual, ensuring accuracy, consistency, and effective task execution during the experience.

- **UN-3400-P3:** XR System should allow the repeat/replay function

This User Need has been **introduced** to support the effective use of AR content during training activities. In particular, it enhances the flexibility and usability of the XR experience, ensuring that content can be consumed iteratively and on demand depending on individual learning pace or operational needs, in alignment with real operational workflows of Pilot 3.

- **UN-3500-P3:** XR System must allow multiple selection of objects for further editing

This UN has been **introduced** to enhance the authoring workflow of the XR experience, as the pilot identified the need to select and manage multiple objects simultaneously within a scene.

During the authoring phase, several elements may require the same type of modification. Allowing multi-object selection enables these changes to be applied consistently and efficiently across all selected elements, reducing repetitive actions, minimising errors, and improving overall efficiency and coherence in the preparation of XR content.

- **UN-3600-P3:** XR System must provide a repository for already available XR assets

This UN has been **introduced** to support the XR scene creation process by ensuring the availability of assets already accessible to the user at the authoring stage. In particular, it highlights the need for a repository where XR assets are preloaded, stored, and ready for use, allowing the user to quickly select and integrate existing assets into XR scenes that will subsequently be experienced by the operator.

- **UN-3700-P3:** XR System must allow the possibility of a seamless creation of new XR assets

This UN has been **introduced** to support the XR content creation workflow by ensuring that new XR assets created ad hoc can be easily hosted within the system repository. In particular, it highlights the need for a repository that can accommodate newly created assets and enable their smooth integration into XR scenes during the authoring phase, ensuring continuity and efficiency in the overall content preparation process.

- **UN-3800-P3:** XR system should guarantee an easy desktop preview of the built exercise

This UN has been **introduced** to support a more efficient and iterative authoring workflow. In particular, it addresses the need to accelerate the creation and validation of XR training content by enabling authors to preview and test exercises directly from a desktop environment. The availability of a desktop preview allows content creators to immediately assess how authoring decisions are translated into the experiencing phase, without the need to deploy the exercise on the XR device for each iteration.

The changes described above, together with the updated list of User Needs, are reported below. The table highlights the User Needs that have been newly introduced as well as those resulting from the rephrasing of previously identified ones. In addition, it explicitly shows the relationship between each User Need and the type of user primarily involved, distinguishing between authoring users, experiencing users, or both.

UN ID	USER NEEDS	AUTHORING	EXPERIENCING
<b>UN-0100-P3</b>	XR System must enable the transmission of basic knowledge about the material Aluminium		X
<b>UN-0200-P3</b>	XR System must be able to suggest the gripping points of Aluminium modules		X
<b>UN-0300-P3</b>	XR System must provide guidance on required PPE		X

<b>UN-0400-P3</b>	XR System must provide guidance on the equipment to be used in the training course	X	X
<b>UN-0500-P3</b>	XR System must be able to allow request for support from an experienced operator	X	X
<b>UN-0600-P3</b>	XR System must show the steps of the process operations step by step		X
<b>UN 0710-P3</b>	<b>XR System must present contents in a way that ensures clear visibility and high perceptual quality</b>		X
<b>UN-0810-P3</b>	<b>XR System must guide the trainee at times consistent with the exercise</b>		X
<b>UN-0900-P3</b>	XR System must show the correct ways to handle the tools needed for assembly		X
<b>UN-1000-P3</b>	XR System must show the correct ways to perform assembly operations		X
<b>UN-1100-P3</b>	XR System must be able to provide access to view manuals and/or other documentation useful to the process	X	X
<b>UN-1200-P3</b>	XR System must be able to provide the guidance in different languages	X	X
<b>UN 1310-P3</b>	<b>XR System should operate on affordable devices (mid-range XR headsets)</b>		X
<b>UN-1400-P3</b>	XR System must allow the user to be able to run an entire process without restricting the user's hands		X
<b>UN-1500-P3</b>	XR System must allow stable and secure wearability		X
<b>UN-1600-P3</b>	XR System must allow adaptable wearability for different users		X
<b>UN-1700-P3</b>	XR System must offer a comfortable user experience	X	X
<b>UN-1710-P3</b>	<b>XR System must prevent user overexposure</b>		X
<b>UN-1720-P3</b>	<b>XR System must allow to finish the XR session at any time through an easily accessible and unambiguous action</b>		X
<b>UN-1800-P3</b>	XR System must have a distinctive layout	X	X
<b>UN-1900-P3</b>	XR System must have a clear and defined layout	X	X
<b>UN-2000-P3</b>	XR System must allow for well-defined element visibility	X	X
<b>UN-2100-P3</b>	XR System must have a stable internet connection	X	X
<b>UN-2200-P3</b>	XR System must enable well-defined visibility of elements in indoor environment	X	X
<b>UN-2300-P3</b>	XR System must provide a runtime of at least <b>1 hour</b>		X

<b>UN-2400-P3</b>	XR System must be able to provide audio indications	X	X
<b>UN-2500-P3</b>	XR System must allow saving of executed steps and steps not yet executed	X	
<b>UN-2510-P3</b>	<b>XR System must allow the segmentation of procedures to create short duration session</b>	X	
<b>UN-2600-P3</b>	XR System must be able to track elements on the workstation		X
<b>UN-2800-P3</b>	XR System must provide feedback on the use of correct tools	X	X
<b>UN-2910-P3</b>	<b>XR System must make searching for information on the manual intuitive, quick and sufficiently precise</b>	X	
<b>UN-3000-P3</b>	<b>XR System must guarantee an easy creation/modification of the scenario</b>	X	
<b>UN-3100-P3</b>	<b>XR System must have a progress indication of the scenario</b>	X	X
<b>UN-3200-P3</b>	<b>XR System must support voice commands for basic functions (Play/Stop, Next/Previous)</b>		X
<b>UN-3300-P3</b>	<b>XR System can reset the position of the elements to their starting position</b>		X
<b>UN-3400-P3</b>	<b>XR System should allow the repeat/replay function</b>		X
<b>UN-3500-P3</b>	<b>XR System must allow multiple selection of objects for further editing</b>	X	
<b>UN-3600-P3</b>	<b>XR System must provide a repository for already available XR assets</b>	X	
<b>UN-3700-P3</b>	<b>XR System must allow the possibility to a seamless creation of new XR assets</b>	X	
<b>UN-3800-P3</b>	<b>XR system should guarantee an easy desktop preview of the built exercise</b>	X	

TABLE 5: PILOT 3 USER NEEDS.

### 2.3.3 USER REQUIREMENTS

Based on the revisions carried out jointly with the Pilot partners on the User Needs, which were updated to reflect the requirements expressed by the end users, the entire list of User Requirements was also reviewed. This step was necessary to realign each User Requirement with the updated User Needs following the modifications and additions introduced. The changes applied to the User Requirements list are therefore reported below, together with the rationale that led to the revision of the set originally defined in the first release of the deliverable.

Here following, a list of removed and modified URs is reported:

- **UR-NFUN-1300-P3:** Battery

This UR has been **rephrased** and reformulated as *UR-NFUN-1310-P3 - Operational autonomy*, to provide a clearer definition of device battery autonomy management, in alignment with the training or maintenance experiences foreseen within the pilot scenario. The revision ensures that battery-related constraints are explicitly considered in relation to the expected duration and usage patterns of the XR sessions.

- **UR-NFUN-1400-P3:** Price

This UR has been **rephrased** and reformulated as *UR-NFUN-1410-P3 - Compatibility*, in alignment with the updates introduced in the related User Needs. The revision provides a clearer and more consistent linkage between this requirement and the need to enable the fruition of XR experiences on mid-range devices, ensuring that the overall solution remains economically accessible and non-prohibitive for the end user.

- **UR-NFUN-2200-P3:** Working area

This UR has been **removed** following the removal of the related User Need (UN-2700-P3). Based on the final definition of the Pilot 3 use case and the selected see-through AR setup, the implementation of functionalities related to virtual safety work area boundaries was not considered necessary and would not provide additional value within this pilot context.

- **UR-FUNC-2600-P5:** Voice recognition

This UR has been **rephrased** and reformulated as *UR-FUNC-2610-P3 - Voice interaction*, to better reflect the need more clearly and in greater detail as identified by the Pilot. The updated formulation focuses on the use of voice commands to control selected experience-related functions (e.g. play, stop, navigation), enabling easier and more intuitive interaction with the XR experience across different scenes and reducing reliance on manual controls during operation.

Here following a list of the newly added User Requirements:

- **UR-FUNC-0410-P3:** XR predefined assets

This UR has been **introduced** to align the traced User Needs with concrete implementation strategies, specifically addressing the definition of a repository of predefined XR assets. The inclusion of this requirement supports the implementation of a structured asset repository capable of effectively responding to the identified user needs and facilitating the preparation of XR scenes during the authoring phase.

- **UR-FUNC-0420-P3:** XR assets creation

This UR has been **introduced** to trace the user needs related to the creation of new XR assets, ensuring that such assets can be developed and subsequently integrated into a shared repository. The inclusion of this requirement supports the definition of implementation strategies that enable the availability, management, and reuse of newly created assets within the common XR asset repository.

- **UR-FUNC-2700-P3:** Multiple Selection

This UR has been **introduced** to align with the newly added User Need related to multi-object selection for further editing (UN-3500-P3). The inclusion of this requirement ensures that the system allows users, during the authoring phase, to select and manage multiple objects simultaneously, enabling common edits to be applied efficiently and consistently across the selected elements.

- **UR-FUNC-2800-P3:** Remote viewing

This UR has been **introduced** to align with the newly added User Need related to the ability to easily preview the built exercise on a desktop environment (UN-3800-P3). The inclusion of this requirement ensures that the system supports a desktop-based preview of the created XR exercise, allowing users to review, verify, and refine the experience according to the experts' evaluations.

- **UR-FUNC-2900-P3:** Quick exit mode

This UR has been **introduced** to align with the newly added User Needs related to the ability to terminate the XR experience at any time. The inclusion of this requirement ensures that the system provides a quick, easily accessible, and unambiguous exit mechanism, allowing users to safely leave the XR program whenever needed.

- **UR-FUNC-3000-P3:** Remote call

This UR has been **introduced** to address the need for remote support from an experienced operator, enabling the on-field operator to consult with a remote expert when needed. The inclusion of this requirement supports collaborative interaction within the pilot scenario, allowing guidance and feedback to be provided remotely in order to help the operator complete the operation correctly and efficiently.

Following the updates introduced with respect to the first release of the User Requirements list, the revised table is presented below. It reports the updated User Requirements together with their associated verification methods, which are essential for validating the correct implementation of the requested functionalities. The Table 6 also distinguishes the User Requirements according to the type of user involved in the verification process, differentiating between experiencing users and authoring users.

UR ID	UR NAME	DESCRIPTION	UN REF	VERIFICATION METHOD	PRIORITY
<b>UR-FUNC-0100-P3</b>	XR process	Guided visualization of the process steps	UN-0200-P3 UN-0600-P3 UN-0900-P3 UN-1000-P3	To test the created exercise for visual guidance and highlights of intervention points	M

			UN-0600-P3	To test the possibility to create detailed process steps	
<b>UR-FUNC-0200-P3</b>	XR textual information	Virtual spaces containing useful written details	UN-0100-P3 UN-0600-P3 UN-2800-P3	To test the possibility to read contents in the scene	M
			UN-0600-P3	To test the possibility to create textual contents	
<b>UR-FUNC-0300-P3</b>	3D models	Visualisation of 3D elements useful for the exercise fruition	UN-0900-P3 UN-2000-P3	To test the presence of 3D contents in the scene of the created exercise	M
			UN-2000-P3	To test the possibility to insert 3D contents	
<b>UR-FUNC-0400-P3</b>	2D/3D animations	Guided process through the presence of virtual elements	UN-0200-P3 UN-0600-P3 UN-0810-P3 UN-0900-P3 UN-1000-P3 UN-2800-P3 UN-3300-P3	To test the proper run of animations in the created exercise	M
			UN-0600-P3	To test the possibility to create 2D/3D animations	
<b>UR-FUNC-0410-P3</b>	<b>XR predefined assets</b>	<b>Repository with a predefined set of XR assets already available for authoring</b>	<b>UN-3600-P3</b>	<b>To test the possibility to use 2D/3D assets already available in a common repository</b>	<b>M</b>
<b>UR-FUNC-0410-P3</b>	<b>XR assets creation</b>	<b>Intuitive creation of new XR assets</b>	<b>UN-3700-P3</b>	<b>To test the possibility to create and save XR assets in a common repository</b>	<b>M</b>

<b>UR-NFUN-0500-P3</b>	Easy to use	The system needs to be usable by non-experts	UN-1200-P3 UN-1700-P3 UN-1720-P3 UN-1900-P3 UN-3100-P3	To be verified by usability test foreseen in WP7	M
			UN-1200-P3 UN-1700-P3, UN-1900-P3 UN-2910-P3 UN-3000-P3 UN-3100-P3 UN-3600-P3 UN-3700-P3	To be verified by usability test foreseen in WP7	
<b>UR-FUNC-0600-P3</b>	Back/Forward instructions	Process step execution flow aligned with actual operator progress	UN-0600-P3 UN-0810-P3 UN-1900-P3 UN-3100-P3 UN-3400-P3	To be verified by testing the possibility to move back and forward between scenes	M
			UN-0600-P3 UN-1900-P3 UN-2500-P3 UN-3000-P3 UN-3100-P3	To be verified by testing the possibility to implement back and forward action buttons to allow the user to move among scenes	
<b>UR-FUNC-0700-P3</b>	Homepage	Possibility to return to homepage at any time	UN-1700-P3 UN-1900-P3	To test the possibility to jump to the homepage anytime	M
			UN-1700-P3 UN-1900-P3	To test the possibility to implement the homepage link button in every scene	
<b>UR-FUNC-0800-P3</b>	Wi-fi connection	XR device networking	UN-0600-P3 UN-2100-P3	To test the possibility to run the experience smoothly and to have a remote assistant call	M
			UN-0600-P3 UN-2100-P3	To test the possibility to access and create smoothly a new	

				maintenance experience	
<b>UR-FUNC-0900-P3</b>	Data storage	Local/Offline storage of instruction manuals, videos or other documentation (flag)	UN-0100-P3 UN-1100-P3	To test the possibility to run a video or read a document within the created XR experience	M
			UN-3600-P3 UN-3700-P3	To test the possibility to access data stored locally and load them as assets	
<b>UR-FUNC-1000-P3</b>	Data Input/Output	Audio instruction and remote interaction with experienced users (audio/image/video streaming)	UN-0500-P3 UN-2400-P3	To test if the XR experience has audio inputs where necessary and if remote support can be easily activated and used	M
			UN-0500-P3 UN-2400-P3	To test the possibility to add audio files to provide hints in the procedures and help the user to perform the entire process, to test the possibility to add a Remote Call action in every scene	
<b>UR-NFUN-1100-P3</b>	Wearability	Comfortable and adjustable wearability for all different types of users	UN-1500-P3 UN-1600-P3	To test the possibility to adapt the headset on different users and guarantee a stable wearability	M
<b>UR-FUNC-1200-P3</b>	Instructions language	Opportunity to see instructions	UN-1200-P3	To test if the XR experience is	W

		in different languages		available in different languages	
			UN-1200-P3	To test the possibility to change language in the authoring UI	
<b>UR-NFUN-1310-P3</b>	<b>Operational autonomy</b>	<b>Ensure sufficient operational autonomy for the intended application</b>	<b>UN-2300-P3</b>	<b>To test the possibility to complete the selected training with battery power or to plug the headset if longer sessions are expected</b>	<b>W</b>
<b>UR-FUNC-1410-P3</b>	<b>Compatibility</b>	<b>Able to run also on affordable devices (mid-range XR headsets)</b>	<b>UN-1310-P3</b>	<b>To test the possibility to run the experience on mid-range headsets (i.e. HOLOLENS (medium price range device))</b>	<b>C</b>
<b>UR-FUNC-1500-P3</b>	Saving steps	Opportunity to continue the process at different times since the last save of the executed operations	<b>UN-2500-P3</b>	<b>To test the possibility to save unfinished XR experience creation</b>	<b>S</b>
<b>UR-FUNC-1600-P3</b>	Quality of virtual elements	Visibility of instructions and virtual elements present in process instructions	UN-0710-P3 UN-1700-P3 UN-2000-P3 UN-2200-P3	To test the user's capability to properly recognise contents in the scenes	<b>M</b>
			UN-1700-P3 UN-2000-P3 UN-2200-P3	To test the possibility to use high quality XR contents and to properly set the visual quality parameters	

				based on the intended use	
<b>UR-FUNC-1700-P3</b>	Recognizable layout	Identification of an effective element display system and distinctive elements	UN-1700-P3 UN-1800-P3	To test the UI for consistency and recognizability	M
			UN-1700-P3 UN-1800-P3	Not applicable, already tested in UR-FUNC-2400-P3	
<b>UR-FUNC-1800-P3</b>	Tracking	Real element identification system for correct alignment of virtual elements in the working scene	UN-2600-P3	To be verified by checking the capability of the system to recognise and track the correct parts	M
<b>UR-FUNC-1900-P3</b>	See-through system	AR visualization of virtual elements in the scene	UN-0200-P3 UN-1400-P3 UN-2200-P3 UN-2600-P3	To be tested by visualizing virtual elements in the XR experience	M
			UN-2200-P3	To be verified by testing the possibility to set visualization features of virtual elements according to the intended use	
<b>UR-FUNC-2000-P3</b>	Safety information	Provide the operator safety instruction (i.e. Recommend which PPE should be used for the selected process)	UN-0300-P3 UN-1710-P3	To test the presence of safety-related messages (i.e. force breaks; PPE; warning on tools, etc.)	M
			UN-2510-P3	To test the possibility to split a complete training in smaller procedures to reduce the duration of the training session	

<b>UR-FUNC-2100-P3</b>	Tools information	Illustration of the equipment needed for the process	UN-0400-P3	To test the presence of tools details to guide in the proper tool selection and in their correct use	S
<b>UR-FUNC-2300-P3</b>	Searching info system	Quick search mode for files and words contained in documents	UN-2910-P3	To test the possibility to easily search among assets	C
<b>UR-FUNC-2400-P3</b>	Customizable panels	Textures, specific images or background colours to text panels or buttons	UN-1800-P3 UN-1900-P3	Not applicable, already tested in UR-FUNC-1700-P3	M
			UN-1800-P3 UN-1900-P3	To test the possibility to use specific palette colour, icon sets etc. to create the experience in a recognizable way	
<b>UR-FUNC-2500-P3</b>	Gesture controls	Interaction with operator without controllers	UN-1400-P3	To test the correct response to the users' gesture controls	M
<b>UR-FUNC-2610-P3</b>	<b>Voice interaction</b>	<b>XR System must support voice commands for basic functions (Play/Stop, Next/Previous)</b>	UN-3200-P3	<b>To test the proper response of XR System to simple voice commands to navigate among scenes</b>	<b>M</b>

<b>UR-FUNC-2700-P3</b>	<b>Multiple Selection</b>	<b>XR System must allow multiple selection of objects for further editing</b>	<b>UN-3500-P3</b>	<b>To test the possibility to select multiple objects and edit their features</b>	<b>M</b>
<b>UR-FUNC-2800-P3</b>	<b>Remote viewing</b>	<b>Desktop preview of the created exercise</b>	<b>UN-3800-P3</b>	<b>To test the possibility to preview the created XR experience without wearing the headset</b>	<b>C</b>
<b>UR-FUNC-2900-P3</b>	<b>Quick exit mode</b>	<b>The system needs to provide users with an easy self-termination option so they can exit sessions quickly if discomfort intensifies</b>	<b>UN-1720-P3</b>	<b>To be verified by testing the possibility to exit the XR experience anytime in an easy and recognisable way</b>	<b>M</b>
<b>UR-FUNC-3000-P3</b>	<b>Remote call</b>	<b>Remote call with an expert</b>	<b>UN-0500-P3</b>	<b>To test the possibility to call remotely an experienced operator to share view</b>	<b>M</b>
			<b>UN-0500-P3</b>	<b>To test the possibility to add a remote call action</b>	

TABLE 6: PILOT 3 USER REQUIREMENTS.

## 2.4 PILOT 4 – ELECTRIC DISTRIBUTION INDUSTRY

The Electric Distribution Industry Pilot will be focused on Training activities and Onsite assistance during inspections and maintenance of wooden poles of electricity distribution network. It could be disruptive to provide real time information to guide technicians into pole characterisation processes, whose results define the nature of the next activity (maintenance, replacement or reinforcement). MOTIVATE XR tools could be used while the technician is performing onsite intervention, improving access to technical documentation. Training and remote support are both actions that could be improved thanks to XR tools.

### 2.4.1 SCENARIO DESCRIPTION

HEDNO S.A. (Hellenic Electricity Distribution Network Operator S.A.) conducts operation, maintenance and development of the power distribution network in Greece, as well as the assurance of a transparent and impartial access of consumers and of all network users in general.

The tasks related to the MOTIVATE XR project for HEDNO are the maintenance and inspection of wooden poles in the distribution network. Both for the maintenance task and the inspection task of wooden poles, HEDNO carries out multi-day trainings for the involved personnel. Technicians acquire both a theoretical and a practical background in the field and are examined in order to obtain the necessary HEDNO certification.

The first pole maintenance must take place 15 years after its initial installation and, if performed correctly, can prevent its rotting for at least 10 years. After the first maintenance, it must be repeated every 10 years.



FIGURE 7: POLE INSPECTION



FIGURE 8: POLE MANTAINANCE.

First, HEDNO technicians determine the group of poles to be maintained, which are then visually inspected, and a 45 cm deep hole is dug below the ground surface. Pole selection is made using electrical drawings rather than the ID number of the pole, which happens to be missing in some cases (a metal label). The pole is then inspected using hammers and drills. The damaged parts of the pole are located and removed and, if possible, the remaining strength of the pole is estimated. This evaluation is based on relevant criteria and technicians characterise it as suitable for maintenance / to be replaced / to be reinforced using an algorithm based on written guidelines (around 15 pages).

Poles are then classified as either suitable for maintenance or rejected. Rejected poles may additionally be characterised as hazardous. Technicians proceed with pole maintenance procedure for poles deemed suitable for maintenance. The procedure includes hole refilling with liquid preservative, external application of preservative paste on the pole and marking of the year and maintenance method on the pole. Rejected poles are not maintained and are marked with specific identification labels to indicate their status. The same applies to hazardous poles, which are also not maintained and are marked with a distinct warning label, different from that used for standard rejected poles, to ensure they are easily recognised by field personnel. Details are then recorded on special forms, the Wooden Pole Inspection and Maintenance Report.

Through MOTIVATE XR, it becomes possible to develop Augmented Reality (AR) tools suitable for training and support activities related to HEDNO's operations, such as the inspection and maintenance of wooden poles. The system aims to simplify workflow processes for trainees, instructors, and technical personnel by offering:

- Reduced working time for inspection and maintenance of wooden poles.
- Efficient training of technicians.
- Remote and synchronised support for field technicians performing inspection and maintenance.
- Improved operational efficiency and safety.

## 2.4.2 USER NEEDS

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Within this activity, all User Needs previously collected from the Pilot partners were analysed and jointly reviewed with them after a more in-depth definition of the pilot scenario. Building on the User Needs already identified in the first release, this process led to the integration, refinement, or removal of those needs that, for various reasons, were not fully aligned with the actual expectations and requirements of the end users.

The User Needs that have been revised or removed, as outlined, are listed below. For each change, the underlying rationale is also provided to clearly explain the motivations behind the revision or deletion.

Here following a list of UNs reviewed or deleted:

- **UN-1400-P4:** XR System must have a non-prohibitive cost

This UN has been **rephrased** and reformulated to reflect the updated requirements of the end user. In particular, it has been rewritten to provide a more precise reference to the economic

sustainability of use, shifting from a generic or estimated cost value to the specification that the XR experience should be accessible through mid-range hardware devices. The revised user need is identified as *UN-1410-P4 - XR System should operate on affordable devices (mid-range XR headsets / tablet)*, and is highlighted in the table below.

- **UN-2700-P4:** XR System must allow saving of executed steps and steps not yet executed

This User Need has been **removed**, as the operations foreseen within the pilot scenario are expected to be completed within the same working day in which they are started, with no planned interruptions during execution. As a result, the capability to save partially completed operations was not considered necessary and does not provide added value for the end user in this context.

In addition, a set of new User Needs is reported below. These were not included in the first release, as they emerged from further analyses and additional discussions with the Pilot partners, and were also informed by the key SEL objectives examined within Task 3.1.

Here below a list of newly added UNs is provided:

- **UN-2010-P4:** XR System must prevent overexposure

This UN has been **introduced** to address one of the “quick wins” mitigation measures identified within the SEL analysis carried out in Task T3.1, specifically the recommendation to limit session durations and reduce the risk of user overexposure. In particular, it highlights the need to avoid excessively prolonged XR sessions, which could negatively affect user comfort and overall user experience. The inclusion of this user need aims to ensure that XR usage actively supports overexposure prevention with relatively low effort solutions such as automated break prompts for the experiencing users.

- **UN-2020-P4:** XR System must allow to finish the XR session at any time through an easily accessible and unambiguous action

This UN has been **introduced** to address one of the “quick wins” mitigation measures identified within the SEL analysis carried out in Task T3.1, specifically the recommendation to monitor users for signs of discomfort (e.g., dizziness, nausea, irregular movements) and to allow or trigger session termination when necessary. Since the implementation of automated solutions for detecting user discomfort falls outside the scope of the project, this requirement focuses on ensuring that users remain in full control of the XR experience and can independently decide to terminate the session whenever increasing discomfort is perceived. In this context, the User Need emphasises the importance of providing a clearly identifiable and always accessible “exit” or “end session” action, enabling a safe, intuitive, and stress-free interruption of the ongoing XR experience.

In this context, the User Need emphasises the importance of providing a clearly identifiable and always accessible “exit” or “end session” action, enabling a safe, intuitive, and stress-free interruption of the ongoing XR experience.

- **UN-2610-P4:** XR System must allow the segmentation of procedures to create short duration session

This UN has been **introduced** to address one of the “quick wins” mitigation measures identified within the SEL analysis carried out in Task T3.1, specifically the recommendation to limit session durations and reduce the risk of user overexposure. In this context, allowing the segmentation of training procedures into shorter sessions represents a practical and effective way to operationalise such mitigation measures within the XR training environment. By enabling content creators to divide complex procedures into shorter, self-contained segments, the system supports the definition of task-specific maximum durations and the introduction of checkpoint-based breaks between sessions. This approach facilitates safer and more manageable training experiences, while preserving the overall instructional coherence of the procedure.

- **UN-3600-P4:** XR System must provide a repository for already available XR assets

This UN has been **introduced** to support the XR scene creation process by ensuring the availability of assets already accessible to the user at the authoring stage. In particular, it highlights the need for a repository where XR assets are preloaded, stored, and ready for use, allowing the user to quickly select and integrate existing assets into XR scenes that will subsequently be experienced by the operator.

- **UN-3700-P4:** XR System must allow the possibility to a seamless creation of new XR assets

This UN has been **introduced** to support the XR content creation workflow by ensuring that new XR assets created ad hoc can be easily hosted within the system repository. In particular, it highlights the need for a repository that can accommodate newly created assets and enable their smooth integration into XR scenes during the authoring phase, ensuring continuity and efficiency in the overall content preparation process.

The changes described above, together with the updated list of User Needs, are reported below. The table highlights the User Needs that have been newly introduced as well as those resulting from the rephrasing of previously identified ones. In addition, it explicitly shows the relationship between each User Need and the type of user primarily involved, distinguishing between authoring users, experiencing users, or both.

UN ID	USER NEEDS	AUTHORING	EXPERIENCING
<b>UN-0100-P4</b>	XR System must provide the option for the user to register the pole	X	X
<b>UN-0200-P4</b>	XR System must be able to provide the option to select the type of action to be performed by the operator		X
<b>UN-0300-P4</b>	XR System must provide guidance on required PPE		X
<b>UN-0400-P4</b>	XR System must suggest actions to be taken in the maintenance process		X

<b>UN-0500-P4</b>	XR System must guide the operator to use the necessary tools in the maintenance process		X
<b>UN-0600-P4</b>	XR System must have a clear and defined layout	X	X
<b>UN-0700-P4</b>	XR System must show the correct ways to perform inspection operations		X
<b>UN-0800-P4</b>	XR System must show the correct ways to perform maintenance operations		X
<b>UN-0900-P4</b>	XR System must show the steps of the process operations step by step	X	X
<b>UN-1000-P4</b>	XR System must provide the operator the safety conditions for the maintenance training		X
<b>UN-1100-P4</b>	XR System must be able to track elements on the workstation		X
<b>UN-1200-P4</b>	XR System must provide access with credentials	X	X
<b>UN-1300-P4</b>	XR System must enable well-defined visibility of elements in outdoor environment		X
<b>UN-1410-P4</b>	<b>XR System should operate on affordable devices (mid-range XR headsets / tablet)</b>		X
<b>UN-1500-P4</b>	XR System must be able to provide access to view manuals and/or other documentation useful for the on-site training		X
<b>UN-1600-P4</b>	XR System must be able to provide the guidance in different languages	X	X
<b>UN-1700-P4</b>	XR System must allow the user to be able to run an entire process without restricting the user's hands		X
<b>UN-1800-P4</b>	XR System must allow stable and secure wearability		X
<b>UN-1900-P4</b>	XR System must allow adaptable wearability for different users		X
<b>UN-2000-P4</b>	XR System must offer a comfortable user experience		X
<b>UN-2010-P4</b>	<b>XR System must prevent overexposure</b>		X
<b>UN-2020-P4</b>	<b>XR System must allow to finish the XR session at any time through an easily accessible and unambiguous action</b>		X
<b>UN-2100-P4</b>	XR System must allow for well-defined element visibility	X	X
<b>UN-2200-P4</b>	XR System must have a stable internet connection	X	X
<b>UN-2300-P4</b>	XR System must be able to provide audio feedback		X
<b>UN-2400-P4</b>	XR System must be able to upgrade data from a previously registered process done		X

<b>UN-2500-P4</b>	XR System must be able to collect the pole location executed	X	X
<b>UN-2600-P4</b>	XR System must provide a runtime of at least 4 hours		X
<b>UN-2610-P4</b>	<b>XR System must allow the segmentation of procedures to create short duration session</b>	X	X
<b>UN-2800-P4</b>	XR System must be able to input data through the operator's input in order to fill in the inspection data		X
<b>UN-2900-P4</b>	XR System must provide an evaluation of the pole's state according to the inspection process		X
<b>UN-3000-P4</b>	XR System must be able to project the result of the evaluation		X
<b>UN-3100-P4</b>	XR System must be able to provide access to view semantic information for contextual assistance		X
<b>UN-3200-P4</b>	XR System must retrieve onsite some technical data from data base	X	X
<b>UN-3300-P4</b>	XR System must allow easy solution to upload and create process documentation	X	
<b>UN-3400-P4</b>	XR System must be able get the coordinates of the user's actual location		X
<b>UN-3500-P4</b>	XR System must be able to allow request for support from an experienced operator	X	X
<b>UN-3600-P4</b>	<b>XR System must provide a repository for already available XR assets</b>	X	
<b>UN-3700-P4</b>	<b>XR System must allow the possibility to a seamless creation of new XR assets</b>	X	

TABLE 7: PILOT 4 USER NEEDS.

### 2.4.3 USER REQUIREMENTS

Based on the revisions carried out jointly with the Pilot partners on the User Needs, which were updated to reflect the requirements expressed by the end users, the entire list of User Requirements was also reviewed. This step was necessary to realign each User Requirement with the updated User Needs following the modifications and additions introduced. The changes applied to the User Requirements list are therefore reported below, together with the rationale that led to the revision of the set originally defined in the first release of the deliverable.

Here following a list reporting all the modified and deleted URs:

- **UR-NFUN-1300-P4:** Battery

This UR has been **rephrased** and reformulated as *UR-NFUN-1310-P4 - Operational autonomy*, to provide a clearer definition of device battery autonomy management, in alignment with the

training or maintenance experiences foreseen within the pilot scenario. The revision ensures that battery-related constraints are explicitly considered in relation to the expected duration and usage patterns of the XR sessions.

- **UR-NFUN-1400-P4:** Price

This UR has been **rephrased** and reformulated as *UR-NFUN-1410-P4 – Compatibility*, in alignment with the updates introduced in the related User Needs. The revision provides a clearer and more consistent linkage between this requirement and the need to enable the fruition of XR experiences on mid-range devices, ensuring that the overall solution remains economically accessible and non-prohibitive for the end user.

- **UR-FUNC-2600-P4:** Retrieve company's data

This UR has been **rephrased** and reformulated as *Retrieve product's data* to better reflect the actual needs expressed by the Pilot. The revision clarifies that the data to be retrieved and managed within the XR system are primarily related to the product under inspection, rather than to general company information. For this reason, the requirement has been renamed accordingly to ensure clearer alignment with the pilot scenario.

Here following a list of the newly added User Requirements:

- **UR-FUNC-0410-P4:** XR predefined assets

This UR has been **introduced** to align the traced User Needs with concrete implementation strategies, specifically addressing the definition of a repository of predefined XR assets. The inclusion of this requirement supports the implementation of a structured asset repository capable of effectively responding to the identified user needs and facilitating the preparation of XR scenes during the authoring phase.

- **UR-FUNC-0420-P4:** XR assets creation

This UR has been **introduced** to trace the user needs related to the creation of new XR assets, ensuring that such assets can be developed and subsequently integrated into a shared repository. The inclusion of this requirement supports the definition of implementation strategies that enable the availability, management, and reuse of newly created assets within the common XR asset repository.

- **UR-FUNC-2800-P4:** Remote call

This UR has been **introduced** to address the need for remote support from an experienced operator, enabling the on-field operator to consult with a remote expert when needed. The inclusion of this requirement supports collaborative interaction within the pilot scenario, allowing guidance and feedback to be provided remotely in order to help the operator complete the operation correctly and efficiently.

- **UR-FUNC-2900-P4:** Quick exit mode

This UR has been **introduced** to align with the newly added User Needs related to the ability to terminate the XR experience at any time. The inclusion of this requirement ensures that the

system provides a quick, easily accessible, and unambiguous exit mechanism, allowing users to safely leave the XR program whenever needed.

Following the updates introduced with respect to the first release of the User Requirements list, the revised table is presented below. It reports the updated User Requirements together with their associated verification methods, which are essential for validating the correct implementation of the requested functionalities. The table also distinguishes the User Requirements according to the type of user involved in the verification process, differentiating between experiencing users and authoring users.

UR ID	UR NAME	DESCRIPTION	UN REF	VERIFICATION METHOD	PRIORITY
<b>UR-FUNC-0100-P4</b>	XR process	Guided visualization of the process steps	UN-0200-P4 UN-0400-P4 UN-0700-P4 UN-0800-P4 UN-0900-P4	To test the created XR experience for visual guidance and highlights of intervention points	M
			UN-0900-P4	To test the possibility to create detailed process steps	
<b>UR-FUNC-0200-P4</b>	XR textual information	Virtual spaces containing useful written details	UN-0900-P4 UN-1200-P4 UN-3100-P4	To test the possibility to read contents in the scene	M
			UN-0900-P4 UN-1200-P4	To test the possibility to create textual contents	
<b>UR-FUNC-0300-P4</b>	3D models	Visualisation of 3D elements useful for the exercise fruition	UN-0500-P4 UN-2100-P4	To test the presence of 3D contents in the scene	M
			UN-2100-P4	To test the possibility to insert 3D contents	
<b>UR-FUNC-0400-P4</b>	2D/3D animations	Guided process through the	UN-0300-P4 UN-0900-P4	To test the proper run of animations in	M

		presence of virtual elements		the created XR experience	
			UN-0900-P4	To test the possibility to create 2D/3D animations	
<b>UR-FUNC-0410-P4</b>	<b>XR predefined assets</b>	<b>Repository with a predefined set of XR assets already available for authoring</b>	<b>UN-3600-P4</b>	<b>To test the possibility to use 2D/3D assets already available in a common repository</b>	<b>M</b>
<b>UR-FUNC-0420-P4</b>	<b>XR assets creation</b>	<b>Intuitive creation of new XR assets</b>	<b>UN-3700-P4</b>	<b>To test the possibility to create and save XR assets in a common repository</b>	<b>M</b>
<b>UR-NFUN-0500-P4</b>	Easy to use	The system needs to be usable by non-experts	UN-0600-P4 UN-1600-P4 UN-2000-P4	To be verified by usability test foreseen in WP7	W
			UN-0600-P4 UN-1600-P4 UN-3300-P4	To be verified by usability test foreseen in WP7	
<b>UR-FUNC-0600-P4</b>	Back/Forward instructions	Process step execution flow aligned with actual operator progress	UN-0600-P4 UN-0900-P4 UN-2000-P4	To test the possibility to move back and forward between scenes	M
			UN-0600-P4 UN-0900-P4	To test the possibility to implement back and forward action buttons to allow the user to move among scenes	
<b>UR-FUNC-0700-P4</b>	Homepage	Possibility to return to homepage at any time	UN-0600-P4 UN-2000-P4	To test the possibility to jump to the homepage anytime	M
			UN-0600-P4	To test the possibility to implement the homepage link	

				button in every scene	
<b>UR-FUNC-0800-P4</b>	Wi-fi connection	XR device networking	UN-2200-P4	To test if the XR experience can be downloaded on the selected device	M
			UN-2200-P4	To test the possibility to run the authoring tool on internet and to upload the created manual on the storage cloud	
<b>UR-FUNC-0900-P4</b>	Data storage	Local/Offline storage of instruction manuals, videos or other documentation (flag)	UN-1500-P4 UN-3200-P4	To test the possibility to access data stored locally, previously integrated into the experiencing process manual	S
			UN-3200-P4 UN-3300-P4 UN-3600-P4 UN-3700-P4	To test the possibility to access and upload assets stored locally	
<b>UR-FUNC-1000-P4</b>	Data Input/Output	Interaction with helpful data (audio/image/video/user localization)	UN-2300-P4 UN-2800-P4 UN-3400-P4	To test the XR experience for audio instructions to the user. To test the capability to provide user localization	S
<b>UR-NFUN-1100-P4</b>	Wearability	Comfortable and adjustable wearability for all different types of users	UN-1800-P4 UN-1900-P4	To test the possibility to adapt the headset on different users and guarantee a stable wearability	W
<b>UR-FUNC-1200-P4</b>	Instructions language	Opportunity to see instructions	UN-1600-P4	To test the possibility to	C

		in different languages		experience different languages	
			UN-1600-P4	To test the possibility to change language in the authoring UI	
<b>UR-NFUN-1310-P4</b>	<b>Operational autonomy</b>	<b>Ensure sufficient operational autonomy for the intended application</b>	<b>UN-2600-P4 UN-2610-P4</b>	<b>To test the possibility to complete the selected XR experience with battery power or to plug the headset if longer sessions are expected</b>	<b>W</b>
<b>UR-NFUN-1410-P4</b>	<b>Compatibility</b>	<b>Able to run also on affordable devices (mid-range XR headsets)</b>	<b>UN-1410-P4</b>	<b>To test the possibility to run the experience on the selected device (medium price range device)</b>	<b>S</b>
<b>UR-FUNC-1500-P4</b>	Saving steps	Opportunity to continue the process at different times since the last save of the executed operations	UN-2610-P4	To test the possibility to save unfinished exercises creation	S
<b>UR-FUNC-1600-P4</b>	Quality of virtual elements	Visibility of instructions and virtual elements present in process instructions	UN-1300-P4 UN-2000-P4 UN-2100-P4	To test the user's capability to properly recognise contents in the scenes	M
			UN-2100-P4	To test the possibility to use high quality XR contents and to properly set the visibility features based on the intended use	

<b>UR-FUNC-1700-P4</b>	Recognizable layout	Identification of an effective element display system and distinctive elements	UN-0600-P4 UN-2000-P4	To test the UI for consistency and recognisability	M
			UN-0600-P3	Not applicable, already tested in UR-FUNC-2400-P4	
<b>UR-FUNC-1800-P4</b>	Tracking	Real element identification system for correct alignment of virtual elements in the working scene	UN-1100-P4	To test the correct alignment between virtual elements and real environment	M
<b>UR-FUNC-1900-P4</b>	See-through system	AR visualisation of virtual elements in the scene	UN-1100-P4 UN-1300-P4 UN-1700-P4	To test if the user can correctly visualise virtual elements into the real environment during the experiencing process manual	M
<b>UR-FUNC-2000-P4</b>	Safety information	Provide the operator safety instruction (i.e. Recommend which PPE should be used for the selected process)	UN-0300-P4 UN-1000-P4	To test the presence of safety-related messages (i.e. force breaks; PPE; warning on tools, etc.)	M
			UN-2610-P4	To test the possibility to split a complete training in smaller procedures to reduce the duration of the training session	

<b>UR-FUNC-2100-P4</b>	Tools information	Illustration of the equipment needed for the process	UN-0500-P4	To test the presence of tools details to guide in the proper tool selection and in their correct use	C
<b>UR-FUNC-2200-P4</b>	Working location	Collection of information about the intervention location	UN-0100-P4 UN-2400-P4 UN-2500-P4	To test the possibility to set the boundaries of the working areas on the headset (indoor use)	S
<b>UR-FUNC-2300-P4</b>	Evaluation feedback	Easy review of the steps conducted and evaluation display mode	UN-2900-P4 UN-3000-P4	To test the possibility to visualise an evaluation of the concluded procedure	W
<b>UR-FUNC-2400-P4</b>	Customizable panels	Textures, specific images or background colours to text panels or buttons	UN-0600-P4 UN-2100-P4	Not applicable, already tested in UR-FUNC-1700-P4	M
			UN-0600-P4 UN-2100-P4	To test the possibility to use specific palette colour, icon sets etc. to create the experience in a recognisable way	
<b>UR-FUNC-2500-P4</b>	Gesture controls	Interaction with operator without controllers	UN-1700-P4	To test the correct response to the user gesture controls	C
<b>UR-FUNC-2600-P4</b>	<b>Retrieve product's data</b>	<b>Access to DB for useful data</b>	<b>UN-3200-P4</b>	<b>To test the possibility to upload data from the database</b>	<b>S</b>

			<b>UN-3200-P4</b>	<b>To test the possibility to upload data correctly from a database</b>	
<b>UR-FUNC-2700-P4</b>	Login/Logout	Credential access to a specific process manual	UN-1200-P4	To the test the correct access credentials	C
			UN-1200-P4	To test the correct link to allow the user connection to access with credentials	
<b>UR-FUNC-2800-P4</b>	Remote call	Remote call with an expert	UN-3500-P4	To verify the possibility to call remotely an experienced operator	S
			UN-3500-P4	To test the possibility to add a remote call action	
<b>UR-FUNC-2900-P4</b>	Quick exit mode	<b>The system needs to provide users with an easy self-termination option so they can exit sessions quickly if discomfort intensifies</b>	UN-2010-P4 UN-2020-P4	To test the possibility to exit the XR experience anytime in an easy and recognisable way	M

TABLE 8: PILOT 4 USER REQUIREMENTS.

## 2.5 PILOT 5 – ROBOT – HUMAN HYBRID MANUFACTURING

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Robot-human hybrid manufacturing industry scenario will be focused on a real production environment where assembly procedures are conducted by an operator usually supported by printed manuals or, at best, explanatory videos. This scenario is quite far from the one of the Smart Digital Factory that Bi-Rex aims to simulate and promote, so MOTIVATE XR tools would be useful to work in this direction. Indeed, the main focus of this Pilot will be on simplifying assembly procedures by introducing a Collaborative Robot (cobot) in the assembly station and providing the operator mixed reality instructions for an effective collaboration with the Robot.

### 2.5.1 SCENARIO DESCRIPTION

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BI-REX is one of the 8 Italian Competence Centres funded by the Italian Ministry of the Economic Development, within the Industry 4.0 National Plan.

Its public-private Consortium, born in 2018, with headquarter in Bologna (Italy), gathers in partnership 61 players among Universities, Research Centres and Companies of excellence, to support companies in their digitisation, sustainability and innovation processes and in the adoption of enabling technologies with a view to Industry 4.0 framework, BI-REX offers a complete Pilot Plant.

The BI-REX pilot line simulates a production line, with machines and equipment, as usually happens in the places where Collaborative Robots are installed. Usually, these environments are characterised by shelving, storage areas, areas where machinery is present, warehouses and more. The floor is often marked with lanes, walkways, prohibited areas, etc.

Currently, at the stations, assembly is carried out by operators, supported by a printed manual or, at best, an explanatory video. The collaborative robot will have to be intuitively and efficiently programmed to ensure the correct picking of components: once picked, the components can be precisely positioned within the work plan of the assembly station.

In order to make operations simpler and more easily adaptable in a smart digital factory context, the new scenario developed within the MOTIVATE XR project will simplify assembly by smoothly implementing the various operational steps (the collaborative robot hands the operator the parts to be assembled), supported by mixed reality instructions illustrating how to perform the various operations.

The objective of the application is to make the procedure more flexible, adaptable and simple, using mixed reality technologies and leaving the dexterity tasks to the operator. Rather than just provide instructions for assembly steps, MOTIVATE XR tools should also provide safety-related instructions, (i.e. suggesting when to start assembly operations in a safe way). To support this, a collaboration interaction between the collaborative robot and the user should be defined.

In order to simplify the assembly process, it will be necessary to:

- Define a clear and logical assembly sequence, minimising unnecessary movements of the cobot and the operator. In addition, the cobot will deliver the components in the correct assembly

sequence and ensure that they are adhered to. Using mixed (surely augmented) reality software, once the cobot has picked up the component to be assembled, it delivers it to the operator and instructs the operator how to assemble it, waiting for the signal to retrieve the next part. This process should be supported by intuitive and clearly designed tools that help the operator anticipate the cobot's movements and interaction zones, thereby improving coordination, safety, and task efficiency.

- Clearly define the work areas of the cobot and the operators.



FIGURE 9: ASSEMBLY OF GEARBOX COMPONENTS.



FIGURE 10: HUMAN-MACHINE INTERFACE FOR ASSEMBLY.

In addition, the scenario will involve the use of MOTIVATE XR tools with which all those operations in which the user has to carry out the assembly of the part can be simulated, with the aim of facilitating operator training. The use case will involve replacing, or simplifying its recognition by virtual elements, the physical buttons for confirming the various operational steps with defined and developed elements in a virtual environment.

## 2.5.2 USER NEEDS

Within this activity, all User Needs previously collected from the Pilot partners were analysed and jointly reviewed with them after a more in-depth definition of the pilot scenario. Building on the User Needs already identified in the first release, this process led to the integration, refinement, or removal of those needs that, for various reasons, were not fully aligned with the actual expectations and requirements of the end users.

The User Needs that have been revised or removed, as outlined, are listed below. For each change, the underlying rationale is also provided to clearly explain the motivations behind the revision or deletion.

Below is a list of User Needs that have been reformulated or removed:

- **UN-0400-P5:** XR System must be able to enable the possibility to take picture of the executed steps  
This UN has been **rephrased** and reformulated to reflect the updated requirements of the end user. The revised user need is identified as *UN-0410-P5 - XR System must be able to enable the possibility to share the POV of the operator*, and is highlighted in the table below. During the in-depth analysis of the pilot activities, it emerged that live streaming of the operator's point of view is considered more useful than storing individual photos of the scene
- **UN-0700-P5:** XR System must display procedures in a highly visible way  
This UN has been **rephrased** and reformulated to reflect the updated requirements of the end user. In particular, the original intent of the need has been clarified and more precisely expressed in the revised user need *UN-0710-P5 - XR System must present contents in a way that ensures clear visibility and high perceptual quality*, which is highlighted in the table below.
- **UN-0800-P5:** XR System must guide the trainee at times coherent with the exercise (animations speed, screwing speed, etc.)  
This UN has been **rephrased** and reformulated to reflect the updated requirements of the end user. In particular, it has been rewritten in a clearer and more explicit manner to specify that the XR experience must accurately reflect the timings and operational methodologies of the real exercise. The revised user need is identified as *UN-0810-P5 - XR System must guide the trainee at times consistent with the exercise*, and is highlighted in the table below.
- **UN-1300-P5:** XR System must have a non-prohibitive cost  
This UN has been **rephrased** and reformulated to reflect the updated requirements of the end user. In particular, it has been rewritten to provide a more precise reference to the economic sustainability of use, shifting from a generic or estimated cost value to the specification that the XR experience should be accessible through mid-range hardware devices. The revised user need is identified as *UN-1310-P5 - XR System should operate on affordable devices (mid-range XR headsets)*, and is highlighted in the table below.
- **UN-2400-P5:** XR System must be able to provide audio indications  
This UN has been **removed**, as it was considered not necessary and of limited usefulness for the identified and in-depth analysed pilot scenario. The evaluation showed that audio indications would not provide significant added value within the operational context of the pilot and could potentially introduce unnecessary complexity.

In addition, a set of new User Needs is reported below. These were not included in the first release, as they emerged from further analyses and additional discussions with the Pilot partners, and were also informed by the key SEL objectives examined within Task 3.1.

Below is reported a list of User Needs that have been added:

- **UN-1710-P5:** XR System must prevent overexposure

This UN has been **introduced** to address one of the “quick wins” mitigation measures identified within the SEL analysis carried out in Task T3.1, specifically the recommendation to limit session durations and reduce the risk of user overexposure. In particular, it highlights the need to avoid excessively prolonged XR sessions, which could negatively affect user comfort and overall user experience. The inclusion of this user need aims to ensure that XR usage actively supports overexposure prevention with relatively low effort solutions such as automated break prompts for the experiencing users.

- **UN-1720-P5:** XR System must allow to finish the XR session at any time through an easily accessible and unambiguous action

This UN has been **introduced** to address one of the “quick wins” mitigation measures identified within the SEL analysis carried out in Task T3.1, specifically the recommendation to monitor users for signs of discomfort (e.g., dizziness, nausea, irregular movements) and to allow or trigger session termination when necessary. Since the implementation of automated solutions for detecting user discomfort falls outside the scope of the project, this requirement focuses on ensuring that users remain in full control of the XR experience and can independently decide to terminate the session whenever increasing discomfort is perceived. In this context, the User Need emphasises the importance of providing a clearly identifiable and always accessible “exit” or “end session” action, enabling a safe, intuitive, and stress-free interruption of the ongoing XR experience.

In this context, the User Need emphasises the importance of providing a clearly identifiable and always accessible “exit” or “end session” action, enabling a safe, intuitive, and stress-free interruption of the ongoing XR experience.

- **UN-2510-P5:** XR System must allow the segmentation of procedures to create short duration session

This UN has been **introduced** to address one of the “quick wins” mitigation measures identified within the SEL analysis carried out in Task T3.1, specifically the recommendation to limit session durations and reduce the risk of user overexposure. In this context, allowing the segmentation of training procedures into shorter sessions represents a practical and effective way to operationalise such mitigation measures within the XR training environment. By enabling content creators to divide complex procedures into shorter, self-contained segments, the system supports the definition of task-specific maximum durations and the introduction of checkpoint-based breaks between sessions. This approach facilitates safer and more manageable training experiences, while preserving the overall instructional coherence of the procedure.

- **UN-2610-P5:** XR System must allow the relocation of XR assets in the scene

This UN has been **introduced** to address the need of the pilot scenario, which involves moving virtual elements across multiple physical workstations within the real environment. In particular,

it reflects the need to relocate the entire virtual scene to different positions, using tracking points placed where required, in order to ensure spatial coherence and operational continuity across different workstations.

- **UN-2900-P5:** XR System must provide a repository for already available XR assets

This UN has been **introduced** to support the XR scene creation process by ensuring the availability of assets already accessible to the user at the authoring stage. In particular, it highlights the need for a repository where XR assets are preloaded, stored, and ready for use, allowing the user to quickly select and integrate existing assets into XR scenes that will subsequently be experienced by the operator.

- **UN-3000-P5:** XR System must allow the possibility to a seamless creation of new XR assets

This UN has been **introduced** to support the XR content creation workflow by ensuring that new XR assets created ad hoc can be easily hosted within the system repository. In particular, it highlights the need for a repository that can accommodate newly created assets and enable their smooth integration into XR scenes during the authoring phase, ensuring continuity and efficiency in the overall content preparation process.

The changes described above, together with the updated list of User Needs, are reported below. The table highlights the User Needs that have been newly introduced as well as those resulting from the rephrasing of previously identified ones. In addition, it explicitly shows the relationship between each User Need and the type of user primarily involved, distinguishing between authoring users, experiencing users, or both.

UN ID	USER NEEDS	AUTHORING	EXPERIENCING
<b>UN-0100-P5</b>	XR System must enable the transmission of basic knowledge about the robots in use		X
<b>UN-0200-P5</b>	XR System must be able to suggest the gripping points of components		X
<b>UN-0300-P5</b>	XR System must provide guidance on required PPE		X
<b>UN-0410-P5</b>	<b>XR System must be enable the possibility share the POV of the operator</b>		X
<b>UN-0500-P5</b>	XR System must be able to allow request for support from an experienced operator		X
<b>UN-0600-P5</b>	XR System must show the steps of the process operations step by step	X	X
<b>UN-0710-P5</b>	<b>XR System must present contents in a way that ensures clear visibility and high perceptual quality</b>		X
<b>UN-0810-P5</b>	<b>XR System must guide the trainee at times consistent with the exercise</b>		X

<b>UN-0900-P5</b>	XR System must show the correct ways to handle the tools needed for assembly		X
<b>UN-1000-P5</b>	XR System must show the correct ways to perform assembly operations		X
<b>UN-1100-P5</b>	XR System must be able to provide access to view manuals and/or other documentation useful to the process		X
<b>UN-1200-P5</b>	XR System must be able to provide the guidance in different languages	X	X
<b>UN-1310-P5</b>	<b>XR System should operate on affordable devices (mid-range XR headsets)</b>		X
<b>UN-1400-P5</b>	XR System must allow the user to be able to run an entire process without restricting the user's hands		X
<b>UN-1500-P5</b>	XR System must allow stable and secure wearability		X
<b>UN-1600-P5</b>	XR System must allow adaptable wearability for different users		X
<b>UN-1700-P5</b>	XR System must offer a comfortable user experience	X	X
<b>UN-1710-P5</b>	<b>XR System must prevent overexposure</b>		X
<b>UN-1720-P5</b>	<b>XR System must allow to finish the XR session at any time through an easily accessible and unambiguous action</b>		X
<b>UN-1800-P5</b>	XR System must have a distinctive layout	X	X
<b>UN-1900-P5</b>	XR System must have a clear and defined layout	X	X
<b>UN-2000-P5</b>	XR System must allow for well-defined element visibility	X	X
<b>UN-2100-P5</b>	XR System must have a stable internet connection	X	X
<b>UN-2200-P5</b>	XR System must enable well-defined visibility of elements in indoor environment	X	X
<b>UN-2300-P5</b>	XR System must provide a runtime of at least 4 hours		X
<b>UN-2500-P5</b>	XR System must allow saving of executed steps and steps not yet executed	X	
<b>UN-2510-P5</b>	<b>XR System must allow the segmentation of procedures to create short duration session</b>	X	
<b>UN-2600-P5</b>	XR System must be able to track elements on the workstation		X
<b>UN-2610-P5</b>	<b>XR System must allow the relocation of XR assets in the scene</b>		X
<b>UN-2700-P5</b>	XR System must allow the identification of a safety work area		X

<b>UN-2800-P5</b>	XR System must provide feedback on the use of correct tools		X
<b>UN-2900-P5</b>	<b>XR System must provide a repository for already available XR assets</b>	X	
<b>UN-3000-P5</b>	<b>XR System must allow the possibility to a seamless creation of new XR assets</b>	X	

TABLE 9: PILOT 5 USER NEEDS.

### 2.5.3 USER REQUIREMENTS

Based on the revisions carried out jointly with the Pilot partners on the User Needs, which were updated to reflect the requirements expressed by the end users, the entire list of User Requirements was also reviewed. This step was necessary to realign each User Requirement with the updated User Needs following the modifications and additions introduced. The changes applied to the User Requirements list are therefore reported below, together with the rationale that led to the revision of the set originally defined in the first release of the deliverable.

Here below a list of modified or deleted URs:

- **UR-NFUN-1300-P5:** Battery

This UR has been **rephrased** and reformulated as *UR-NFUN-1310-P5 - Operational autonomy*, to provide a clearer definition of device battery autonomy management, in alignment with the training or maintenance experiences foreseen within the pilot scenario. The revision ensures that battery-related constraints are explicitly considered in relation to the expected duration and usage patterns of the XR sessions.

- **UR-NFUN-1400-P5:** Price

This UR has been **rephrased** and reformulated as *UR-NFUN-1410-P5 - Compatibility*, in alignment with the updates introduced in the related User Needs. The revision provides a clearer and more consistent linkage between this requirement and the need to enable the fruition of XR experiences on mid-range devices, ensuring that the overall solution remains economically accessible and non-prohibitive for the end user.

- **UR-FUNC-2500-P5:** Voice recognition

This UR has been **rephrased** and reformulated as *UR-FUNC-2510-P5 - Remote call*, following the removal of the related User Need (UN-2400-P5), which was no longer considered useful or necessary for the pilot scenario. The revision ensures alignment with the user need related to requesting support from an experienced operator, while discarding voice recognition as a standalone functional requirement within the XR solution.

Here following a list of the newly added User Requirements:

- **UR-FUNC-0410-P5:** XR predefined assets

This UR has been **introduced** to align the traced User Needs with concrete implementation strategies, specifically addressing the definition of a repository of predefined XR assets. The inclusion of this requirement supports the implementation of a structured asset repository capable of effectively responding to the identified user needs and facilitating the preparation of XR scenes during the authoring phase.

- **UR-FUNC-0420-P5:** XR assets creation

This UR has been **introduced** to trace the user needs related to the creation of new XR assets, ensuring that such assets can be developed and subsequently integrated into a shared repository. The inclusion of this requirement supports the definition of implementation strategies that enable the availability, management, and reuse of newly created assets within the common XR asset repository.

- **UR-FUNC-2600-P5:** Quick exit mode

This UR has been **introduced** to align with the newly added User Needs related to the ability to terminate the XR experience at any time. The inclusion of this requirement ensures that the system provides a quick, easily accessible, and unambiguous exit mechanism, allowing users to safely leave the XR program whenever needed.

Following the updates introduced with respect to the first release of the User Requirements list, the revised table is presented below. It reports the updated User Requirements together with their associated verification methods, which are essential for validating the correct implementation of the requested functionalities. The table also distinguishes the User Requirements according to the type of user involved in the verification process, differentiating between experiencing users and authoring users.

UR ID	UR NAME	DESCRIPTION	UN REF	VERIFICATION METHOD	PRIORITY
<b>UR-FUNC-0100-P5</b>	XR process	Guided visualisation of the process steps	UN-0200-P5 UN-0600-P5 UN-0900-P5 UN-1000-P5	To test the created exercise for visual guidance and highlights of intervention points	M
			UN-0600-P5	To test the possibility to create detailed process steps	
<b>UR-FUNC-0200-P5</b>	XR textual information	Virtual spaces containing useful written details	UN-0100-P5 UN-0600-P5	To test the possibility to read contents in the scene	M

			UN-0600-P5	To test the possibility to create textual contents	
<b>UR-FUNC-0300-P5</b>	3D models	Visualisation of 3D elements useful for the exercise fruition	UN-0900-P5 UN-2000-P5	To test the presence of 3D contents in the scene	M
			UN-2000-P5	To test the possibility to insert 3D contents	
<b>UR-FUNC-0400-P5</b>	2D/3D animations	Guided process through the presence of virtual elements	UN-0200-P5 UN-0600-P5 UN-0810-P5 UN-0900-P5 UN-1000-P5 UN-2700-P5 UN-2800-P5	To test the proper run of animations in the created exercise	M
			UN-0600-P5	To test the possibility to create 2D/3D animations	
<b>UR-FUNC-0410-P5</b>	<b>XR predefined assets</b>	<b>Repository with a predefined set of XR assets already available for authoring</b>	<b>UN-2900-P5</b>	<b>To test the possibility to use 2D/3D assets already available in a common repository</b>	<b>M</b>
<b>UR-FUNC-0420-P5</b>	<b>XR assets creation</b>	<b>Intuitive creation of new XR assets</b>	<b>UN-3000-P5</b>	<b>To test the possibility to create and save XR assets in a common repository</b>	<b>M</b>
<b>UR-NFUN-0500-P5</b>	Easy to use	The system needs to be usable by non-experts	UN-1200-P5 UN-1700-P5 UN-1710-P5 UN-1720-P5 UN-1900-P5	To be verified by usability test foreseen in WP7	W
			UN-1200-P5 UN-1700-P5 UN-1900-P5 UN-2900-P5	To be verified by usability test foreseen in WP7	
<b>UR-FUNC-0600-P5</b>	Back/Forward instructions	Process step execution flow aligned with	UN-0600-P5 UN-0810-P5 UN-1900-P5	To be verified by testing the possibility to move back and	M

		actual operator progress		forward between scenes	
			UN-0600-P5 UN-1900-P5 UN-2510-P5	To be verified by testing the possibility to implement back and forward action buttons to allow the user to move among scenes	
<b>UR-FUNC-0700-P5</b>	Homepage	Possibility to return to homepage at any time	UN-1700-P5 UN-1900-P5	To test the possibility to jump to the homepage anytime	M
			UN-1700-P5 UN-1900-P5	To test the possibility to implement the homepage link button in every scene	
<b>UR-FUNC-0800-P5</b>	Wi-fi connection	XR device networking	UN-2100-P5	To test the possibility to run the experience smoothly and to have a remote assistant call	M
			UN-2100-P5	To test the possibility to access and create smoothly a new experience	
<b>UR-FUNC-0900-P5</b>	Data storage	Local/Offline storage of instruction manuals, videos or other documentation (flag)	UN-0100-P5 UN-1100-P5	To test the possibility to access data stored locally, previously integrated into the experiencing process manual	S
			UN-2900-P5 UN-3000-P5	To test the possibility to upload new assets	
<b>UR-FUNC-1000-P5</b>	Data Input/Output	Audio instruction and	UN-0500-P5	To test the possibility of	S

		remote interaction with experienced users (audio/image/video streaming)		sharing information during a remote interaction with an expert	
<b>UR-NFUN-1100-P5</b>	Wearability	Comfortable and adjustable wearability for all different types of users	UN-1500-P5 UN-1600-P5	To test the possibility to adapt the headset on different users and guarantee a stable wearability	W
<b>UR-FUNC-1200-P5</b>	Instructions language	Opportunity to see instructions in different languages	UN-1200-P5	To test if the XR experience is available in different languages	C
			UN-1200-P5	To test the possibility to change language in the authoring UI	
<b>UR-NFUN-1310-P5</b>	<b>Operational autonomy</b>	<b>Ensure sufficient operational autonomy for the intended application</b>	<b>UN-2300-P5</b>	<b>To test the possibility to complete the selected training with battery power or to plug the headset if longer sessions are expected</b>	<b>W</b>
<b>UR-NFUN-1410-P5</b>	<b>Compatibility</b>	<b>Able to run also on affordable devices (mid-range XR headsets)</b>	<b>UN-1310-P5</b>	<b>To test the possibility to run the experience on the selected device (medium price range device)</b>	<b>S</b>
<b>UR-FUNC-1500-P5</b>	Saving steps	Opportunity to continue the process at different times since the last save of the executed operations	UN-2500-P5 UN-2510-P5	To test the possibility to save unfinished exercises creation	S

<b>UR-FUNC-1600-P5</b>	Quality of virtual elements	Visibility of instructions and virtual elements present in process instructions	UN-0700-P5 UN-1700-P5 UN-2000-P5 UN-2200-P5	To test the user's capability to properly recognise contents in the scenes	M
			UN-1700-P5 UN-2000-P5 UN-2200-P5	To test the possibility to use high quality XR contents and to properly set the visibility features based on the intended use	
<b>UR-FUNC-1700-P5</b>	Recognizable layout	Identification of an effective element display system and distinctive elements	UN-1700-P5 UN-1800-P5	To test the UI for consistency and recognisability	S
			UN-1700-P5 UN-1800-P5	Not applicable, already tested in UR-FUNC-2300-P5	
<b>UR-FUNC-1800-P5</b>	Tracking	Real element identification system for correct alignment of virtual elements in the working scene	UN-2600-P5 UN-2610-P5	To test the correct alignment between virtual elements and real environment	M
<b>UR-FUNC-1900-P5</b>	See-through system	AR visualisation of virtual elements in the scene	UN-0200-P5 UN-1400-P5 UN-2200-P5 UN-2600-P5 UN-2610-P5	To test if the user can correctly visualise virtual elements into the real environment during the experiencing process manual	M
			UN-2200-P5	Not applicable	
<b>UR-FUNC-2000-P5</b>	Safety information	Provide the operator safety instruction (i.e. Recommend which PPE should be used	UN-0300-P5	To test the presence of safety-related messages (i.e. force breaks; PPE; warning on tools, etc.)	M

		for the selected process)	UN-2510-P5	To test the possibility to split a complete training in smaller procedures to reduce the duration of the training session	
<b>UR-FUNC-2100-P5</b>	Operator's point of view	Streaming of the operator actual view	UN-0410-P5	To verify the possibility to share the actual user point of view in a remote session with an expert	S
<b>UR-FUNC-2200-P5</b>	Working area	Visualisation of the boundary at the working area	UN-2700-P5	To test the possibility to set the boundaries of the working areas on the headset	C
<b>UR-FUNC-2300-P5</b>	Customizable panels	Textures, specific images or background colours to text panels or buttons	UN-1800-P5 UN-1900-P5	Not applicable, already tested in UR-FUNC-1700-P5	M
			UN-1800-P5 UN-1900-P5	To test the possibility to use specific palette colour, icon sets etc. to create the experience in a recognizable way	
<b>UR-FUNC-2400-P5</b>	Gesture controls	Interaction with operators without controllers	UN-1400-P5	To test the correct response to the user gesture controls	S
<b>UR-FUNC-2510-P5</b>	<b>Remote call</b>	<b>Remote call with an expert</b>	<b>UN-0500-P5</b>	<b>To test the possibility to call remotely an experienced operator</b>	<b>S</b>
<b>UR-FUNC-2600-P5</b>	<b>Quick exit mode</b>	<b>The system needs to provide users with an easy self-termination</b>	<b>UN-1710-P5 UN-1720-P5</b>	<b>To test the possibility to exit the XR experience anytime in an</b>	<b>M</b>

		<b>option so they can exit sessions quickly if discomfort intensifies</b>		<b>easy and recognisable way</b>	
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TABLE 10: PILOT 5 USER REQUIREMENTS.

### 3 CONCLUSIONS

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This deliverable (*D3.4 Industrial User Requirements and Use-Case Scenarios v2*) represents a significant milestone in the user-centred development process of the MOTIVATE XR platform, consolidating the methodological foundations established in the previous WP3 activities and applying them in a phase following the Beta release testing. The work reported in this report clearly demonstrates how **User Needs and User Requirements evolve as system maturity increases** and as real usage conditions become available, emerging from the direct interaction of users with XR tools and authoring workflows.

The second iteration of User Needs and User Requirements highlights the importance of moving beyond initial assumptions by adopting an evidence-based and scenario-driven approach. Several needs, such as those related to usability, perceptual quality, interaction timing, XR session management, operational continuity, and experience optimisation, proved to be more or less relevant, or could be clearly defined only after the Pilots had the opportunity to directly experience the system during the Beta testing phase. In this context, the explicit distinction between authoring and experiencing perspectives proved essential to accurately describe the association of XR content throughout its lifecycle, from creation to fruition.

From a methodological perspective, the deliverable strengthens clarity, consistency, and traceability by systematically documenting the removal, rephrasing, and introduction of User Needs and User Requirements. **The alignment between the updated UNs and the revised URs ensures that each requirement is both meaningful from the end-user perspective and concretely implementable from a technical standpoint.** The decision to conclude the revision process at the level of User Requirements, without redefining generic system requirements, reflects the current maturity of the project and **supports a more effective transition towards the definition of Functional Specifications.**

An additional key value of the work done in *Task 3.2 Industrial User Requirements and Use-Case Scenario* lies and reported here is the systematic association of each User Requirement with a verification method, which reinforces a validation-oriented approach and enables an objective assessment of both already implemented functionalities and those to be implemented in subsequent phases. Furthermore, the classification of requirements according to the type of user involved (authoring, experiencing, or both) contributes to a more robust and informed design process, capable of coherently addressing the diverse operational needs that emerged across the different industrial pilots.

Overall, the work here reported consolidates the link between user-centred analysis and technical design, providing a solid foundation for the subsequent development, integration, and validation activities of the MOTIVATE XR platform. The outcomes of this deliverable directly feed into *Task 3.3 Functional Specification and Cybersecure Architecture* (Deliverable D3.6) and contribute to ensuring that the validation activities planned in WP6 and WP7 are fully aligned with real industrial expectations, operational constraints, and end-user needs.

## REFERENCES

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