NEWSLETTER #05

JUNE 2025

“SUN is approaching its last 6 months of operation.”

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Introduction

SUN is approaching its last 6 months of operation.

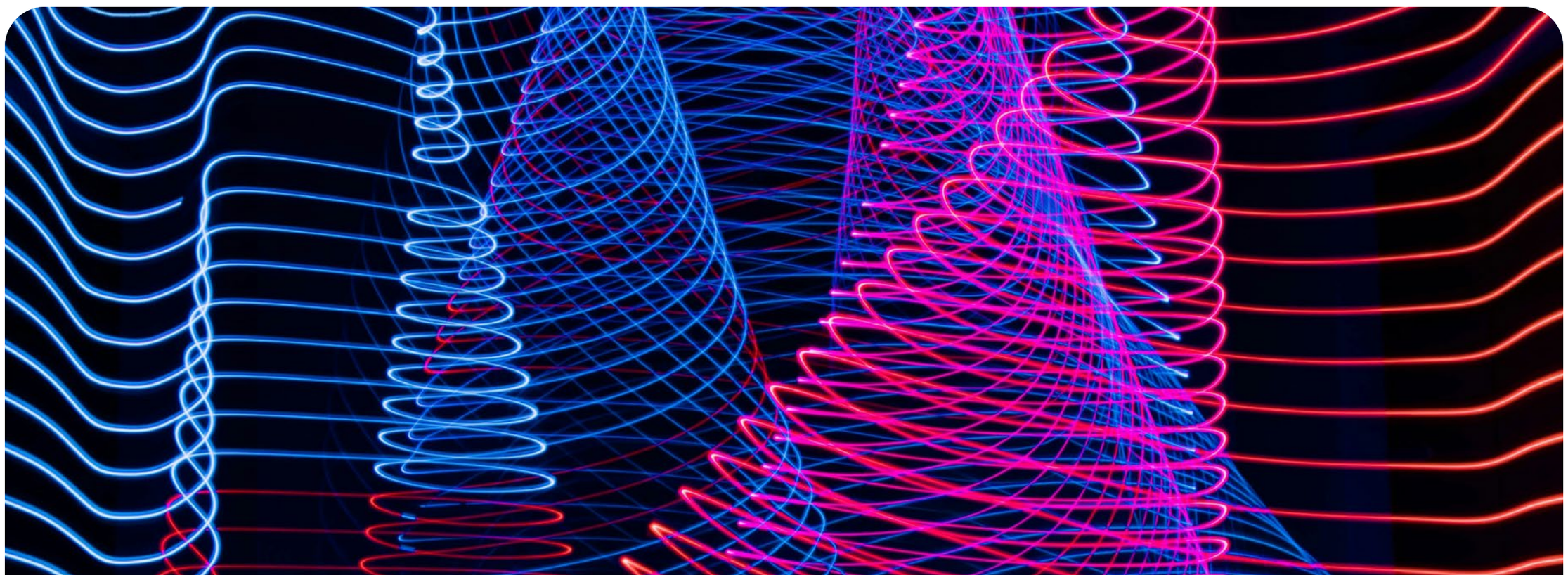
During the last six months, the innovative technologies developed by our technical partners have been tested and validated in 3 Pilots:

1. eXtended Reality for Rehabilitation.
2. eXtended Reality for Safety and Social Interaction at Work.
3. eXtended Reality for People with Serious Mobility and Verbal Communication Diseases.

Moreover, since the beginning of the project, most of the partners have made a great effort, which has resulted in 43 scientific publications.

This Newsletter offers an overview of the validation activities performed and open a window on the future exploitation.

You can be updated on the next exciting activity by visiting our website www.sun-xr-project.eu and following us on social media X, LinkedIn, Facebook and Instagram.



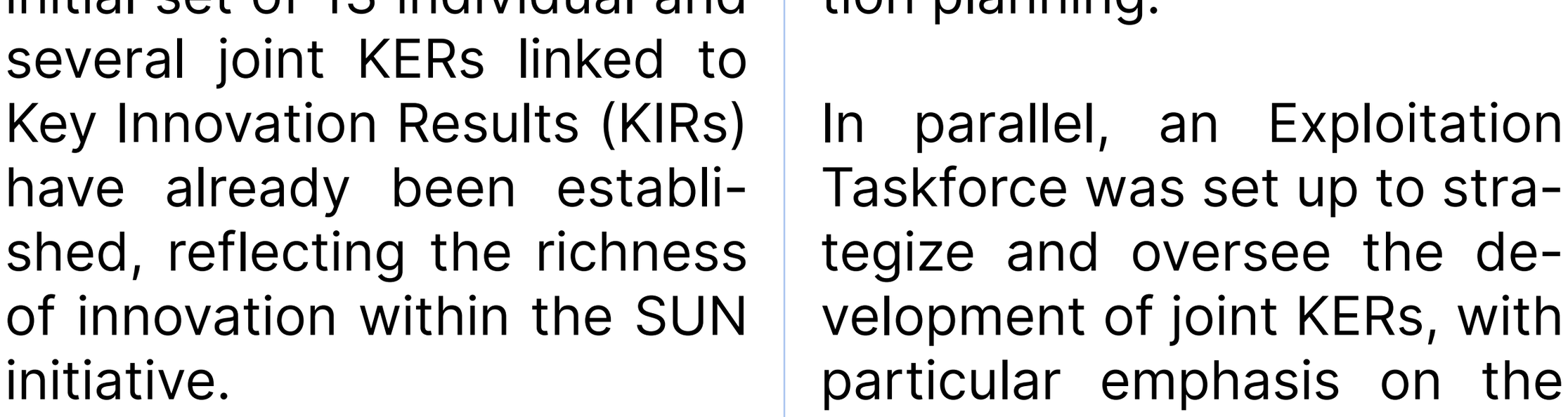
SUN Project Exploitation: Paving the Way for the Future of XR

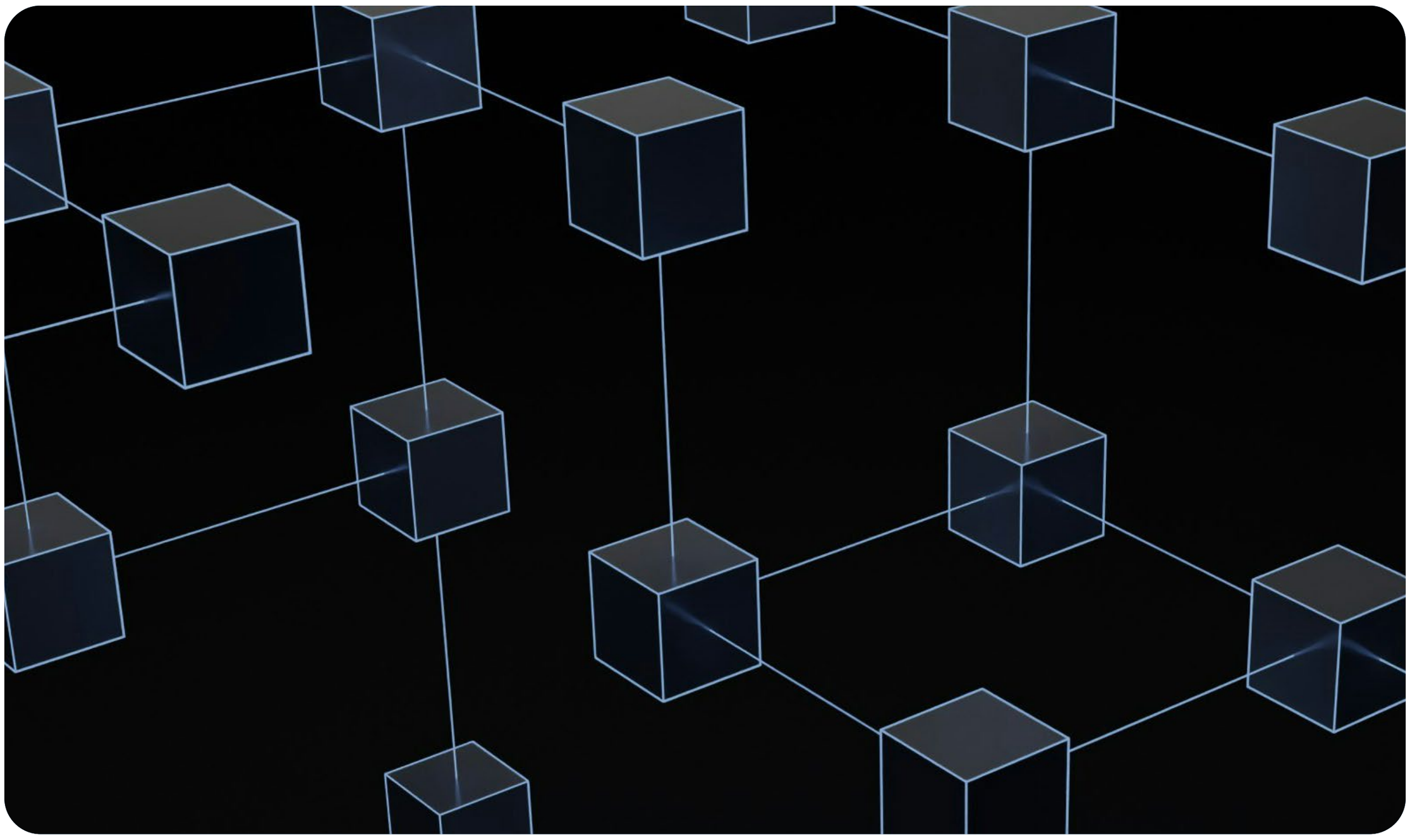
The Social and hUman ceNtered XR (SUN) project is rapidly progressing toward realizing its ambitious vision—integrating physical and virtual worlds to enhance social and human interaction through Extended Reality (XR) solutions. As we approach the final stages of the project, our focus intensifies on ensuring the sustainable and impactful exploitation of our Key Exploitable Results (KERs).

The SUN exploitation strategy involves identifying and leveraging individual KERs, created and owned by specific partners, and joint KERs, developed collaboratively across the consortium. An initial set of 13 individual and several joint KERs linked to Key Innovation Results (KIRs) have already been established, reflecting the richness of innovation within the SUN initiative.

To facilitate the successful market entry and impact of these innovations, IN2 Digital Innovations, who is the Exploitation Manager of the project, has conducted dedicated 1-to-1 business clinic workshops with each KER owner. These clinics enabled a deeper understanding of each KER, explored potential business models, identified key stakeholders, and developed unique value propositions using the Value Proposition Canvas method. Subsequently, participants worked together to create preliminary Business Model Canvases. The workshops received overwhelmingly positive feedback, highlighting this approach as a best practice for future exploitation planning.

In parallel, an Exploitation Taskforce was set up to strategize and oversee the development of joint KERs, with particular emphasis on the SUN Integrated Platform. This flagship result represen-





ts a secure, integrated solution combining advanced 3D acquisition, lifelike virtual experiences, and robust cyber-threat detection mechanisms using blockchain technologies. The platform targets critical markets beyond entertainment, including healthcare, industrial training, assistive technologies, and secure digital asset management.

Our exploitation pathways are diverse and tailored to maximize the impact across multiple domains:

1. Research & Scientific Exploitation: Led by research institutions, this includes academic publications, policy contributions, and the pursuit of further research funding.

2. Pilot Exploitation: Specific pilots aim to deliver targeted impacts—such as further research in rehabilitation (Pilot 1), improved training and services in industry 5.0 (Pilot 2), and innovative applications for the insurance sector (Pilot 3).

3. Spin-off Exploitation: A new start-up company is anticipated from EPFL, fostering innovation-driven entrepreneurship.

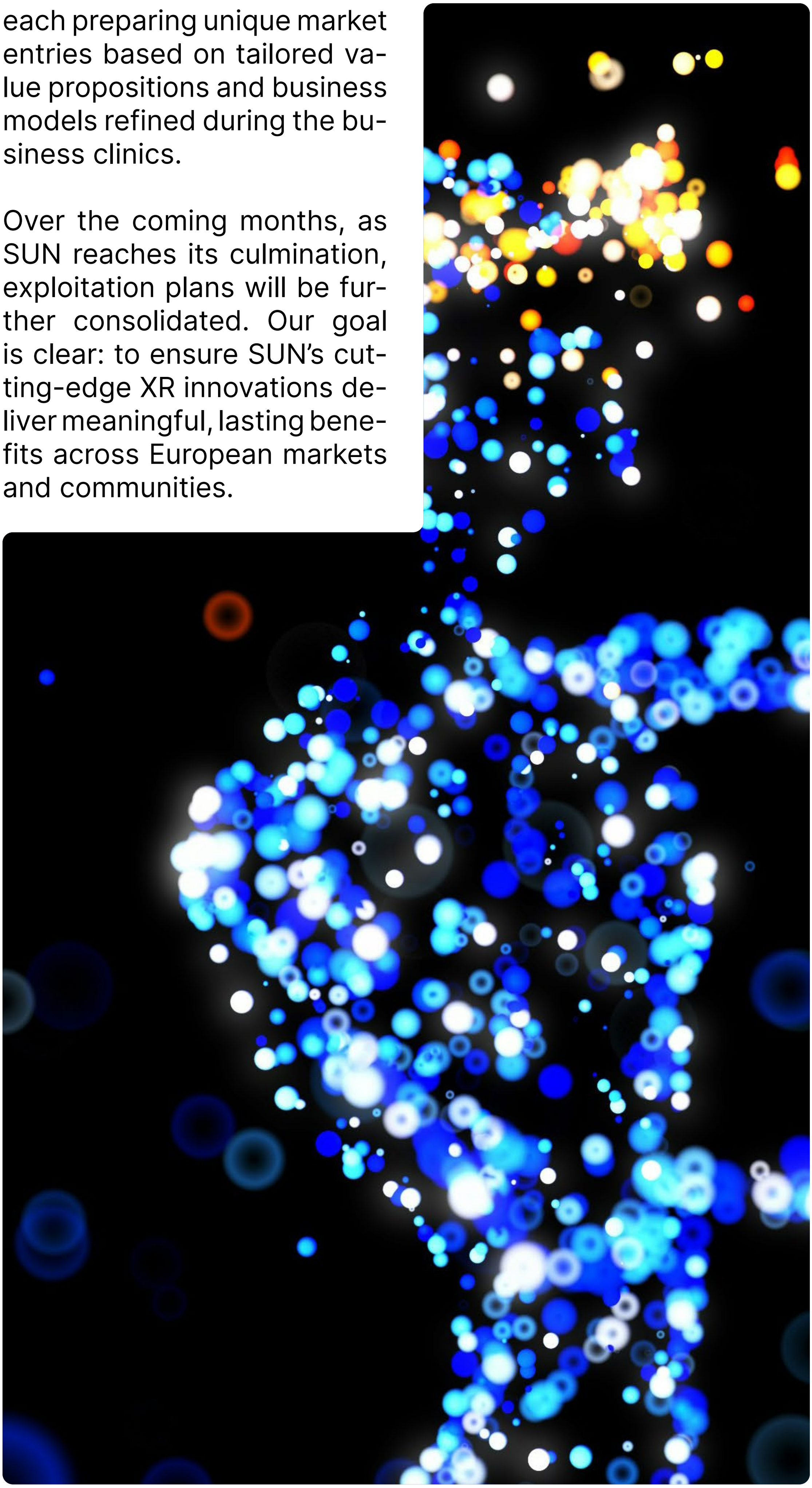
4. Integrated SUN Platform Joint Exploitation: Coordinated by IN2, this exploitation uses an open-core approach blending open-source elements with proprietary solutions, fostering collaboration across the XR ecosystem.

5. Joint KER Exploitation: For instance, collaboration between Thinkgenious and CERTH on advanced Pose Estimation techniques will drive further research and innovation.

6. Individual KER Exploitation: Thirteen KER owners are

each preparing unique market entries based on tailored value propositions and business models refined during the business clinics.

Over the coming months, as SUN reaches its culmination, exploitation plans will be further consolidated. Our goal is clear: to ensure SUN's cutting-edge XR innovations deliver meaningful, lasting benefits across European markets and communities.



Sun XR integrated platform: first validation for rehabilitation scenario

The first validation phase of SUN XR integrated platform for rehabilitation scenario (Pilot 1) took place in two dedicated rooms at Versilia Hospital in Lido di Camaiore – Lucca – Italy involving ten partner of SUN Project consortium.

The rehabilitation scenario outlined in Pilot 1 was developed with the aim of providing innovative solutions for the rehabilitation of orthopaedic, neurological, or oncological conditions, making rehabilitation sessions appealing, engaging, and stimulating from a social, playful, and cognitive perspective, maintaining direct patient-therapist communication.

Particularly innovative is the gait rehabilitation scenario, where the patient sees an avatar of themselves from behind - something that is not possible in real life -, which provides immediate visual feedback for each gait cycle phase.

In fact, motion sensors, electromyographic sensors, and haptic actuators provide feedback both to clinicians and to the patients on the correctness of the exercise execution.

The goal of this initial validation phase was to determining whether the integrated platform can operate in real rehabilitation setting and in particular, whether it is usable by clinical staff and patients in terms of ease of use, acceptance, overall satisfaction, and if the environment was adequate for the final validation phase. Objective of this first validation phase was to identify eventual issues that must be addressed in order to fine tune and adjust to the Pilot's needs for the second validation phase.

A total of eleven healthy volunteers (consisting of a mix between the hospital department staff and other members of the SUN consortium) participated as end-users in the upper limb and lower limb scenarios. Also a cyber-attack has been simulated by testing 22 volunteers.

For the upper limb the time needed for users' preparation (wearing the visor, the sensors, the haptic interface, etc) was approximately 15 min for the upper limb whilst for the lower limb about 30 min were needed.

The exercise consisted of

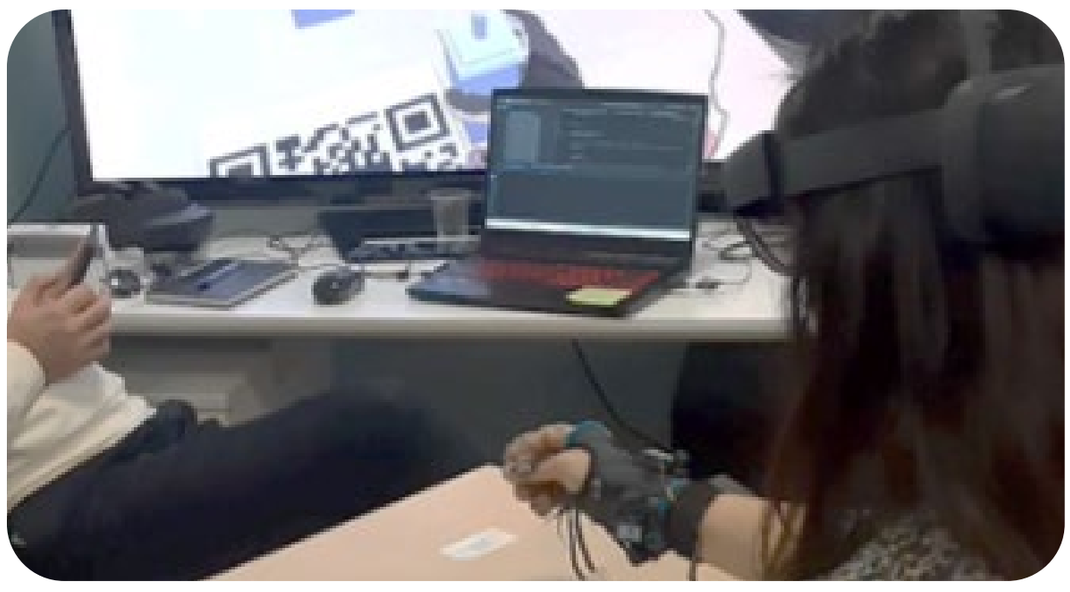
training the pick-and-place functionality. The subject had to reach targets in different areas and heights of the workspace. A game scenario was developed in an AR environment that aimed to train the upper limb motor function. The user was able to view the environment and perform the exercise through the AR HMD device HoloLens 2.

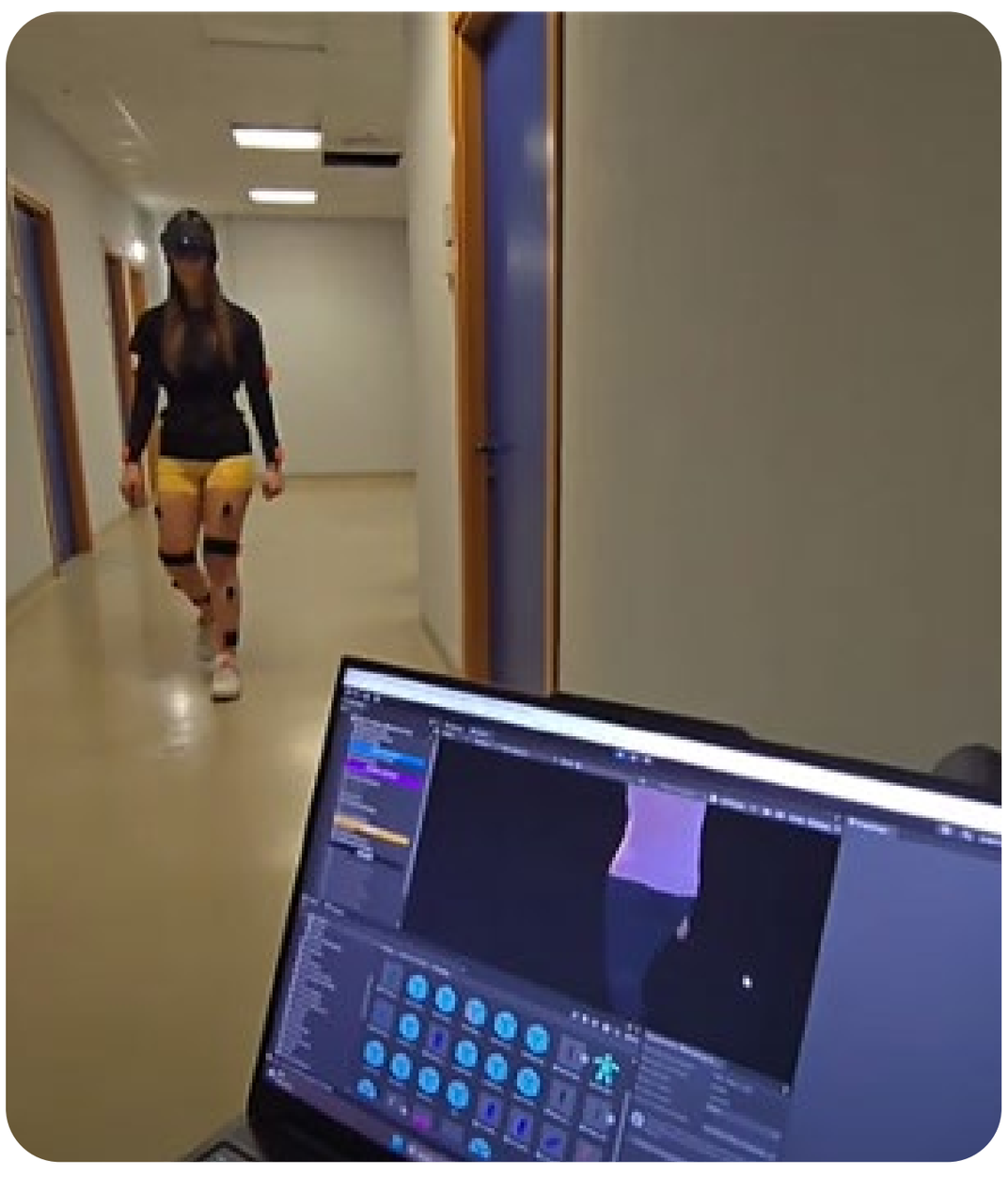
While the person is sitting, 3D objects are presented in front of them at the height of the desk. The subject must choose each of the objects and place them on specific targets on the vertical plane. The users wear a haptic interface on the tip of the finger, which enables the rendering of touch and pressure sensations by means of an actuated band in contact with the fingertip.

Furthermore, the users wear two other sensors, which are able to detect and monitor the emotional state and the effort made by the users while performing the exercises, providing very useful information about how much the users are engaged in the exercises.

Nine volunteers have been recruited (between hospital staff and other members of the sun pilot consortium) for the upper limb rehabilitation scenario.

The lower limb rehabilitation scenario consisted of three





different exercises: sitting leg flexion and extension, squats, and gait training. In this scenario, the AR environment is focused on the avatar, a patient avatar that replicates the patient's movements and provides guidance. At the beginning of the session, one of the three exercises can be chosen through the application menu. For the squat exercise, the avatar is positioned in a mirror image in front of the subject. Similarly, for the seated exercise, the avatar is positioned in front of the subject in a mirror image of the sitting position. For the gait training, the avatar is positioned in front of the subject, but is seen from behind, with a posterior perspective.

During the exercise, the patient's movements are replicated by the avatar and the system provides visual feedback on whether the patient has performed the exercise correctly.

FIRST VALIDATION FOR INDUSTRY SCENARIO

In the pilot 2, 2 cases explore the integration of **mixed reality (MR)** technologies, r**eal-time data analytics**, and **cybersecurity** within a shopfloor environment to enhance safety, operational efficiency, and human-machine interaction.

Case 1: Smart Training through Mixed Reality and AI-enhanced Avatars

In **Case 1**, FACTOR explored immersive training via an advanced MR application hosted within the **SUN-SET framework**. The central focus was the use of an intelligent **Avatar component**, integrated into the SUN-SET Server, to guide operators through hands-on safety and operational training.

The Avatar component serves as a virtual instructor, delivering prompts, feedback, and visual cues—potentially including virtual Personal Protective Equipment (PPE)—as the user progresses. These interactions are further enhanced by a **Hand Gesture Recognizer**, allowing intuitive responses such as thumbs-up (accept) and thumbs-down (decline).

All server-side logic, including the Avatar, gesture recognition, and cybersecurity monitoring (via **Cyber Threat Server**), is contained within the SUN-SET Server. This server streams the application to MR devices, such as the **HoloLens 2** or **Meta Quest 3**, through **Hololight's streaming service**.

On the client side, the **SUN-SET Client** and **Cyber Threat Client** ensure seamless delivery and local protection from cyber threats. Notably, these components are isolated from external communication, ensuring a secure and stable training environment.

External support is provided by components such as:

- **Image Recognizer:** Detects PPE usage using image analysis from server-streamed video.
- **OmniBridge:** Acts as a communication hub, ensuring smooth, secure message transmission.
- **Tokenized Platform:** Stores training materials and manages access rights.

Outcome:

The Case 1 pilot successfully demonstrated an immersive and interactive training solu-

tion that aligns with the industry's increasing demands for **hands-free, adaptive learning environments**. The combination of gesture control, real-time avatar interaction, and cybersecurity monitoring paves the way for safer, smarter, and more efficient onboarding and upskilling in the manufacturing sector.

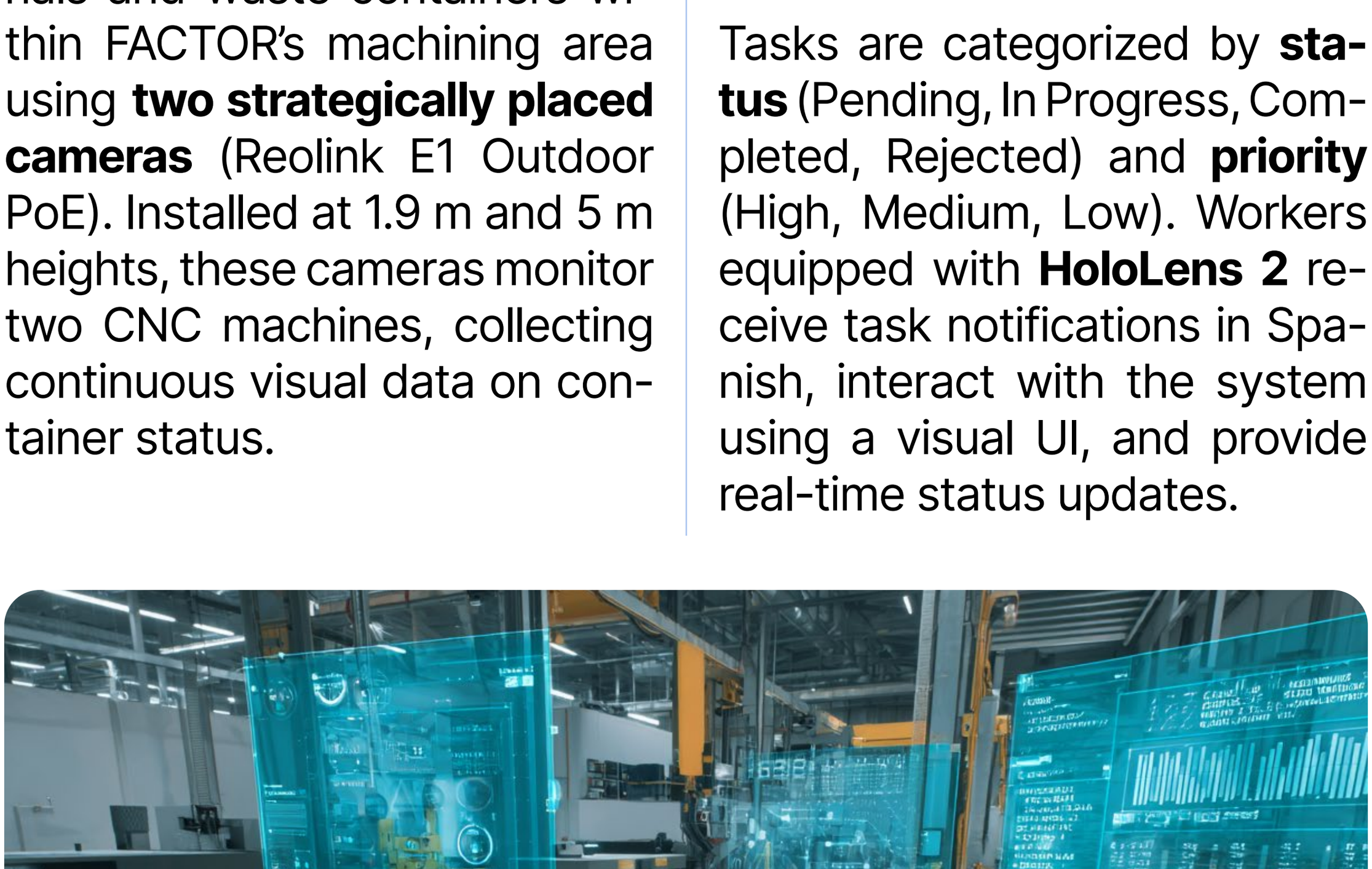
Case 2: Real-Time Shopfloor Monitoring and Task Prioritisation

Case 2 focuses on **real-time monitoring** of raw materials and waste containers within FACTOR's machining area using **two strategically placed cameras** (Reolink E1 Outdoor PoE). Installed at 1.9 m and 5 m heights, these cameras monitor two CNC machines, collecting continuous visual data on container status.

This visual data feeds into the **PRIORI-XR algorithm**, a rule-based task prioritisation engine designed to streamline shopfloor operations. The algorithm dynamically schedules tasks by:

- Identifying empty material containers and generating replenishment jobs.
- Assigning cutting tasks based on saw machine capacity.
- Detecting full waste bins and creating emptying tasks.
- Triggering maintenance tasks during shift changes.

Tasks are categorized by **status** (Pending, In Progress, Completed, Rejected) and **priority** (High, Medium, Low). Workers equipped with **HoloLens 2** receive task notifications in Spanish, interact with the system using a visual UI, and provide real-time status updates.



Validation & Next Steps:

Initial validation confirmed that PRIORI-XR responded accurately to simulated task inputs based on real-time video analysis. However, the team identified the need for:

- Extended testing periods to allow more dynamic interactions.
- Simulated container events to increase task variety and frequency.
- Real-time (not simulated) camera data in future phases.
- Broader factory coverage through **factory modeling**, reducing reliance on additional physical cameras.

Ultimately, FACTOR aims to integrate production metrics and system-wide data to offer a **comprehensive, real-time view of shopfloor operations**, empowering human operators with actionable insights while minimizing manual intervention.

SUN-XR Pilot 3: Successful Technical Validation with Healthy Volunteers

In Europe, incomplete tetraplegia (partial paralysis affecting all four limbs) is more common than complete tetraplegia. This often involves injuries to the cervical spinal cord (C1–C8), resulting in motor disability of the upper limbs. The exact prevalence varies by country, but incomplete lesions constitute a significant proportion of spinal cord injuries (SCI). In Western Europe, the incidence of SCI is about 16 per million translating around 8’000 new cases annually.

Incomplete tetraplegia often results in upper limb motor impairments, which can range from mild weakness to significant loss of hand and arm function. This impairment greatly affects daily living activities and independence. It is therefore vital to develop new tools or new therapeutic approaches to enable these patients to engage in daily activities and interact with their family and friends.

Pilot 3 aims to address significant functional limitations, such as those experienced by individuals with incomplete tetraplegia, by developing robust XR-based tools to improve motor control and social interaction.

In this Pilot, we evaluate the ability of the SUN platform to improve motor control and social interactions. Given the importance of feedback for the use of human-machine interfaces, we will assess the efficiency of multiple feedback strategies to increase engagement, efficiency of interactions within the platform and motor function in general. In particular, we will deliver haptic, thermal and reinforcement feedback to users of the platform and determine the optimal combination of feedback for pleasant and efficient use of the SUN platform.

From April 14-16, 2025, partners convened at Campus Biotech in Geneva to test the integrated innovative system for digital rehabilitation and virtual interaction (designed for individuals with severe motor disabilities) with healthy volunteers from the SUN consortium.

The initial phase was focused on integrating a Virtual Reality (VR) system enabling users with upper limb impairments to interact using Electromyography (EMG)-based control within a VR application with

wearable haptic feedback, integrated thermal feedback, and an emotion recognition module.

Key Outcomes & Learnings:

- **Successful System Integration:** Core components (EMG control, VR, haptic, and thermal feedback) were successfully integrated and demonstrated stable operation.

- **Refined EMG Control:** A move to a direct movement classification for EMG significantly improved decoding accuracy and simplified calibration, enhancing adaptability.

- **Operational Sensory Feedback:** Both haptic and thermal feedback systems functioned effectively, confirming their technical viability.

- **Identified Enhancements:**

    - The need for wireless EMG and thermal systems was identified to prevent signal interference observed with wired components.

    - Streamlined network configurations were noted as important for future deployments.

- **Cybersecurity Validated:** In parallel, UoG successfully tested an Intrusion Detection System (IDS) within the Pilot 3 VR context, demonstrating its effectiveness in detecting simulated attacks and the clarity of its user warnings. This is crucial for ensuring system trustworthiness.

The positive outcomes from this healthy subject validation in Geneva are vital for refining the system's robustness and usability. The refined EMG control, plans for wireless sensory modules, and cybersecurity insights will directly inform the next stage.

Next Steps: Clinical Testing

The SUN-XR Pilot 3 team is now preparing for clinical testing with patients, whic will be crucial for evaluating the system's clinical efficacy and real-world impact, where we will then test the possibility of using such multimodal feedback strategy for patients with motor disability and favour engagement in the platform, immersivity, improvement in motor function, and thereby interaction with others. The next Pilot 3 validation will take place at the Clinique Romande de Réadaptation (CRR-SUVA) in Sion, Switzerland, in October 2025.

The project started on the 1st of december 2022
and will end on the 30th of november 2025

Funded by
the European Union

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