SMART DIGITAL SYSTEMS FOR IMPROVING WORKERS' SAFETY AND HEALTH

ASSISTED REALITY DEVICE FOR REMOTE OSH ASSESSMENTS & AUDIT

1 Introduction

New digital systems and technologies entering EU workplaces are reshaping work environments for workers and employers alike. Innovations in smart wearables, exoskeletons, artificial intelligence (AI), machine learning (ML), internet of things (IoT), virtual and augmented reality (VR and AR), among others, are giving new opportunities for preventing and responding to workplace risks.

As part of EU-OSHA's occupational safety and health (OSH) overview programme (2020-2023)[1], EU-OSHA has examined the challenges and opportunities of smart digital tools and monitoring systems for improving workers' safety and health. These systems, leverage digital technology to collect and analyse data in order to identify and assess risks, prevent and/or minimise harm and promote OSH.[2] EU-OSHA has categorised such systems into proactive (preventive) and reactive, albeit acknowledging the potential overlap between the two.[3] EU-OSHA further provided an overview of the risks and opportunities associated with these systems[4] and explored the workplace resources that could ensure their safe and healthy use.[5]

In order to investigate the practical implementation of smart digital tools and new OSH monitoring systems for improving workers' safety and health, EU-OSHA has developed a number of case studies. This set of case studies includes both cases of smart digital systems at the level of design/development and cases of companies implementing the systems. The case studies accordingly investigate aspects related to the design/development stage and to the implementation stage. OSH aspects including worker's involvement was considered in all case studies taking into account the type of case study. Further all case studies look at possible drivers, barriers and success factors for safe and effective implementation.

To develop these case studies, apart from desk research, a number of interviews with key informants were conducted, including workers' representatives, safety officers, employers and representatives of industry associations. In addition, at company level, up to five interviews were conducted with operators, data protection officers, health and safety engineers, managers, work councillors and technology officers. The interviews had a duration of 1-1.5 hours each and were performed in the participants' native language, if possible, or alternatively in English, an interview guide, while the results of the interviews were anonymised. The case studies referring to designers' results do not contain detailed information on workplace implementation, as there has been limited collection of information from companies in which the systems are installed.

In total 15 cases were identified, and preliminary information was collected for these through a questionnaire, hereafter, nine of them were further developed into case studies.

[1] For more information, see: osha.europa.eu (n.d.) Digitalisation of work. Available at: https://osha.europa.eu/en/themes/digitalisation-work

[2] EU-OSHA (2023). Smart digital monitoring systems for occupational safety and health: uses and challenges, https://osha.europa.eu/en/publications/smart-digital-monitoring-systems-occupational-safety-and-health-uses-and-challenges

[3] Ibid.

[4] Ibid.

[5] EU-OSHA (2023). Smart digital monitoring systems for occupational safety and health: workplace resources for design, implementation and use, https://osha.europa.eu/en/publications/smart-digital-monitoring-systems-occupational-safety-and-health-workplace-resources-design-implementation-and-use

2 Description of smart digital system for OSH

2.1 General company description (implementer & developer)

The user of the system is a German multinational technology company focused on industry, infrastructure, transport and healthcare. The company creates technologies that are used for more resource-efficient factories, resilient supply chains, smarter buildings and grids, cleaner and more comfortable transportation and advanced healthcare. By combining the real and the digital worlds, the company aims to empower its customers to transform their industries and markets.

The system's developer and producer is a global leader in hands-free, wearable computing solutions for frontline workers. The company was founded in 2016 and is headquartered in the United States, with offices worldwide. Through their products, it aims to increase worker performance and improve safety.

2.2 System description

2.2.1 What is the system about?

The solution described in this case study involves using **smart-glasses-type devices** (also called **head-mounted tablets** or assisted or extended reality wearable devices) for the purpose of conducting remote occupational safety and health (OSH) assessments and audits. Such solutions employ digital technologies to **allow OSH professionals, experts and auditors to participate in assessments or audits in real time, remotely**, without the need for a physical presence on site.

Currently, widescale use of more advanced technologies is possible, particularly for hands-free devices such as video headsets and smart glasses for live communication and broadcasting during on-site inspections or walkthroughs. This allows people not present on site to participate remotely in the assessment or audit. The advanced solutions fulfil requirements in terms of quality of audio and video data, administration and secure transmission, ease of use and durability. Furthermore, the current advanced solutions may allow wearers and users of such devices on site to **access and interact with powerful apps, streamline work processes through workflows**, **digitally record findings**, and conveniently **read documents with an integrated document reader**. In this way, the device provides benefits for OSH together with improved efficiency in various industries.

The extent to which remote tools can be used for audits and assessment is flexible: an audit can be fully remote, with no physical presence of OSH professionals on site; or partly remote, when the on-site team is 'virtually' accompanied by additional professionals or experts. Remote solutions can be used for many OSH applications, such as internal or external audits, accident investigations, and safety walks and talks.

Figure 1: Cartoon-style representation of the system

2.2.2 How does the device look?

The device was developed for **industrial environments.** Due to its placement on the user's head, such devices are sometimes termed smart glasses, or in other contexts, assisted or extended reality wearable devices. The device described in this case study is in fact a mini-computer with the following functionalities:
Wi-Fi and Bluetooth connectivity to exchange data, a **high-definition camera** with image stabilisation for capturing and transmitting photos and videos; a small, **high-resolution screen** that displays the operating commands and menus as well as the transmitted image; a **microphone and speakers** that allow two-way audio communication, **voice control and noise reduction**; a replaceable **battery** with 6 to 8 hours capacity; and an **operating system** allowing the use of numerous applications for the device's interface and **off-the-shelf software**.

Frontline workers using assisted reality wearable devices can have access to information, assistance and expertise while keeping their hands free for work. This is a significant advantage over the use of rugged tablets or heavy manuals in terms of usability and contributes to the safety of the worker. **Optionally, the device can be mounted on safety helmets and bump caps, and used with hearing protection, safety glasses or corrective eyewear**. While the screen itself is small, its placement near the user's line of sight gives an effective view, similar to that of a 10-inch tablet. Apps are controlled by voice commands (hands-free), without the need for scrolling, swiping or tapping.

2.2.3 How does the system work?

In the implementation described in this case study, the system is used for remote assessments and audits. The device streams video from the perspective of a worker who is present on site and wears the device on their head, usually attached to a standard safety helmet. The worker receives feedback from other personnel (e.g. OSH professionals) via the small screen or audio. Communication between the wearer and remote participants is handled via existing off-the-shelf software for video conferencing. To exchange data, the device requires an Internet connection, which is provided by a Wi-Fi network or a cell phone hotspot.

Figure 2: OSH monitoring system's use of technologies

Wi-Fi	Assisted reality	Remote connectivity	Cloud-based platform
The Wi-Fi connectivity integrated in the device provides stable Internet access.	Additional information can be displayed on the multifunctional screen.	Multiple persons connect at different locations, using various devices.	Cloud-based software is used for communication and storing documentation.

2.2.4 Examples of use

The company representatives described an internal remote audit at a warehouse site with a dedicated area for spare parts storage and another area for logistics. Because these areas serve different functions, they must **each meet different OSH requirements** and have different aspects that must be inspected. In this example, the audit was the first application of the wearable solution at that specific site. The staff wanted to test several issues: (a) whether the device can be used safely during the walkthrough by the wearer; (b) whether the connectivity allows for continual, undisturbed communication with the personnel participating remotely; and (c) whether all information necessary for the audit can be collected with the use of the smart glasses. The test confirmed that using the device in a remote audit is more than sufficient to check emergency devices such as fire extinguishers, fire

alarm boxes, standardised infrastructure like storage racks, and test badges placed on equipment – without the need for OSH specialists' on-site presence.

Limitations were identified in audio communication with third parties on-site. For the remote participant to communicate clearly with others located at the site who are not in the call, either additional microphones and speakers or direct participation in the call with their own devices is required.

Furthermore, the table below compares a use case example of a remote OSH assessment using hands-free computing with one of a traditional OSH assessment process.

Table 1: Comparison of traditional and remote assessments

Traditional on-site assessment	Assessment with remote technology
Two to four people participate in the assessment on-site, during 4 full workdays; travel time and travel costs need to be considered for all travellers.	Two to four people participate, some on-site and others remotely; assessment duration can be planned flexibly; and travel time and expenses are reduced.
On-site staff resources are committed for a full week. The Site OSH Representative is heavily involved with providing information to assessors prior to and during the assessment.	Assessment activities are more flexible and can be better embedded in the standard operating process: for example, they can be spread over several weeks and split into smaller segments of 1 to 1.5 hours, easing the burden on the Site OSH Representative.
Assessment involves in-person visual inspections, physical observations and compliance sampling, using both hands for the work.	Assessment involves safer and cost-effective virtual visual inspections, physical observations and compliance sampling, using smart glasses for remote assessments and audits, without the necessity of hand use to reference information and work with a remote expert.
Interviews with key facility staff, workers and contractors are conducted on-site.	Interviews with key facility staff, workers and contractors are conducted via remote tools (for example, phone or video conferencing software).
OSH administrative and operating records are reviewed on-site.	OSH administrative and operating records are reviewed off-site.

3 System implementation: drivers and barriers

When it comes to the implementation, the remote assessment process involves several steps, starting with:

1. **Defining the assessment purpose and framework for operation**, e.g. checking the layout of the site to identify the route and safe walking paths together with side staff, and assess barriers, e.g. barricaded areas or areas where filming is not permitted;
2. **Familiarisation with the technical equipment,** includes camera and audio handling, usage of helmets (if necessary) and checking remote connectivity;
3. **Carrying out a short dry run,** with the device user and also the auditor, and if needed, an assistant at the site;
4. **Conducting the remote audit**, and
5. **Reflection and recap** after the audit to reflect on the process and make potential improvements. This includes defining best practices, sharing them with colleagues and communicating them to on-site staff and other company personnel through the relevant channels such as the company's intranet.

Learning throughout the organisation is facilitated thanks to the assessment recording that can be stored in the cloud, replayed on demand, and displayed in the context of relevant documentation.

In the case study at hand, **worker-centricity was key**. The introduction and pilot testing of remote audits and assessments using digital technology were thoroughly discussed across various business locations with local workers councils.

Moreover, **a central agreement with the workers council in Germany** further supported these efforts. The benefits of the system were positively received by the workers in general. According to interviewees, remote assessments conducted with the system lead to the same results as traditional on-site assessments: providing an overall assessment of a facility's capability and compliance with OSH regulations, company policies, standards and plant procedures. The process described above ensures that remote assessments and audits are implemented smoothly and facilitates learning throughout the organisation.

Especially notable was the positive reception from employees during the COVID-19 crisis, appreciating the opportunity to utilize digital tools for remote audits and assessments.

3.1 Motivators and goals

The advent of new technologies for remote assessments, audits and on-site visits was not a sudden development but rather a **result of careful design, piloting and utilisation**. Motivators included the best utilisation of resources across multiple, remote sites, including OSH personnel with adequate experience and expertise and improving OSH processes. However, interviewees believed that it was during the **COVID-19 pandemic** that the true value and potential of these remote technologies for OSH purposes was underscored.

Furthermore, the benefits of remote assessments, audits and on-site visits extend beyond those cases that do not allow physical presence of an auditor. After the pandemic, these technologies were still expected to continue to play a significant role in OSH practices. The **convenience, efficiency and cost-effectiveness offered by remote technologies** make them an attractive option for businesses seeking to optimise their operations, improve safety standards and provide comprehensive risk assessments.

The company described in this case study is extensively exploring and implementing such remote technologies. An internal **initiative called 'Going Remote'** was run across the different businesses of the company. By **providing information and training sessions and conducting pilots globally**, the use of **extended reality devices for quality management (QM) and OSH purposes** increased continuously, and OSH processes were improved. The experiences gained proved particularly valuable during the pandemic, as they provided a viable alternative to traditional in-person assessments, audits and visits. This has allowed businesses and organisations to continue ensuring the safety and health of their workers without compromising on the quality of practices.

Interviewees also noted that motivation to implement new systems can be financial, as remote audits and assessments offer cost-saving benefits. Accidents and incidents in the workplace can be costly due to medical expenses, compensation claims and production downtime. By implementing remote assessment practices, organisations can **proactively identify and address potential risks, thereby reducing the likelihood of costly incidents**.

3.2 Drivers

Technical advancements enable the effective implementation of remote audits and assessments. **Robust and user-friendly remote technologies** provide organisations with the necessary tools to conduct thorough assessments remotely. These technologies ensure seamless communication, data collection and real-time collaboration between auditors and assessors, improving the efficiency and accuracy of the assessment process.

Apart from the educational dimension of the technology and its benefits, other factors were also crucial in implementation. Referring to the scale of adoption throughout the company, interviewees noted that **cybersecurity and data privacy clearance by the internal IT department was a prerequisite** – without this, use of such devices would not be possible. An additional factor is the procurement of such devices and the ordering process for users. The implementing company has its own internal **web shop**

where devices and products can be bought or rented. These technologies have revolutionised remote assessments, audits and on-site visits, optimising communication and collaboration.

Organisational factors also advance the integration of remote audits and assessments. The implementation of remote assessment practices can **address gaps in the OSH management system**. By incorporating remote technologies, organisations can improve their OSH management processes, ensuring comprehensive and effective assessments. This contributes to a more robust overall safety framework within the organisation.

The interviewees noted that the growing number of use cases across business units, sectors and sites is truly remarkable. This proliferation of remote technologies not only demonstrates their effectiveness but also highlights **the positive impact of digitalisation on streamlining OSH processes and QM**. By embracing these innovative solutions, business units have been able to adapt and overcome the challenges posed by the pandemic, while still maintaining a high level of safety and compliance.

The company's representatives also mentioned **reputational considerations** as a driver for adapting remote audits and assessments across different business units and organisations. By demonstrating a commitment to safety and adopting innovative practices, they can improve the attractiveness of its work and inclusivity. Remote assessment practices can help create **a safe and inclusive work environment**, attracting talented individuals and elevating the organisation's reputation.

3.3 Barriers

There have been several barriers and challenges to the adoption of remote audits and assessments, as reported by interviewees. However, over time, these obstacles have changed, and the perceptions of the users and managers have evolved. The challenges are legal, economic, technical and psychological.

Legal barriers have presented a significant challenge in implementing remote audits and assessments. Compliance with regulations and data protection laws has been a concern, particularly the sharing of sensitive information remotely. However, advancements in data privacy laws in the EU and the development of remote technologies that prioritise data security and privacy have eroded these barriers. Employers now have clearer guidelines on how to handle data securely during remote assessments.

Economic factors, such as the initial investment required to set up the remote technologies and train personnel to use them might deter organisations from adopting these solutions. However, over time, remote technologies have become more affordable and thus more accessible to more organisations. Additionally, the potential cost savings gained from reduced travel and increased efficiency have become more apparent, leading to a shift in perception of the economic benefits of remote assessments.

Technical barriers included connectivity, compatibility with existing systems and the reliability of remote technologies. The device requires continuous internet connectivity, which must be available on-site through Wi-Fi or 5G coverage. Without sufficient internet access coverage at the location, a remote OSH process (audit or assessment) is not possible. However, advancements in technology such as improved network infrastructure and more robust remote assessment platforms have addressed many of these challenges. Interviewees noted that technological advancements largely reduced limitations such as durability or battery life. The availability of user-friendly and reliable remote technologies has led to increased confidence in their usage.

And last, as noted by the interviewed managers in the global company, different cultures have varying levels of **acceptance among users and trust** in remote technologies. However, with globalisation and the rise in remote communication, such barriers have gradually dropped. Organisations and individuals from diverse cultural backgrounds now have more exposure to remote technologies, leading to greater acceptance and integration.

4 OSH impact

4.1 Opportunities

The implementation of the system creates multiple opportunities for workers, OSH professionals, and for the OSH system and management.

In terms of security and safety, remote audits and assessments can help mitigate increased risk, exemplifying a proactive approach to OSH monitoring. By **minimising physical presence and reducing potential exposure to hazardous environments**, remote technologies provide a **safer alternative for auditors or OSH professionals conducting assessments**. This is particularly important in high-risk industries. For the device wearer during the walkthrough, the risks are lower since they know the workplace, but are further mitigated by adequate preparation and planning, as described above. Compared to the other solutions used for remote assessments, such as using a smartphone, the most significant benefits of the device are the assisted reality features and the hands-free option. The improved usability and interface can create stronger engagement with OSH procedures.

The system improves communication, enabling mobile real-time communication between on-site workers and remote auditors, allowing remote assistance and **efficient problem-solving as well as immediate clarification and resolution of safety issues.** This contributes to increased efficiency of the OSH assessment or audit, and safety in the workplace while the remote visit is under way.

As an element of OSH monitoring, the system increases **proactive hazard identification, enabling early detection of potential safety hazards** and the ability to implement preventive measures before accidents occur.

With regard to OSH management, company representatives highlighted that the possibilities enabled by digitalisation have **simplified OSH processes as well as QM**. The solution improves the efficiency of OSH processes by reducing the total assessment/audit duration, required workload and effort. It provides an opportunity for efficiency, as travel is also eliminated, and the need for on-site presence of multiple auditors is reduced. At OSH system level, the reduced logistical constraints could increase the frequency of audits, which better support efforts to maintain and improve safety standards. For the OSH professionals and experts involved, the potential to reduced travel time and workload can **improve well-being and work-life balance**.

With the use of digital and remote tools, assessment planning is streamlined, as OSH professionals can be involved flexibly and independently of location. This allows **broader expertise involvement**, enabling the organisation to use geographically dispersed expertise, particularly important when specific experience or specialised knowledge is required. Moreover, collaborative audits with multiple experts providing diverse insights are possible. The solution creates the opportunity of improved adaptability to different environments and flexibility to audit various types of workplaces, including those that are hard to access.

The reactive approach to OSH monitoring is another benefit; the device can be used **for accident investigation, provide data for corrective measures and thus contribute to the continuous cycle of OSH improvement**. As assessments can easily be recorded, the documentation and tracking of issues is simplified. This increases transparency, providing comprehensive and verifiable records of audits, and improves the accountability in maintaining safety standards. Moreover, the recordings can later be used for additional assessment, training or sharing of best practice, enhancing training and skill development. The device's communication features can also be used in live demonstrations and remote coaching during audits.

4.2 Challenges

Apart from its opportunities, the use of the system must also be viewed in terms of OSH risks and challenges.

As with any device, **technical failures** need to be considered. There is a risk of equipment malfunction, and certain environmental limitations need to be taken into account: the performance in adverse conditions (for example, extreme temperatures and poor lighting) and the durability and resilience in rugged environments. Interviewees noted that the specific assisted reality device described in this case study performs well in such conditions and environments. However, to serve its purpose, the device requires continuous internet connectivity, which needs to be available on-site. Without sufficient

coverage, interruptions in video and audio transmission are possible, which may be an issue during critical audits and may even lead to incorrect assessments.

The assisted reality device described in this case study is placed on the user's head (such devices are sometimes termed smart glasses), which may also pose risks. Potentially, such devices can cause **mental and cognitive overload, disorientation, visual strain or long-term issues related to sight**. In certain environments, wearing the device might pose **physical safety hazards**. There may also be issues with **human-machine interface.** However, interviewees stressed that the health and safety risks were addressed during product design and in training, while users reported that after training, the interface is user-friendly. For example, as mentioned in the interviews:

> *"At the at the beginning some colleagues were a bit sceptical about the weight of the device and also the monitor in front of the eye, but once they did have the chance to test it, after a short time they got used it and also to the voice commands and they're started really liking it".*

Another challenge relates to the **accuracy and reliability of the technology**. There are limitations to what the device can capture, and an auditor present on site may better comprehend the full context of conditions. Nevertheless, there is a risk of *missing subtle but critical safety issues* when conducting a remote assessment.

Similarly to other new OSH monitoring systems, the solution covered in this case study brings the risk of **over-reliance on technology**. Traditional safety practices may be neglected, and human judgement skipped if workers and auditors become complacent. Such considerations highlight that new solutions need to be implemented as **part of the broader OSH system**, and not as a substitute for it.

Interviewees indicated that psychological and behavioural factors have influenced the adoption of remote audits and assessments. Potential OSH challenges include resistance from the workforce – **reluctance among workers to be monitored and concerns about privacy and constant surveillance**; and **challenges in training and adaptation** – the need for comprehensive training for effective use of the device and time and resources required to integrate its use in OSH processes. The implementing company responded by *providing organisational support during the set-up of the solution across business units.* The technology was presented at in-person and online events which included question-and-answer sessions, and an intranet website was set up, featuring a broad range of information: testimonials, use cases in different business units, explanations of how to use the device, an option to provide feedback, and an option to request support.

There are challenges to **interpersonal communication intrinsically linked to remote solutions**, and this is also the case of the system described here. As in-person visits are substituted by remote collaboration, face-to-face interactions and relationship-building are hindered. The effectiveness of some audits may potentially be reduced by the dependence on virtual communication.

However, according to interviewees, as remote work and virtual collaboration have grown more prevalent, individuals and organisations within the company have become more accustomed to remote technologies. The perception of remote assessments has shifted: it is no longer seen as a disruption but is recognised as an efficient and effective alternative, and in fact an improvement in safety.

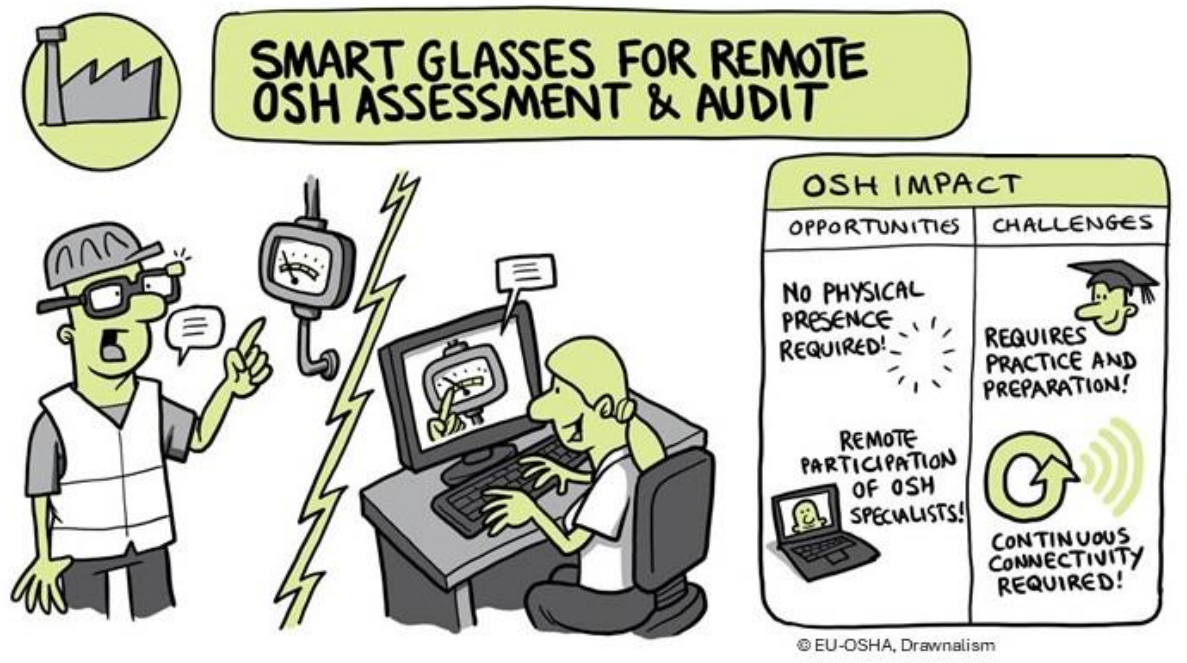
Since the technology is digital, the organisation must also implement adequate **data protection and cybersecurity** measures to mitigate vulnerability to cyberattacks and unauthorised data access. Data privacy regulations and laws related to remote monitoring and recording need to be considered when conducting assessments and planning the processing of the information that has been collected. **While the system is not used for surveillance, the company needs to ensure that the system is used properly and data that have been collected are used ethically.** According to interviewees, the implementing company responded to these challenges by close collaboration with the IT and legal departments.

As highlighted by company managers, effective use of remote technologies for OSH purposes requires adequate **preparation and planning.** It can be challenging in new locations, or with managers and staff who are unaware of remote technologies. The technology must be **introduced and tested prior**

to its application, and the expectations of all parties must be clarified and managed. However, the interviewees noted that with appropriate measures in place, risks can be mitigated and the challenges overcome.

Figure 3 presents a cartoon-style depiction of the system in remote assessments and audits, along with the respective opportunities and potential challenges.

Figure 3: Smart glasses, opportunities and challenges for OSH



5 Takeaways for development and implementation

This section outlines a balance between technological reliance and human vigilance through training and awareness programmes;

- ensure data accuracy: regularly calibrate and validate the systems to ensure accurate data capture and interpretation
- improve cybersecurity: implement robust cybersecurity measures, including regular security audits, encryption and secure access controls
- address privacy concerns: engage workers or their representatives to address concerns over personal data collection, provide comprehensive information and establish clear policies on data usage and worker monitoring, ensuring transparency and consent;
- monitor cognitive load: set guidelines for usage to prevent cognitive and visual strain, and provide regular breaks;
- plan for implementation and maintenance: allocate sufficient resources for the proper implementation and worker involvement and regular maintenance of the system;
- act on the data insights to foster a proactive safety culture in the workplace;
- adequately plan and prepare remote assessments so the process is conducted safely and comfortably for on-site personnel.

List of abbreviations

AI	Artificial intelligence
AR	Augmented reality
IoT	Internet of things
ML	Machine learning
OSH	Occupational safety and health
QM	Quality management
VR	Virtual reality

Author: Paweł Hess (Ecorys).

Project management: Annick Starren and Ioannis Anyfantis — European Agency for Safety and Health at Work (EU-OSHA).

This case study was commissioned by the European Agency for Safety and Health at Work (EU-OSHA). Its contents, including any opinions and/or conclusions expressed, are those of the authors alone and do not necessarily reflect the views of EU-OSHA.