HUMAN CENTERED

APPROACH IN

INDUSTRIAL

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CORE

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Wearable Technologies for Safety at Work: A Human-Centered Approach in Industrial Environments

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If you don't like
something, change it

ABSTRACT

The manufacturing environment is a context characterized by **high physical and cognitive demands**, complex safety dynamics, and a traditional safety system that is often fragmented and reactive. At the same time, the introduction of digital monitoring technologies may be perceived as intrusive and control-oriented. This thesis aims to **investigate the potential of wearable technologies and data-centric approaches** in the context of safety and well-being while maintaining trust, usability, and the centrality of the human.

The project consists of the development of an ecosystem composed mainly of CORE-bands, external artifacts for data collection, and the CORE system.

CORE-band is a wrist device that, along with other external artifacts, calculates physical, cognitive, and environmental data during the work shift. It helps workers remain aware of their psychophysical state and communicate quickly in emergency situations. Interaction with the wearable device is non-invasive, ensuring compatibility with the high demands of the work environment.

Core System, on the other hand, splits in two to provide a general view of the data collected from the CORE-bands and associated artifacts for the workers and supervisors. The main task of the system is to focus on patterns, trends and environmental context instead of focusing on studying the individual. This is very important as it meets safety management requirements while respecting worker autonomy and independence. For workers, it provides trends and insights into the psycho-physical progress at work, while for supervisors it offers a means of analysis and correction to ensure safety. Core-System is avilable in **both desktop and mobile versions**.

The project is based on **a human-centered design approach**, considering the user research, the scenario building, and the interface prototyping methodologies. The final system follows the values and **principles of Industry 5.0**, focusing on well-being, flexibility and responsible use of data. This thesis will show how the design process can facilitate the relationship between technological innovation and human needs, introducing the idea of a security ecosystem that supports both the individual and the organization in modern production scenarios.

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PART I

CONTEXT AND THEORETICAL FRAMEWORK

FIRST CHAPTER
Introduction

1.1 Research motivations

The rationale behind conducting this study is inspired by the **increasing complexity** of working environments in industries and the necessity of revaluating occupational safety in a **human-oriented manner.** On one hand, technological developments had greatly enhanced productivity and efficiency in working environments of industries. On the other hand, new risks in relation to automation and human interaction with machines or automated systems are also introduced in industries because of such technological advancements.

Wearable technology has recently gained attention as a promising means for **enhancing working conditions and improving safety at the workplace**. Nevertheless, a vast majority of existing solutions tend to place a strong emphasis on their technical parameters, rather than on the perception and needs of the personnel. This study is driven by a desire to establish a link between these two facts and examine the possibility of developing wearable safety solutions for the manufacturing industry not only as technical objects, but rather as tools for enhancing the personnel's well-being and acceptance.

1.2 General and specific objectives

The general aim of the research will be to **explore the use of wearable technology in improving workplace safety in the manufacturing industry**. This will be done in line with human-centered design principles. This aim will enable the researcher to understand how wearable technology can be utilized to improve the physical and cognitive aspects of workplace safety in a manufacturing setting where automation and digitalization have taken over.

In detail, this study will aim to analyze existing wearable safety systems, determine prominent risk types within a production environment, and examine the perceptions and attitudes of workers towards these systems. In addition, it will be important for this study to investigate how factors like usability, comfort, usefulness, and data protection are associated with system acceptances. The purpose of this study is, therefore, to create a wearable safety system concept that matches technological capabilities and actual user needs.

1.3 Research questions

Underpinning these objectives, a range of questions inform the direction of the research. First, what are the primary safety concerns and difficulties for those within modern manufacturing environments? Second, how are current wearable safety systems employed, and what are the restrictions of existing solutions from a worker-centric perspective? Third, from a wearer perspective, what is the perception of wearable devices for utility, invasiveness, and trust, particularly in relation to data? Finally, how might the learnings from the wearer perspective be used for informing design requirements for improved wearable safety solutions?

1.4 Methodology

In respect to answer the above-mentioned questions, this study uses a qualitative-oriented and exploratory method, together with a combination of desk research and user research. Initial analysis on the existing literature, industry reports, and case studies has helped to understand a brief overview of current wearable technology in personal protection. Following an understanding from this initial study, industry has been chosen as a focus area since there is appropriate data available, followed by a range of dangers being associated with industries in a manner relevant to Industry 4.0 or Industry 5.0.

A survey was then designed and administered using Google Forms to glean ideas and perspectives directly from the workers in a manufacturing setup. The survey was divided into seven different portions and consisted of multiple-choice questions and an open-ended question, giving the respondents an opportunity to convey their personal experiences and opinions and expectations. The data collected was analyzed in an attempt to determine recurring themes and key topics, and these were fundamental in the design of a human-centered wearable safety concept.

SECOND CHAPTER
Industry 5.0: Paradigm, Values, and Transformations

2.1 From Industry 4.0 to Industry 5.0: key differences

The manufacturing sector is currently experiencing a major shift as digital technologies increasingly merge with the traditional production systems. This evolution signifies a departure from earlier industrial models and is widely recognized as the **Fourth Industrial Revolution**, a phase expected to fundamentally transform how production processes are designed, managed, and executed.

Historically, each industrial revolution has been marked by a major technological shift. The first introduced mechanization through steam power, the second enabled mass production using electricity, and the third integrated electronics and information technologies, laying the foundations for automation. The current phase, commonly referred to as Industry 4.0, is centered on digitalization and is driven by technologies that support the development of smart factories, where machines and systems can communicate, exchange data, and respond to real-time conditions (Secchi, 2019).

Industry 4.0 promotes a highly interconnected and adaptive industrial model that is characterized by automation, continuous data exchange, and increasingly autonomous decision-making processes. The key elements of this paradigm include real-time data analytics, flexible and reconfigurable manufacturing systems, machine-to-machine communication, and advanced product personalization. Together, these capabilities allow companies to improve productivity while responding more effectively to the rapid changing market demands.

As highlighted by IBM (2021), organizations that adopt Industry 4.0 principles benefit from intelligent infrastructures that enable integrated data flows across machines, production systems, and business units. This level of integration supports more informed decision-making, greater operational agility, and enhanced coordination throughout the value chain. This leads to more informed decision-making, agile operations, and improved responsiveness to customization demands, even down to producing individual units cost-effectively. Predictive analytics further allow factories to anticipate disruptions and continuously optimize performance (IBM, 2021).

In this context, the concept of **Industry 5.0** has emerged, not simply as a continuation of Industry 4.0, but as a complete rethinking of industrial innovation. Industry 5.0 expands the focus from automation and efficiency to broader societal goals such as sustainability, resilience, and human well-being. According to the European Commission (2021), this new paradigm positions industry as a key player in achieving climate goals and leading the transition to a circular economy (TeamSystem, 2024).

Unlike its predecessor, Industry 5.0 emphasizes collaboration between humans and intelligent machines, aiming to create sustainable and personalized solutions that respect both the environment and workers' well-being. The European Commission's report, Industry 5.0: Towards a sustainable, human-centric and resilient European industry, highlights that this model benefits not just industries but also employees and society at large.

The expected impact of Industry 5.0 on businesses includes several key changes:

1. **Redesign of operations:** Workflows and organizational models will be reshaped to support human–machine collaboration.
2. **Technological investments:** Despite high upfront costs, adopting advanced technologies will be critical to staying competitive.
3. **Workforce development:** Upskilling workers to interact with emerging technologies will be essential, requiring continuous learning.
4. **Adaptability to consumer needs:** Enhanced customization will enable firms to meet diverse and evolving customer expectations.
5. **International competitiveness:** Aligning with Industry 5.0 standards will enhance a company's ability to deliver sustainable and high-value products in global markets.

Rather than viewing Industry 5.0 as a mere technological advancement, it should be seen as a paradigm shift that reevaluates the role of people and the environment in industrial processes. While Industry 4.0 prioritized digital integration, Industry 5.0 seeks a synergistic relationship between people and technology, where innovation is aligned with ethical, social, and environmental considerations (TeamSystem, 2024).

2.2 Human–centered approach in the workplace

The rapid development of digital technologies and the increasing automation of industrial activities have raised fundamental questions about the future of employment and the evolving function of human labor within modern production systems. Unlike previous industrial revolutions, which largely emphasized efficiency through mechanization and automation, the transition to Industry 5.0 introduces a **human-centric vision that explicitly recognizes the irreplaceable value of human intelligence, creativity, and decision-making**. Rather than positioning technology as a substitute for human labor, this new paradigm reframes innovation as a means to support and enhance human capabilities within industrial systems.

This shift reflects broader societal expectations for technological development that is not only efficient, but also sustainable, ethical, and people-centered. In this context, acknowledging the role of human beings within industrial environments becomes essential for understanding how organizations can evolve without compromising workers' rights, dignity, or overall well-being. Industry 5.0 therefore moves beyond purely technical optimization, placing social and human considerations at the core of industrial transformation.

Concerns regarding potential job displacement due to automation are frequently raised during periods of technological change. However, the European Commission emphasizes that, when implemented responsibly, technological innovation can improve workplace safety, inclusiveness, and employee satisfaction, while also enhancing quality of life. Data from Eurostat supports this perspective, showing that sectors with lower levels of automation tend to report higher rates of occupational accidents, particularly in physically demanding or hazardous roles (Eurostat, 2021).

Within this framework, Industry 5.0 explicitly places people at the center of production systems. The model promotes an approach that safeguards fundamental labor values such as autonomy, dignity, and data privacy. As highlighted by TeamSystem (2024), this perspective reshapes how companies understand both innovation and work environments, encouraging a culture in which employee well-being is regarded not merely as an ethical obligation, but as a strategic asset.

The human-centered approach of Industry 5.0 is based on three fundamental pillars:

- **Employee well-being and self-worth:** One of the defining goals is to improve the quality of the work environment. Instead of replacing humans, advanced technologies are intended to support them, creating safer, more inclusive, and dignified workplaces.
- **Harmonizing automation with human input:** Industry 5.0 promotes a balanced integration of human skills and machine capabilities. Rather than fully replacing manual labor, it seeks to enhance efficiency while preserving and respecting workers' roles and expertise.
- **Corporate social responsibility:** Organizations are encouraged to adopt ethical practices, ensuring that technological innovation does not result in job losses or violations of fundamental rights. This vision encourages companies to foster responsible, human-first innovation strategies grounded in respect for social and environmental values.

2.3 Resilience, sustainability, and personalization

In today's rapidly changing global landscape, marked by environmental challenges, geopolitical instability, and evolving consumer expectations, Industry 5.0 offers a strategic vision for how industries can adapt and thrive. This new industrial paradigm promotes a model structured around three core dimensions: resilience, sustainability, and personalization. These principles reflect the growing need for industrial systems that are not only technologically advanced, but also capable of responding to complex and rapidly changing global conditions.

The European Commission has highlighted how structural vulnerabilities in the European industrial system have been revealed by recent crises, such as the COVID-19 pandemic and ongoing geopolitical instability (Eurostat, 2021). These interruptions have shown that long-term industrial performance and resilience depend on the capacity to quickly and successfully adapt to change. In response, Industry 5.0 defines resilience as an organization's ability to withstand shocks, adjust to changing circumstances, and change under duress.

According to this viewpoint, investing in robust production systems and infrastructures is a strategic tool for long-term competitiveness, especially in international markets, rather than just a preventative measure. According to the European Commission (2021), adopting Industry 5.0 practices may present short-term economic challenges, but companies would face far greater long-term risks, such as diminished relevance and decreased competitiveness, if they did not participate in the shift toward a sustainable and human-centered industrial model.

Environmental sustainability represents a second foundational pillar of Industry 5.0. According to CorCom (2025), the European Commission strongly encourages manufacturers to accelerate the transition toward renewable energy sources and to significantly reduce greenhouse gas emissions, with the objective of achieving a 55% reduction in carbon emissions by 2030. Reaching this target requires the widespread adoption of circular economy principles, such as reuse, recycling, and the repurposing of materials, aimed at minimizing waste and environmental impact throughout the production cycle.

Alongside resilience and sustainability, personalization has emerged as a key differentiating factor in contemporary industrial strategies. Enabled by technologies such as the Internet of Things and additive manufacturing, companies are now able to deliver customized products and services at smaller scales, including economically viable single-unit production (Network360, 2024). This capability responds to increasing demand for individualized solutions while allowing firms to operate with greater flexibility and responsiveness to market dynamics.

Taken together, resilience, sustainability, and personalization form the foundation of the Industry 5.0 approach. Rather than being treated as separate objectives, these dimensions are integrated within a unified framework that positions technological innovation in service of human and environmental priorities. In this sense, Industry 5.0 should be understood not simply as an extension of previous industrial models, but as a transformative paradigm that redefines long-term industrial success in ethical, social, and ecological terms.

2.4 Enabling technologies

A central element of the Industry 5.0 transformation is the adoption of advanced enabling tech-nologies that support production systems which are smarter, more adaptive, and increasingly human-centered. Among these, Artificial Intelligence (AI), Digital Twins, the Internet of Things (IoT), and collaborative robotics play a key role in shaping the next generation of industrial oper-ations.

As per Il Sole 24 Ore (2025), AI is the key driver for the evolution of traditional manufacturing to obtain truly intelligent environments and systems. Organizations can expect better market forecasts, operational risk anticipation, and equipment management thanks to AI's regular processing of data and on-time insights generation. These functions ensure less unplanned downtimes and support a transition from a reactive to a proactive maintenance frame.

In this context, generative AI allows for the creation of dynamic workflows that can adapt to changing production conditions or customer requirements, further expanding industrial flexibility. AI-powered virtual assistants and chatbots can also assist on-site technicians with contextual information while carrying out operations without disrupting the workflow and enhancing productivity. Furthermore, advanced data analysis and decision-support algorithms are being increasingly adopted in supply chain and inventory management.

A key technological component in Industry 5.0 is the digital twin which refers to the virtual representation of a machine, a production process or an entire factory. Using digital twins manufacturers may simulate operations and test out process changes in a no-risk digital environment. These models help lower development costs and reduce time-to-market for new products by decreasing reliance on physical prototyping.

At the shop floor level, collaborative robots or cobots are gaining significance as a means of supporting the human workers and not replacing them. Cobots are not like industrial robots. They are designed to work with the operators. With the help of advanced sensing and decision-making systems, they can adapt to their environment while working. Moreover, they can also perform repetitive or physically demanding tasks. In this way, they contribute to improved efficiency while preserving worker safety.

Underlying all these technologies is connectivity, which acts as the enabling layer that allows systems to communicate and coordinate effectively. The deployment of 5G networks has already enhanced data transmission speed and reliability across industrial environments, supporting re-al-time interaction between machines, digital systems, and human operators.

Looking ahead, the development of 6G networks is expected to further enhance machine-to-machine communication, leading to even more synchronized and responsive production envi-ronments.

Together, these enabling technologies create an ecosystem of intelligence and interactivity, empowering organizations to achieve the core goals of Industry 5.0: resilience, personalization, sustainability, and, above all, a human-centric approach to innovation.

2.5 Impacts on the world of work

The introduction of Industry 5.0 marks a significant shift in how businesses approach both production and human resources. This model not only enables greater customization of goods and services to meet individual customer preferences but also supports the creation of more flexible and responsive operational frameworks. As a result, companies can better align their outputs with dynamic market demands, opening up new opportunities for growth and innovation.

By fostering closer cooperation between humans and intelligent systems, Industry 5.0 enhances both efficiency and adaptability across manufacturing processes. This integration enables companies to adjust production in real time, optimize resource utilization, and reduce waste while maintaining high standards of quality and personalization.

One of the most significant advantages of this transition is the automation of repetitive and low-value tasks. By transferring routine activities to machines, human workers are able to focus on tasks that require critical thinking, creativity, and problem-solving skills. This redistribution of responsibilities not only improves overall operational performance but also contributes to increased job satisfaction, as employees engage in more meaningful and cognitively stimulating roles.

At the same time, Industry 5.0 reinforces a strong commitment to environmental sustainability. Organizations are encouraged to adopt renewable energy sources and incorporate circular economy principles, such as recycling, reuse, and waste reduction, into their production systems. Beyond lowering environmental impact, this ecological orientation also strengthens corporate reputation, particularly among stakeholders and consumers who increasingly value sustainable and ethically responsible business practices.

However, realizing the full potential of Industry 5.0 requires more than simply adopting a human-centered and eco-conscious mindset. It also demands a technological foundation built on the achievements of Industry 4.0. The digital infrastructure, automation tools, and interconnected systems developed in the previous industrial phase are essential for supporting the complex innovations introduced by the fifth industrial revolution.

As noted by Intesa Sanpaolo (2024), implementing truly sustainable and circular production models is only possible when supported by robust technologies capable of measuring, controlling, and optimizing every stage of the value chain. In this sense, Industry 4.0 should be viewed as the enabling layer that makes the goals of Industry 5.0 both achievable and scalable across industries and supply chains.

In conclusion, Industry 5.0 redefines the nature of work and professional roles, placing emphasis on human creativity, ethical responsibility, and technological integration. To succeed in this new environment, businesses must strategically combine digital innovation with a renewed focus on people and the planet.

2.6 New needs in terms of safety, well-being, and cognitive support

The shift toward increasingly intelligent and automated industrial systems highlights the urgent need to rethink how worker safety and well-being are managed, especially in environments where human labor interacts closely with complex technologies. While earlier industrial revolutions focused primarily on physical safety, the context of Industry 5.0 calls for a broader and more comprehensive perspective, one that also includes cognitive and psychological well-being. Today, ensuring safety in the workplace means protecting not only the body, but also the mental processes and decision-making capabilities of workers operating in increasingly complex, technology-driven environments.

As machines and systems become more autonomous, human operators are required to manage and interpret growing volumes of information, often under time pressure or conditions of uncertainty. This shift places new cognitive demands on workers and makes cognitive ergonomics a critical component of contemporary industrial design. In such contexts, safety is no longer solely a matter of physical protection, but also of supporting attention, comprehension, and effective decision-making.

In his 2004 study, Francesco Di Nocera investigated how individuals interact with complex automated systems, drawing insights from the aviation sector, where precision, sustained attention, and decision-making under stress are essential. His findings demonstrate that the mere introduction of automation does not automatically lead to improvements in safety or performance. When human factors are not adequately considered, automation can result either in excessive reliance on systems or in reduced trust, both of which may negatively affect operator effectiveness and safety (Di Nocera, 2004).

Di Nocera's research further suggests that the effectiveness of automation depends on how well systems are aligned with human cognitive strengths and limitations. When this alignment is lacking, operators may experience confusion, make errors, or react too slowly in critical situations. These insights have important implications not only for system design, but also for how workers are trained, supported, and assisted during their daily activities.

As Industry 5.0 continues to evolve, organizations are therefore required to adopt a truly human-centered approach to safety that explicitly accounts for cognitive demands and mental well-being, alongside traditional physical safety considerations. This approach includes:

Designing interfaces and systems that reduce mental overload and support intuitive decision-making;

- Providing cognitive support tools, such as AI-based assistants or real-time alerts;
- Maintaining an organizational culture that values worker autonomy, trust, and psychological well-being.

In this new phase of industrial evolution, protecting workers means going beyond physical safeguards to include mental resilience and cognitive support, ensuring that humans can thrive in environments shaped by constant technological interaction.

THIRD CHAPTER
Regulations

3.1 The European regulatory framework for Industry 5.0

According to the latest State of Smart Manufacturing global report, the pace of industrial transformation continues to accelerate. More than half of manufacturers, about 56%, are currently experimenting with smart manufacturing processes, while 20% have already deployed them at scale and another 20% are planning future investments (Rockwell Automation, 2025).

In the European context, Industry 5.0 does not establish a standalone regulatory framework. Instead, it builds on a constellation of existing directives, regulations, and international standards that collectively enable its three core pillars: a human-centric approach, sustainability, and technological resilience (European Union, 2021).

Worker protection remains anchored in the foundational Occupational Safety and Health Framework Directive 89/391/EEC, complemented by the Machinery Directive, that is now replaced by the new Machinery Regulation 2023/1230, and by key ergonomics standards such as ISO 6385, ISO 9241, and ISO 10075. These norms are crucial for designing systems that minimize both physical strain and cognitive workload for operators (Network360, 2025).

The increasing integration between humans and robots, which characterizes the shift toward Industry 5.0, is governed by collaborative robotics standards including ISO 10218 and ISO/TS 15066. These define safety requirements, force-limiting thresholds, and parameters for safe interaction, supported by functional safety norms such as ISO 13849 and IEC 61508 (Network360, 2025).

On the digitalization and artificial intelligence front, Europe has introduced an advanced regulatory landscape with the AI Act (2024). This regulation establishes transparency, robustness, and risk-management obligations for AI systems identified as high risk, aligning with international technical standards like ISO/IEC 22989, ISO/IEC 23053, and ISO/IEC 23894 (Parlamento Europeo, 2023).

Cybersecurity, an increasingly critical component of interconnected industrial and cyber-physical environments, is guided by ISO/IEC 27001 and the IEC 62443 series, which outline the protections required for both IT and OT infrastructures (Firemon, 2025).

Sustainability, another central pillar of Industry 5.0, is supported by standards such as ISO 14001, ISO 14040/44, and ISO 50001, along with the new European Sustainability Reporting Standards (ESRS) (European Union, 2023).

Overall, Industry 5.0 evolves through an integrated regulatory ecosystem that brings together safety, ergonomics, trustworthy AI, cybersecurity, and environmental responsibility. This multilayered framework ensures that technological progress remains aligned with European values, maintaining a strong focus on human well-being and ecological stewardship.

3.2 The Transition 5.0 Plan: the italian regulatory Framework

The Transition Plan 5.0 is Italy's new national program designed to support companies as they move toward a production model that is more sustainable, digitally integrated, and centered on human–technology collaboration. The initiative is financed through the National Recovery and Resilience Plan and was introduced by Decree-Law 19/2024, followed by implementing decrees issued by the relevant ministries.

The plan provides tax credits for investments in smart technologies, energy-efficiency improvements, renewable energy systems, and workforce training. It represents Italy's operational implementation of the key principles of Industry 5.0 outlined by the European Commission. Working in synergy with the previous Transition Plan 4.0, the new measure is part of a broader national strategy that aims to accelerate both digital and energy transformation. For the period 2024 to 2025, the program allocates 12.7 billion euros to Italian enterprises (Governo Italiano, 2025).

Aligned with the short and medium-term actions defined under the REPowerEU strategy, Transition Plan 5.0 dedicates 6.3 billion euros to initiatives that encourage companies to redesign their production processes in response to the dual digital and energy transitions. Its main objectives include the following:

1. **Reducing companies' energy consumption** through advanced digitalization.
2. **Promoting the adoption of intelligent and interoperable technologies**.
3. **Supporting investments** in energy efficiency and on-site renewable energy production.
4. Strengthening **industrial resilience**.
5. Encouraging the integration of **human-centric solutions**.

Depending on the level of improvement achieved in these areas, companies can benefit from tax credits ranging from 15 percent to 45 percent, calculated according to the degree of energy savings obtained (Governo Italiano, 2025).

3.3 From control to proactive prevention

As highlighted in the previous analysis, a defining pillar of this fifth industrial revolution is its human-centric orientation, which shifts the focus toward the central role of the individual. At the heart of this concept lies the protection of the worker, meaning that innovation must also transform the way safety is understood, managed, and regulated. Until now, most efforts have concentrated on accelerating the response to emergency situations. While rapid reaction and the ability to correctly interpret an alarm scenario remain essential, recent technological advancements make it increasingly necessary to reconsider how such situations are managed. Traditional risk management approaches have long been based on reactive strategies, supported by quantitative and qualitative models in which risks are identified through static assessments conducted at fixed intervals, such as annually or semiannually. As a result, decisions are often grounded in hypothetical scenarios rather than real-time insights.

Although this approach has proven adequate in many contexts, it presents significant limitations. These include a reduced ability to adapt to sudden economic, technological, or geopolitical changes, limited visibility over emerging or previously unidentified threats, and growing difficulties in managing and interpreting large volumes of data (Network360, 2025). Such constraints highlight the need for new methodologies capable of improving responsiveness and enhancing the accuracy of risk prediction.

In response to these challenges, corporate governance must adopt a more proactive posture, moving beyond traditional risk-management practices and integrating innovative tools such as predictive analytics and continuous monitoring. A proactive approach does not simply involve responding to risks once they have materialized; rather, it focuses on anticipating potential issues and developing strategies to mitigate their impact before they result in harm. This shift allows organizations to reduce uncertainty, protect value, and significantly lower the likelihood of critical disruptions.

Within this context, predictive analytics that is enabled by machine learning algorithms and artificial intelligence, plays a central role by making it possible to analyze historical data and forecast future events, supporting more informed and timely decision-making.

This capability represents a transformative resource for modern risk management. By integrating these technologies into operational processes, companies can strengthen their competitive position by identifying early indicators of potential threats, assessing their likelihood and potential impact, and designing mitigation strategies that are both targeted and timely (Network360, 2025).

3.4 Introduction of wearables in safety

As support tools for workplace safety management, a growing number of solutions have been developed and, in some industrial environments, recently implemented to monitor workers and collect relevant safety data. This category of solutions is commonly referred to as wearable safety technology, as these systems typically consist of personal devices worn directly by employees during their daily activities. Their functioning is based on integrated sensors capable of monitoring both the worker and the surrounding environment, allowing for timely interventions and contributing to enhanced overall protection.

These technologies originate from the evolution of everyday consumer wearables, such as smartwatches, which already enable the monitoring of vital parameters and user activities. The widespread adoption of these consumer devices has paved the way for the development of similar technologies specifically adapted to industrial contexts, where the focus shifts from personal lifestyle tracking to workplace safety and risk prevention. The evolution of such consumer devices has paved the way for a new generation of wearables specifically designed for industrial settings, where the emphasis shifts from lifestyle monitoring to worker safety and risk prevention.

PART II

SECTOR ANALYSIS: WEARABLE SAFETY TECHNOLOGY

FOURTH CHAPTER
Safety Wearables: Overview and Taxonomy

4.1 Introduction of wearable devices in workplace safety

For many years, workplace safety systems were largely based on reactive solutions. Traditional personal safety devices required workers to consciously recognize a hazardous situation and manually trigger an alert. Tools such as whistles or panic buttons relied entirely on the user's physical capability and situational awareness, which often proved insufficient in sudden, complex, or high-risk scenarios.

Recent technological developments have introduced a clear paradigm shift toward **proactive and predictive safety models**. Within this transition, Smart Personal Protective Equipment (PPE) plays a central role. Conventional PPE (such as helmets, safety vests, gloves, and goggles) is increasingly being augmented with embedded sensors and communication capabilities, transforming passive protective equipment into active safety systems. For instance, smart helmets can monitor vital signs, detect impacts or hazardous environmental conditions, and automatically notify supervisors or emergency responders when predefined thresholds are exceeded. In a similar way, smart gloves can identify excessive vibration exposure or unsafe hand movements, supporting earlier detection of potential risks and contributing to preventive safety strategies.

As described by Wangfred for Inair in a 2026 article, contemporary wearable safety technologies are designed to anticipate potential dangers and, in many cases, activate protective responses automatically. By continuously monitoring both the worker and the surrounding environment, these systems are able to identify abnormal conditions and initiate interventions without requiring direct user action (Inair, 2026).

This evolution has been made possible by significant advancements in sensing technologies. Progress in micro-electromechanical systems has enabled accelerometers, gyroscopes, altimeters, and positioning modules to become increasingly compact, accurate, and suitable for seamless integration into body-worn devices. At the same time, developments in biosensing technologies have expanded monitoring capabilities to include physiological indicators such as heart rate, blood oxygen saturation, and stress-related responses. Together, these sensing technologies allow wearable systems to capture a more comprehensive picture of both environmental exposure and the worker's physical and cognitive condition.

Artificial intelligence and machine learning play a key role in transforming this continuous flow of data into meaningful safety insights. As noted by Inair (2026), intelligent algorithms continuously process sensor inputs to identify behavioral patterns and detect deviations from normal conditions. This analytical capability enables systems to distinguish routine activities from potentially dangerous ven- ts, such as differentiating normal movement from a fall or identifying early signs of physiological distress before they escalate into critical situations. Through this analytical process, wearable devices move beyond simple data collection toward anticipatory risk detection.

Within the context of workplace safety, wearable technologies therefore represent a fundamental shift in risk management strategies. Rather than focusing solely on post-incident response, these systems support a preventive and adaptive approach that reduces reliance on human reaction time in critical situations. By integrating real-time sensing, intelligent data processing, and automated responses, wearable devices contribute to safer, more resilient, and human-centered work environments.

4.2 Categories of industrial wearable safety devi–ces

Industrial wearable safety devices can be systematically categorized according to their primary function within the workplace, highlighting how different technological solutions contribute to safety in complementary ways. Monitoring devices form the foundational layer of this system, as they continuously collect physiological and environmental data in order to identify early signs of health risks or hazardous conditions. Supporting wearables, in contrast, address the physical demands of industrial work by assisting workers during repetitive or strenuous tasks, reducing the likelihood of musculoskeletal injuries while also facilitating communication and access to task-related information. Safety is further extended through training-oriented wearables, which support skill acquisition and reinforcement in controlled environments, often through augmented and virtual reality, thereby minimizing exposure to risk during learning phases. Finally, tracking devices operate at an organizational level, enhancing situational awareness by providing real-time information on worker location and proximity to hazards, which is crucial for effective coordination and emergency response. Taken together, these categories show that wearable safety technologies function not as isolated tools, but as interconnected elements of a broader safety ecosystem that supports prevention, assistance, learning, and risk management across industrial operations.

	Examples of devices	What they do	How they help
Monitoring	Fitness trackers, smart rings, smart glasses, body sensors, smart clothing, and implantable werable safety devices.	Track vital signs (like heart rate, temperature, and blood pressure) and workplace conditions (such as heat or radiation).	Help spot health issues before they become serious, monitor the environmrnt, and make sure workers have the right safety gear.
Supporting	Exoskeletons, lifting patches, werable robots, and headsets.	Meke lifting easier, support posture, help workers talk to each other, and assist with task information.	Lower the risk of injuries, improve communication, and provide hand-free guidance with diagrams or AR.
Training	Smart glasses, smart helmets, and heads-up displays.	Give feedback during tasks and use virtual reality (VR) or AR to safely practice hard or risky work.	Let workers learn safely, build skills, and reduce mistakes on the job.
Tracking	Smart bracelets, smart clothes, smart boots, and digital pedometers.	Show where workers are and how close they are to hazards.	Improve emergency response, avoid equipment accidents, and manage crews more efficiently.

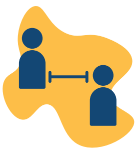
Figure 1 showes the Categories of Industrial Wearable Safety Devices

Building on this functional framework and its contribution to proactive and predictive safety strategies, the following examples illustrate how wearable technologies are already being applied to transform occupational health and safety practices in real-world industrial contexts:

1. **Vital signs monitoring:** Wearable devices that track vital signs are becoming increasingly common in high-risk industries. These devices can monitor heart rate, body temperature, and other physiological signals to detect early signs of heat stress, fatigue, or other health-related issues.

2. **Downed worker detection:** Downed worker devices use accelerometers and additional sensors to detect falls or extended periods of inactivity. When a potential incident is detected, these systems can automatically notify supervisors or emergency responders, reducing response time in critical situations. Typical functionalities include automatic fall detection, panic buttons that allow workers to manually request assistance, and Global Positioning System (GPS) tracking to support rapid localization and intervention.

3. **Fatigue monitoring:** Fatigue monitoring systems combine wearable devices with artificial intelligence algorithms to identify patterns associated with drowsiness or reduced alertness. By continuously analyzing physiological and behavioral signals, these systems are able to warn both workers and supervisors when fatigue levels approach critical thresholds, helping to prevent accidents caused by exhaustion. Such solutions are particularly relevant in contexts such as long-haul transportation, heavy machinery operation, and night shift work, where sustained attention is essential.



4. **Lone worker safety:** Lone worker monitoring devices provide an additional layer of protection for employees who operate in isolation or remote environments. These solutions typically integrate GPS tracking, two-way communication, and emergency alert functions, enabling regular check-ins, immediate requests for assistance, and continuous awareness of worker location. In this way, they help mitigate the risks associated with delayed intervention in emergency situations.

5. **Location geofencing:** Geofencing technologies use GPS or Radio Frequency Identification (RFID) to establish virtual boundaries around specific work areas. When integrated with wearable devices, they can:

- alert workers when entering hazardous or restricted zones;
- prevent unauthorized access to dangerous areas;
- track worker movements to support safety compliance.

6. **Permit-to-work applications:** Digital permit-to-work systems support the management of high-risk tasks by ensuring that workers receive the neces-

sary authorizations and safety briefings before beginning an activity.

7. Key advantages include:

- real-time updates on permit status;
- improved compliance with safety procedures;
- reduced paperwork and administrative workload.

4.3 Workers' perception: acceptance, distrust, ethical issues

The introduction of wearable technologies in industrial workplaces has been accompanied by both growing acceptance and persistent concerns among workers, particularly in relation to data privacy and transparency. As companies continue to invest in digital solutions aimed at improving productivity and reducing workplace accident risks, wearable devices are increasingly being integrated into operational management, particularly within the broader transformation associated with Industry 4.0 (Schwambach et al., 2022). Although these technologies are generally perceived as beneficial for both safety and performance, their adoption also brings forward critical questions related to employee trust, acceptance, and the perceived implications of continuous monitoring.

According to the study conducted by Schwambach et al. (2022), which investigated the acceptance and perception of wearable technologies among employees in Brazilian and European companies, overall acceptance levels within the workplace are relatively high. The results show an acceptance rate of 81.74% in Europe, indicating that most workers are willing to use wearable devices when they are clearly associated with workplace safety objectives. This implies that wearable technologies are typically viewed as acceptable instruments for health monitoring and accident prevention in industrial settings rather than as invasive control mechanisms. The study emphasizes that data privacy is still a major concern, especially in the European context, despite this general transparency. Concerns about the gathering, transmission, and possible misuse of personal data have grown as a result of the growing interconnectedness of industrial systems and the extensive use of Internet of Things technologies.

Because wearable devices are capable of gathering sensitive biometric information, including physiological and behavioral data, employees often express apprehension about how this information is managed and who is granted access to it (Schwambach et al., 2022). These concerns tend to be amplified in situations where workers are not adequately informed about the purpose of data collection or the safeguards implemented to protect their data.

The findings further reveal a clear relationship between privacy concerns and technology acceptance. Employees who report higher levels of concern regarding data privacy generally show lower acceptance of wearable technologies, even when such devices are explicitly intended for safety purposes. Within the European sample, only 61.54% of respondents who described themselves as very concerned about data privacy expressed willingness to accept wearable technologies in the workplace, illustrating how trust and transparency directly influence adoption (Schwambach et al., 2022). This result is consistent with previous studies indicating that employee acceptance decreases when the objectives and management of collected data are not clearly communicated.

Overall, these findings underline that the successful integration of wearable safety devices depends not only on technological performance, but also on organizational strategies that actively involve workers. Transparent communication, clear data governance policies, and employee participation throughout the implementation process emerge as critical factors in reducing diffidence and fostering long-term acceptance.

From a human-centered design perspective, addressing workers' perceptions and concerns is therefore essential to ensure that wearable safety technologies are perceived as supportive tools rather than sources of surveillance or control.

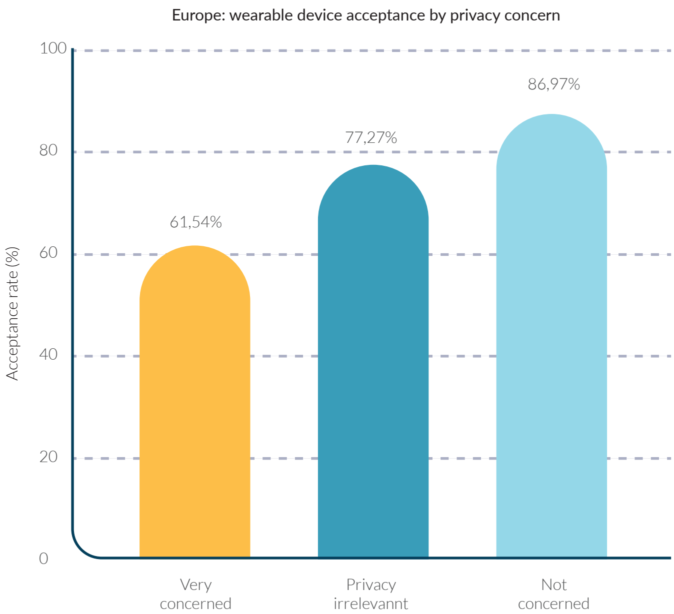


Figure 2. Wearable device acceptance by level of privacy concern among European workers (%). Adapted from Schwambach et al. (2022).

4.4 Future outlook

The future development of wearable safety technologies is expected to play a central role in the evolution of workplace safety systems, driven primarily by advancements in artificial intelligence and connectivity. According to Convergenze (2025), the integration of intelligent technologies into workplace safety systems is set to accelerate significantly over the next decade. AI-powered platforms are becoming increasingly capable of learning from and dynamically adapting to specific work environment conditions. This development will improve risk prediction accuracy and make automatic responses to critical events more effective, promoting the transition from reactive safety models to fully proactive risk management systems.

At the same time, wearable devices are also destined for profound technological evolution. The integration of increasingly advanced biometric sensors, augmented reality capabilities, and enhanced connectivity through 5G networks will enable these devices to simultaneously monitor physiological parameters, environmental conditions, and ergonomic risks. Such a level of integration will enable continuous communication between workers, machinery, and centralized monitoring platforms, contributing to the creation of highly interconnected and intelligent safety ecosystems (Convergences, 2025). The adoption of wearable technologies for safety, moreover, will not be limited to traditional industrial settings. Sectors such as agriculture, healthcare, and logistics, where occupational risks have historically been difficult to systematically monitor, are increasingly being recognized as suitable areas for the introduction of intelligent safety devices. The evolution of international standards on health and safety at work will also contribute to strengthening this trend, which will most likely increasingly explicitly include the role of digital technologies and wearable devices within reference regulatory frameworks (Convergences, 2025).

From an industrial point of view, the prospects for wearable technologies dedicated to safety appear particularly promising. As highlighted by SlateSafety (2025), next-generation devices are becoming increasingly compact and multifunctional, integrating real-time alerts, vital signs monitoring, proximity sensing and environmental condition analysis into a single solution. The introduction of AI-based predictive analytics systems enables companies not only to react to situations of immediate danger, but also to anticipate and prevent potential risks before they result in accidents. Companies like SlateSafety, Rombit, StrongArm, Palladyne AI, and Ottobock are actively helping define this scenario, developing innovative solutions that redefine the boundaries of worker protection. Taken together, these trends indicate how wearable safety technologies are set to play an increasingly central role in transforming work environments, making them safer, more efficient, and truly person-oriented (SlateSafety, 2025).

FIFTH CHAPTER
Identification of the Specific Industrial Sector

5.1 Selection analysis

The analysis of the selected case studies revealed three main sectors as preferred application areas for wearable devices dedicated to workplace safety: the logistic sector, construction, and manufacturing, particularly automated warehouses.

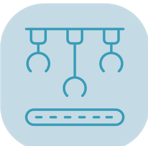
Among these, logistics stands out as one of the fastest-growing and most relevant contexts, driven above all by the global expansion of e-commerce, which has exceeded $6.3 trillion and continues to grow at an annual rate of between 12% and 15% (EAN, 2025).

This sector is also characterized by a **high incidence of workplace injuries**, often related to physical overload, repetitive lifting, poor posture, collisions with robots and self-driving vehicles, as well as significant cognitive stress due to increasingly intense work schedules. In Italy, the transport and warehousing sector has seen a worrying increase in accidents: between 2020 and 2024, over 242,000 reports were reported, including 923 deaths, an overall increase of 13.6% compared to 2020 (IlSole24ORE, 2025). In particular, workplace accidents increased by '8.8%, while those related to commuting recorded an even more marked growth.

Despite the rapid spread of Industry 5.0 technologies, such as autonomous warehouses, collaborative robots, and real-time tracking systems, the development of truly integrated wearable solutions capable of seamlessly connecting workers and intelligent machines remains limited. This gap opens up important design opportunities for wearable devices designed not as simple alarm systems, but as true ergonomic and cognitive supports, capable of preventing incorrect postures, engaging with robots to optimize workflows and ensure dynamic safety zones, reducing cognitive load through contextual cues, and monitoring stress and fatigue to support worker well-being and performance.

An equally critical scenario is found in the construction sector, which continues to be among the most dangerous globally and is **responsible for over 20% of serious workplace accidents in the European Union**. Between 2013 and 2022, 628 deaths were recorded in the construction sector, with falls from heights accounting for approximately 60% of all fatal events (IlSole24ORE, 2025). Added to these are accidents caused by falling materials from a height and by overturning or hitting vehicles. The situation is further aggravated by the presence of irregular work: more than '11% of deceased workers did not have a formal contract.

Many small and medium-sized enterprises in the sector still lack advanced safety technologies, making the market largely uncovered. At the same time, however, the increasing introduction of digital tools such as IoT sensors, digital twins, and increasingly stringent regulations is creating the conditions for the adoption of next-generation wearable solutions. In this context, such devices could play a key role in fall prevention, integrating environmental data rather than relying solely on ground-based human detection systems, in real-time monitoring of dynamic construction site risks, and in supporting temporary or foreign workers through multimodal interfaces that combine haptic, visual, and contextual feedback. Furthermore, connecting with predictive safety management platforms would allow for monitoring the entire construction site and anticipating potentially dangerous situations before accidents occur.

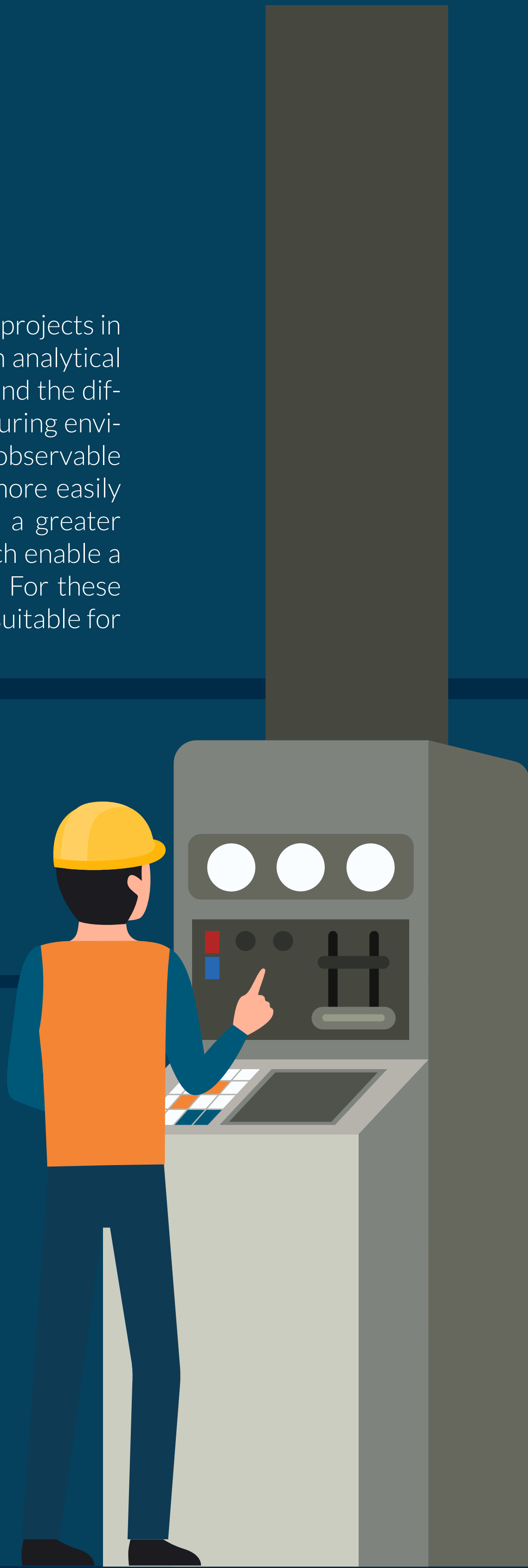


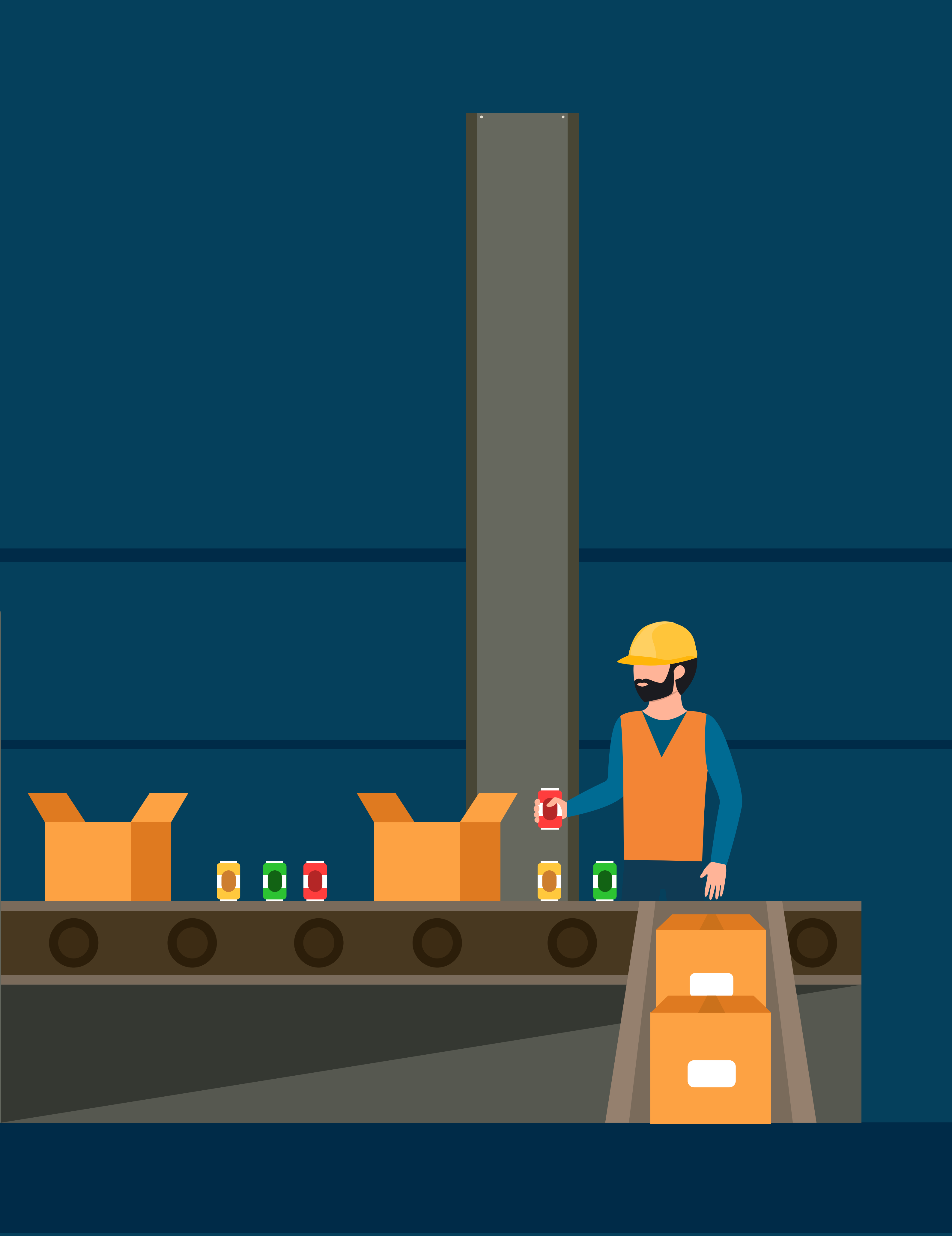
The manufacturing sector has a different, but equally complex, risk profile. Workers are exposed to multiple hazards, including high temperatures, harmful gases, excessive noise levels, and potentially dangerous machinery. According to the most recent Eurostat data, work-related deaths in manufacturing fell to **178 cases in 2023**, a reduction compared to previous years; despite this, the sector continues to occupy second place in terms of fatal accidents, just behind construction (Eurostat, 2025). The activities most involved are the manufacture of metal products, the manufacture of machinery and the food industry. While many companies are beginning to adopt Industry 5.0-related technologies, the focus is often primarily on optimizing machines, rather than directly supporting human operators. A further limitation is the fragmentation of safety data: personal protective equipment generally functions as isolated systems, offering only a partial view of the worker's actual conditions.

This context highlights a clear design opportunity for a wearable device conceived as a central personal safety hub, capable of integrating data relating to noise, vibration, heat, gas exposure, posture and fatigue. Such a system could communicate directly with machines and robots to prevent collisions, reduce human error and cognitive load, and generate information useful for predictive monitoring of human conditions, contributing to a more advanced and truly human-centered approach to industrial safety.

5.2 Rationale for the Selection

After analyzing the three research areas from different perspectives, the final choice was guided mainly by considerations related to the ease of access and interpretation of the data. Although both the construction and logistics sectors offer numerous interesting insights for the development of innovative projects in the field of workplace safety, both present some critical issues from an analytical perspective, particularly regarding the fragmentation of information and the difficulty in obtaining homogeneous and comparable data. The manufacturing environment, on the other hand, is configured as a more structured and observable context, in which production processes, risks, and technologies are more easily documented. In addition, the manufacturing sector makes available a greater amount of supporting materials, statistical data and case studies, which enable a more in-depth and methodologically sound analysis to be developed. For these reasons, the choice of manufacturing sector appeared to be the most suitable for the development of the thesis project.





5.3 Risk types and worker needs in the manufacturing sector

In the world of industrial production, safety at work is not just a regulatory obligation: it is a real strategic lever for business continuity, quality of work and competitiveness. Yet even today, many manufacturing companies underestimate the impact of structured and proactive safety management, limiting themselves to minimal and often only formal measures.

However, it is enough to read the INAIL reports to understand that the numbers speak for themselves: manufacturing is among the sectors with the highest rates of accidents and occupational diseases (INAIL, 2024). Machinery in motion, chemical agents, noise, incorrect postures, handling loads: the risks are concrete, daily, and often systemic. This is why every company in the sector has a duty to invest in training, prevention, document updating, and qualified technical advice.

In manufacturing, safety and productivity are two sides of the same coin. Ensuring safe working environments means reducing accidents, but also improving efficiency, reducing machine downtime, protecting know-how, and protecting the company from penalties, indirect costs, and reputational damage.

Unlike other sectors, manufacturing industry presents a high inherent risk, because it involves potentially hazardous people, machinery, materials, and substances. The intensive use of industrial machinery, contact with chemicals, and the high and often repetitive pace make this operating environment particularly exposed to accidents and occupational diseases.

Factory safety is also a cultural factor: companies investing in training and organizing prevention demonstrate attention to the human value of work, increase employee involvement, and improve labor relations.

From a regulatory point of view, then, no company is exempt: Legislative Decree 81/08 clearly establishes that the employer is responsible for safety, and is required to identify risks, draw up the DVR (Risk Assessment Document), train workers and adopt all necessary measures for health protection, meaning superficial safety management is no longer tolerable, neither ethically nor legally. And businesses that want to grow in the long run can't ignore it.

Risks in manufacturing are multiple and often interconnected. These are not just "major accidents" but everyday situations that, if overlooked, can lead to injuries, absences, material damage and penalties. Risk assessment must consider the specificities of the production environment, technological processes, the substances used, and the organization of work (zerorischio, 2025).

Here are the main risks to consider in manufacturing industry DVR:

- **Risks from industrial machinery**: misuse, poor maintenance, lack of protection, accidental starts, human-machine interaction.

- **Chemical risks**: exposure to vapors, solvents, oils, paints, dusts, metal fumes. Presence of irritant, flammable, carcinogenic agents.
- **Noise risk**: noisy environments with values above 80-85 dB(A), impacting hearing and the nervous system.Risk from manual handling of loads: lifting, pushing or transporting heavy materials, with musculoskeletal risk.
- **Ergonomic risk**: fixed positions, repetitive movements, poor posture, biomechanical stress.
- **Electrical and system risks**: direct or indirect contact with dangerous voltages, faults, lack of grounding.
- **Fire or explosion risk**: presence of flammable materials, combustible dust, unprotected electrical systems.
- **Organizational risks**: long shifts, work-related stress, cognitive loads or high responsibilities.

These risks are not all present in every company, but must be precisely analyzed, based on the actual tasks, environments and activities. A generic assessment is not enough. We need a dv, drawn up by expert consultants who know the sector and know how to translate the legislation into practical and effective solutions (zerorischio, 2025).

5.4 Regulatory obligations

In the manufacturing sector, compliance with legal obligations regarding workplace safety is essential not only to avoid sanctions, but also to ensure business continuity and worker protection. The relevant legislation is Legislative Decree 81/08, the so-called Consolidated Law on Safety, which imposes a series of very specific obligations on the employer (artser, 2025).

The main regulatory obligations:

1. **DVR – Risk Assessment Document**

It is the heart of the business prevention system. It must be drawn up before the start of operation and updated whenever operating conditions change. To be valid, it must:

- Identify all risks present
- Evaluate the level of exposure

- Define prevention and protection measures
- Establish an improvement plan
- Indicate the figures involved

A well-made manufacturing industry DVR analyzes mechanical, chemical, ergonomic, and organizational risks in detail, and includes department-specific operating procedures.

2. **Compulsory training**

All workers must be trained before the start of the activity, with courses in:

- General training (4 hours)
- Specific training (low, medium, high risk: 4 to 12 hours)
- Five-year update
- Training for managers, managers, fire and first aid workers

Training must be traceable, documented and up to date, not just formal.

3. **Supply and use of PPE**

The employer is obliged to provide Personal Protective Equipment that is suitable and complies with EC legislation. PPE must be accompanied by instructions for use, periodic checks and training in use.

Helmets, gloves, noise-cancelling headphones, filtering masks, harnesses: each PPE must be chosen based on the risks detected in the DVR and must be used correctly by workers.

Seeking workplace safety advice therefore becomes an operational necessity, especially for companies that want to work in compliance, protect workers, and prevent production shutdowns or sanctions.

The consultant supports the employer at every stage of the safety process, with a professional, technical and tailor-made approach. His skills go far beyond just writing the DVR.

Here's what an occupational safety consultant can do:

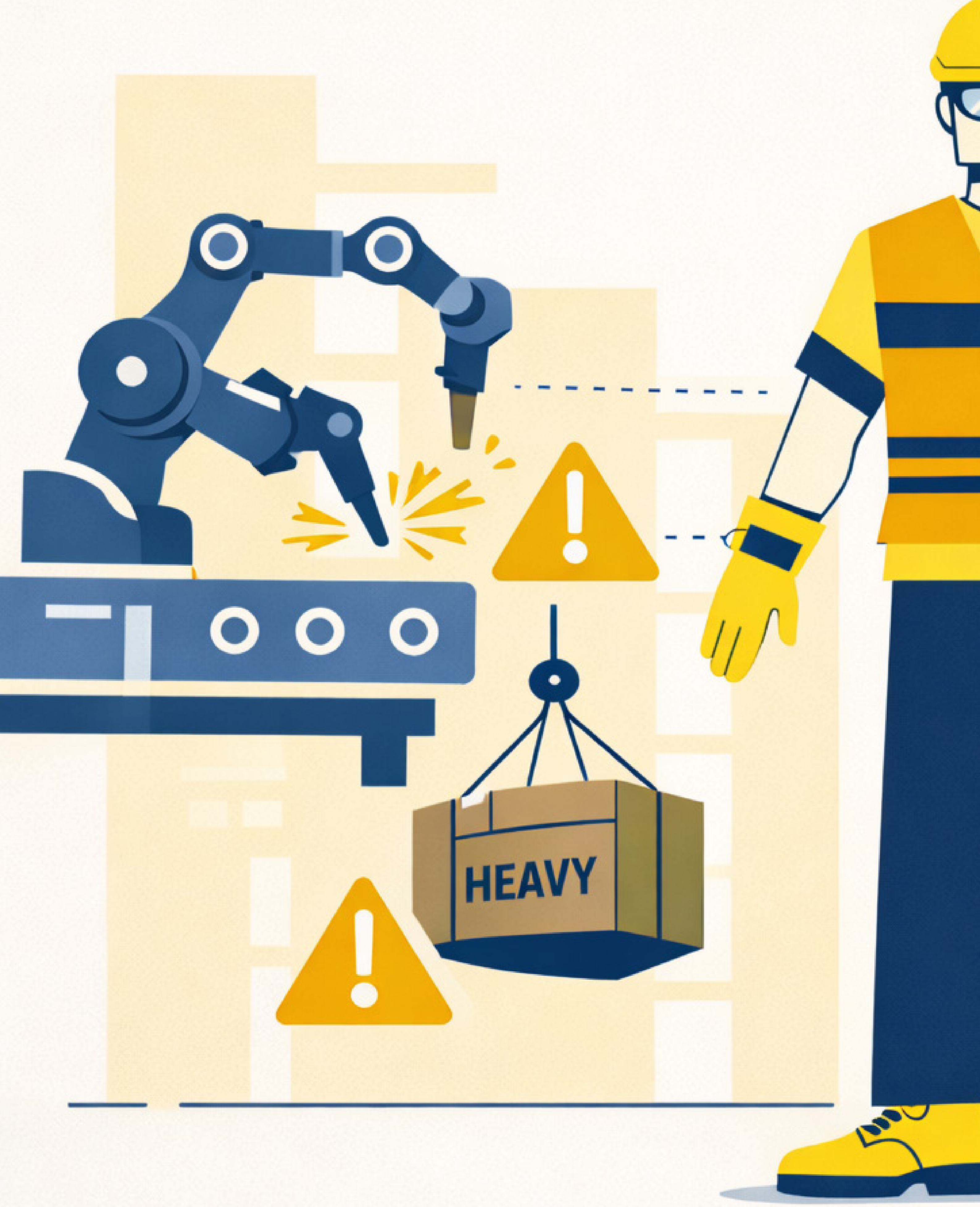
- In-depth analysis of production processes and related risks
- Technical inspections in the department to map real critical issues

- Drafting specific DVRs for each area and task
- Support in equipment management (verifications, booklets, maintenance)
- Preparation of operational procedures and checklists
- Tailored training plans
- Emergency simulations and tests
- Assistance in case of inspections or disputes

In the manufacturing sector, where every process has its own level of risk and every piece of machinery can pose a danger, it is essential that consulting is not generic but immersed in the company's production reality.

To conclude, in the manufacturing sector, talking about workplace safety is not just about respecting the law. It means making a long-term choice, which protects people, machinery, and ensures production continuity for your company.

Having an up-to-date DVR, training staff, having adequate PPE, and methodically managing prevention is not a plus, but a minimum condition for competing in the market. Those who neglect safety at work today expose themselves not only to fines and blockades, but to reputational damage and a loss of competitiveness.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PART III

USER RESEARCH AND INSIGHTS

SIXTH CHAPTER
Qualitative Research Methodology

6.1 Research objectives

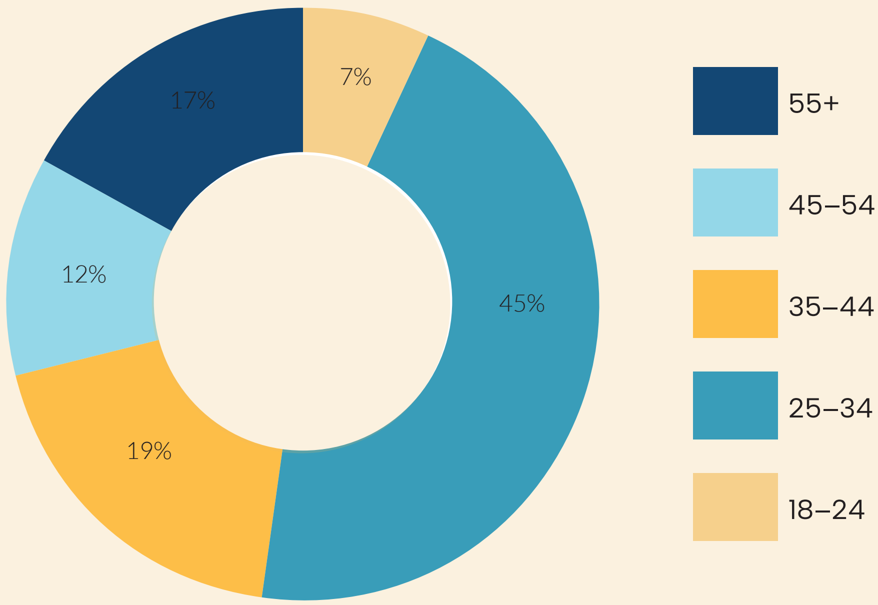
The main point of this research is to explore workers' perceptions, experiences, and needs related to the occupational safety inside the manufacturing environments. In particular, the study aims to better understand how workers perceive the main risks that are present in the manufacturing settings, their level of awareness and acceptance of werable safety technologies. Also important is to understand the key factor that influence their adoption, such as usability, comfort, and data privacy. The insights gathered through this research are intended to inform the design of a human-centered wearable safety solution, ensuring that design decisions are grounded in real user needs and everyday working conditions rather than purely technical considerations.

6.2 Survey structure

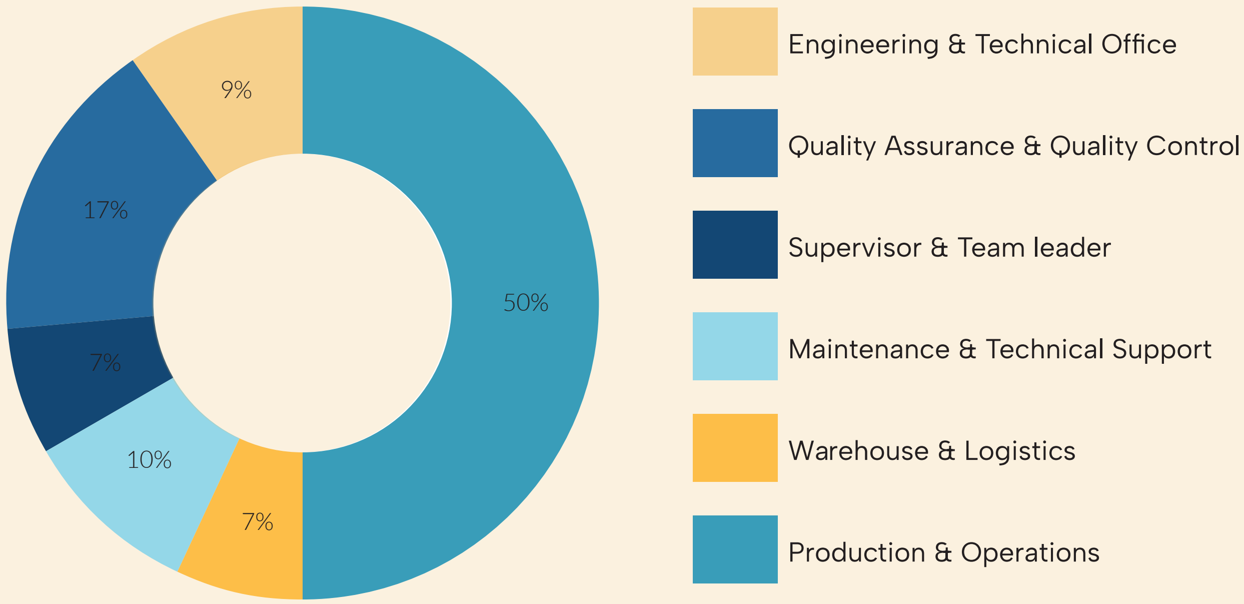
The survey was developed on Google Forms to facilitate its sharing and reception by people in the manufacturing sector. It is divided into seven sections: Participant Profile, Work Environment, Safety Perception, Current Safety Technologies, Wearable Safety Solutions, Privacy & Acceptance, and Final Feedback.

The survey consists of **18 multiple-choice questions and a final open-ended question**. The first questions are needed to understand how workers perceive and experience safety within companies today, while the final open-ended question is intended as a space to leave a personal comment, useful for more fully expressing their needs in the field of workplace safety.

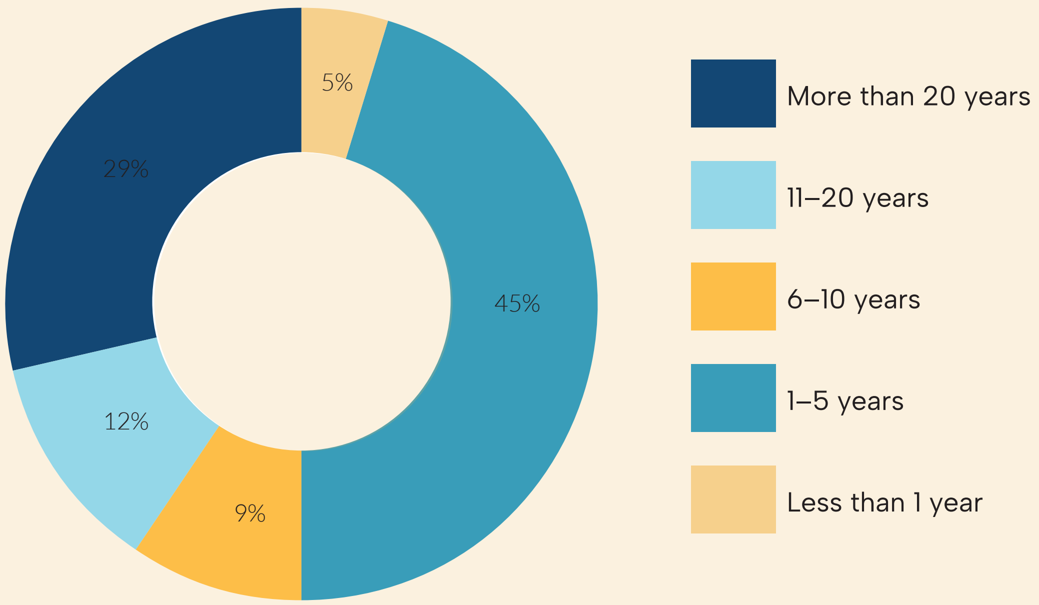
1. What is your age group?



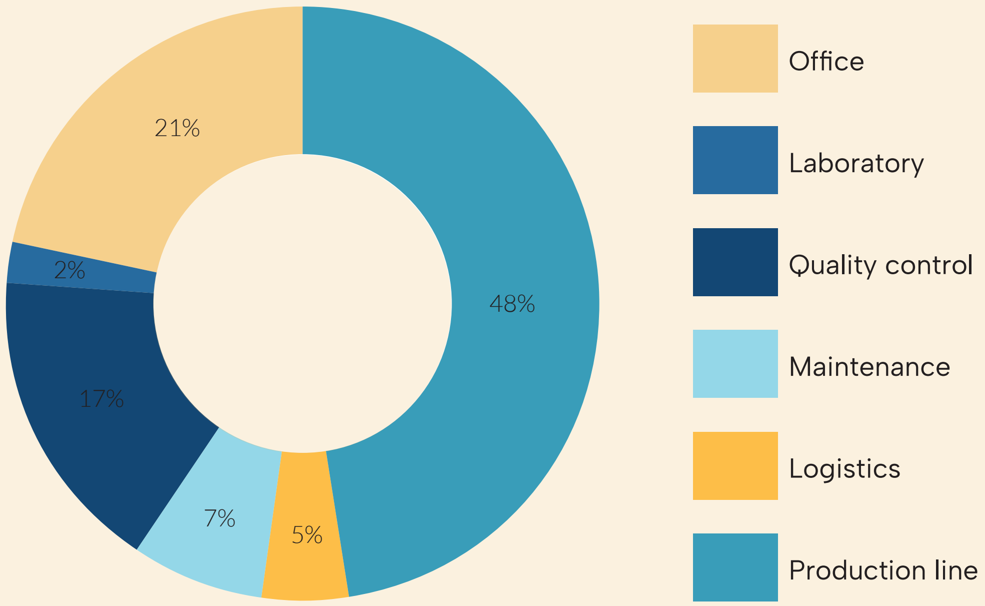
2. What is your main role in the company?



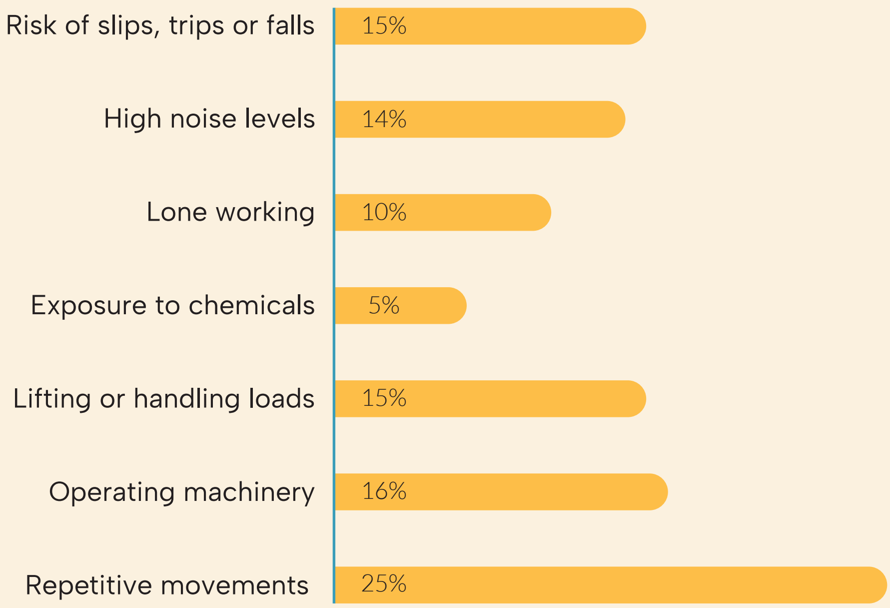
3. How long have you worked in the manufacturing sector?



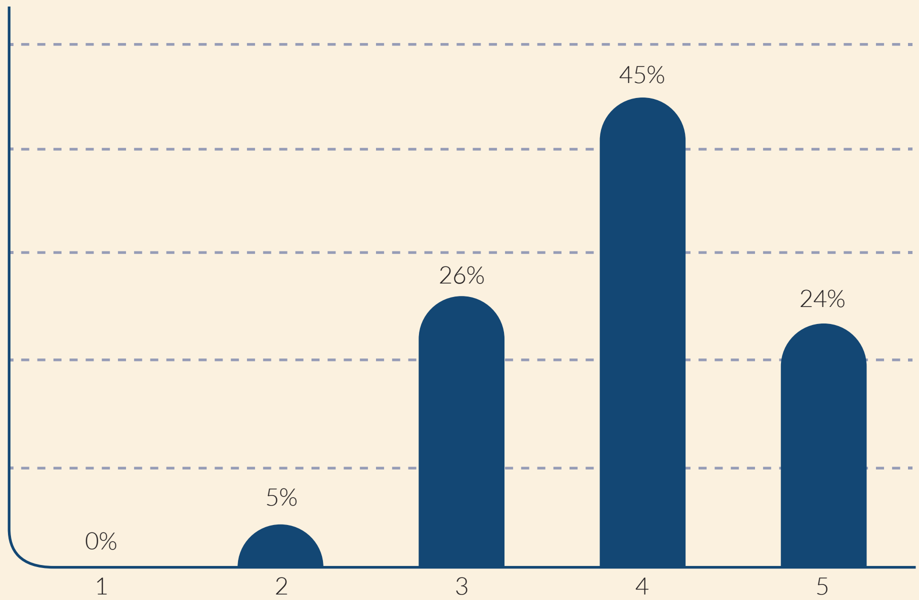
4. Where do you mainly work?



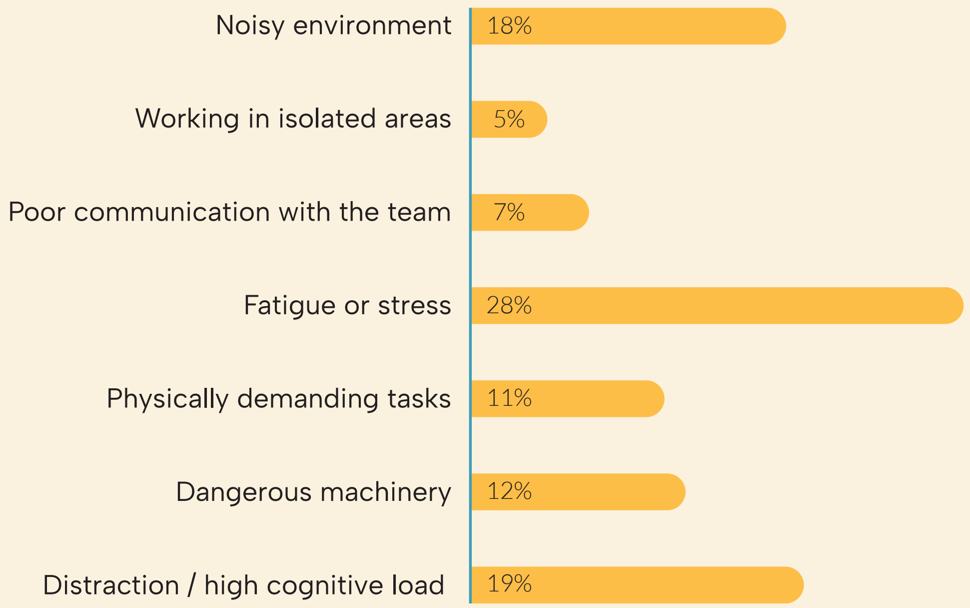
5. Your work involves (select all that apply):



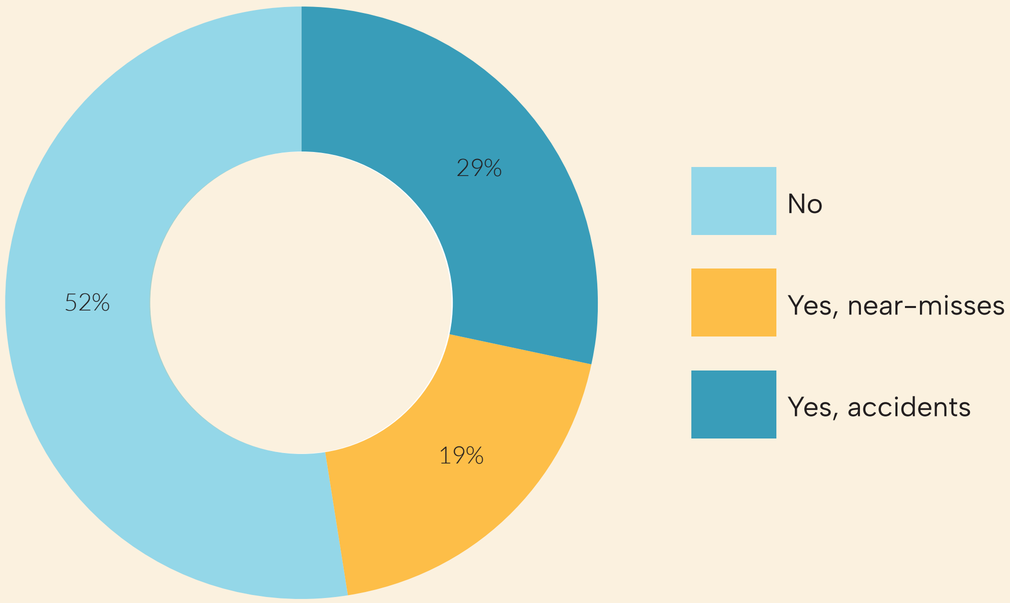
6. How safe do you feel while performing your job?



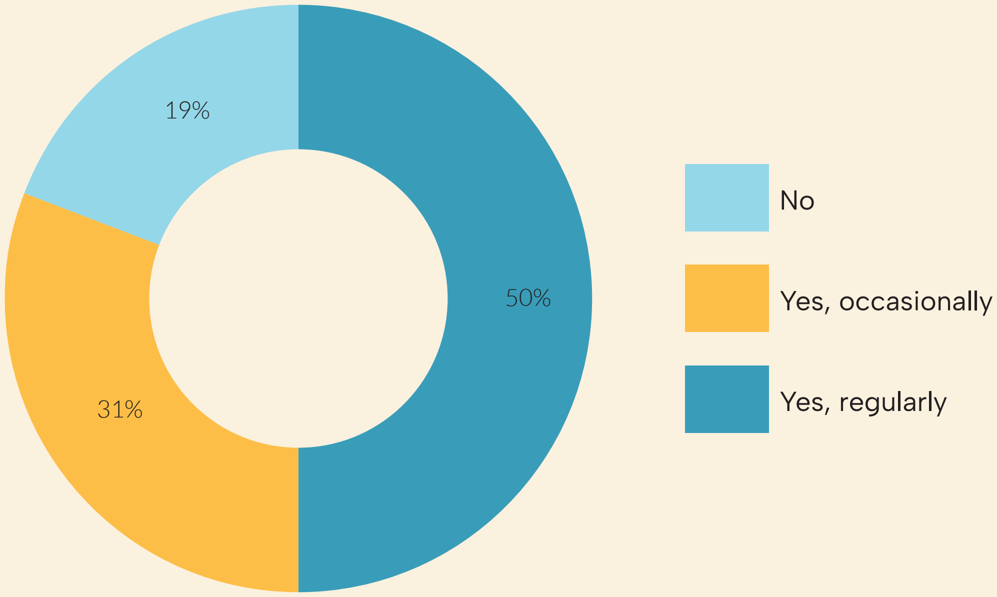
7. What are the main risk situations you encounter?



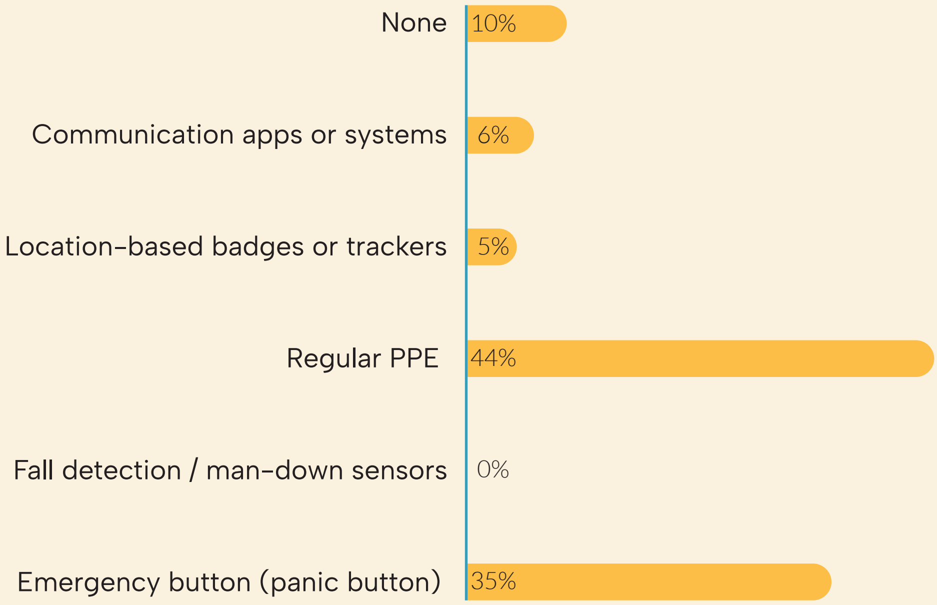
8. Have you ever experienced accidents or near-miss events at work?



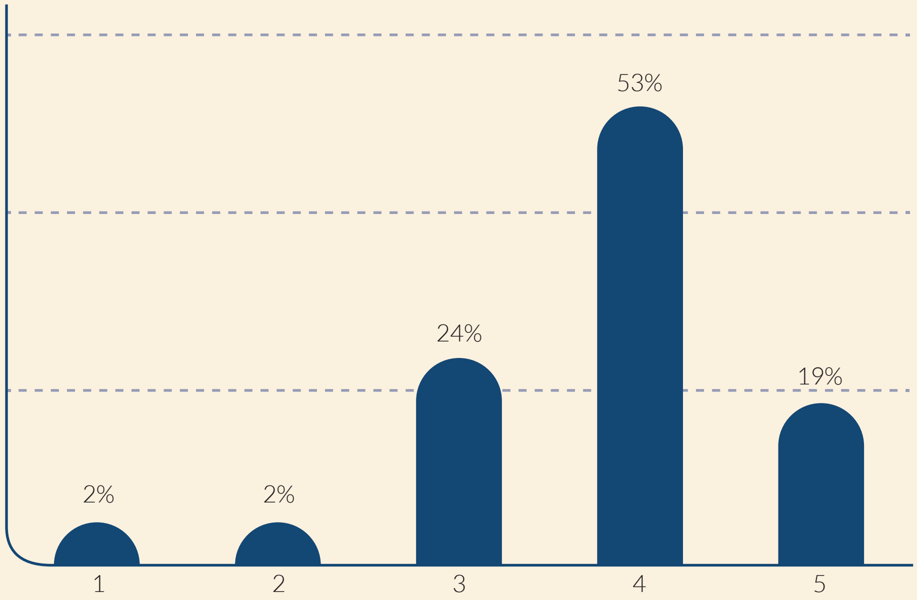
9. Do you currently use any safety-related technological devices?



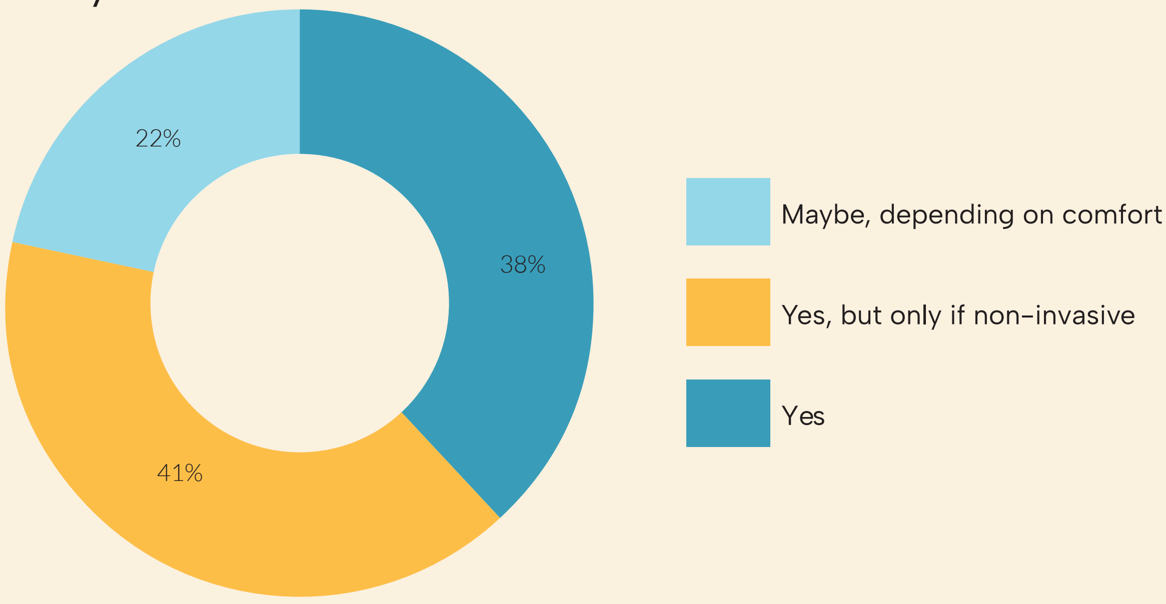
10. Which types of devices do you use or have used?



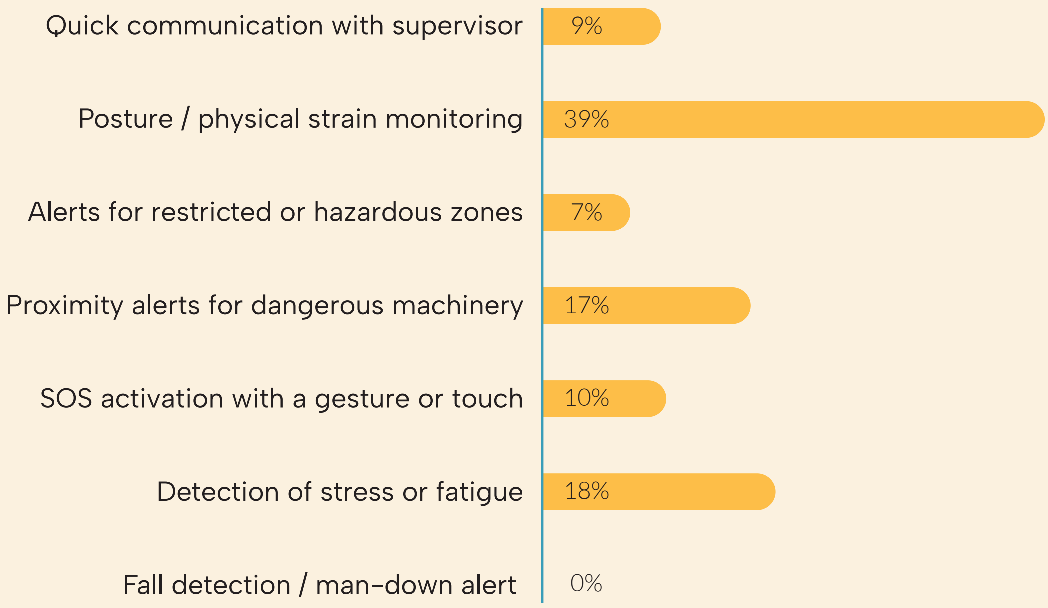
11. How effective do you find the current safety devices?



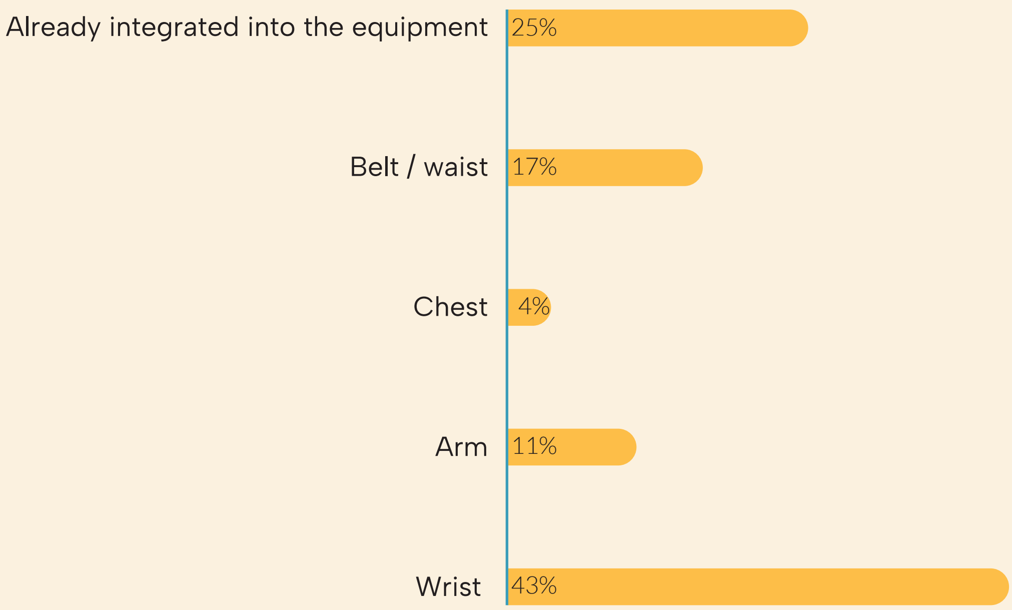
12. Would you be willing to use a wearable device to improve your safety?



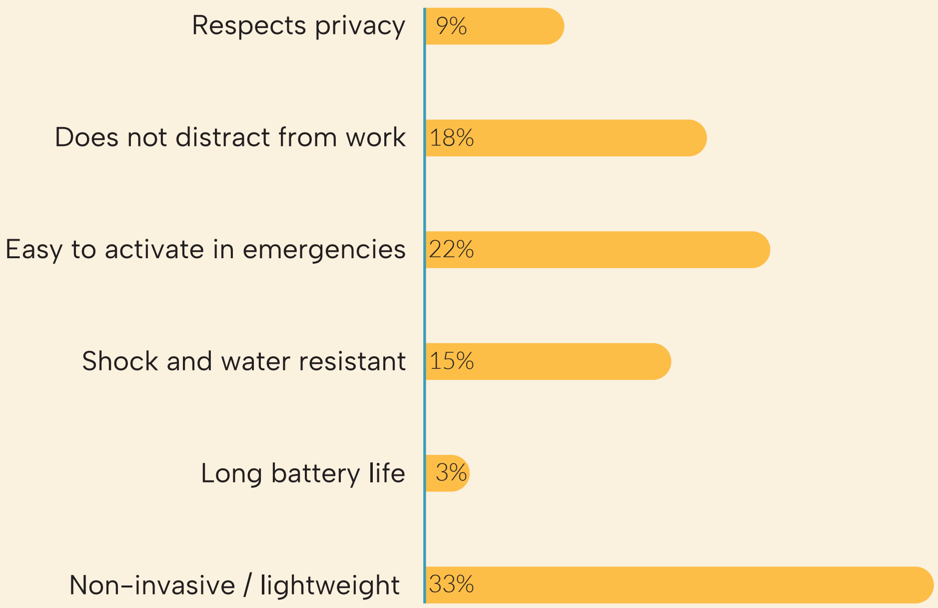
13. Which functions would be most useful for you?



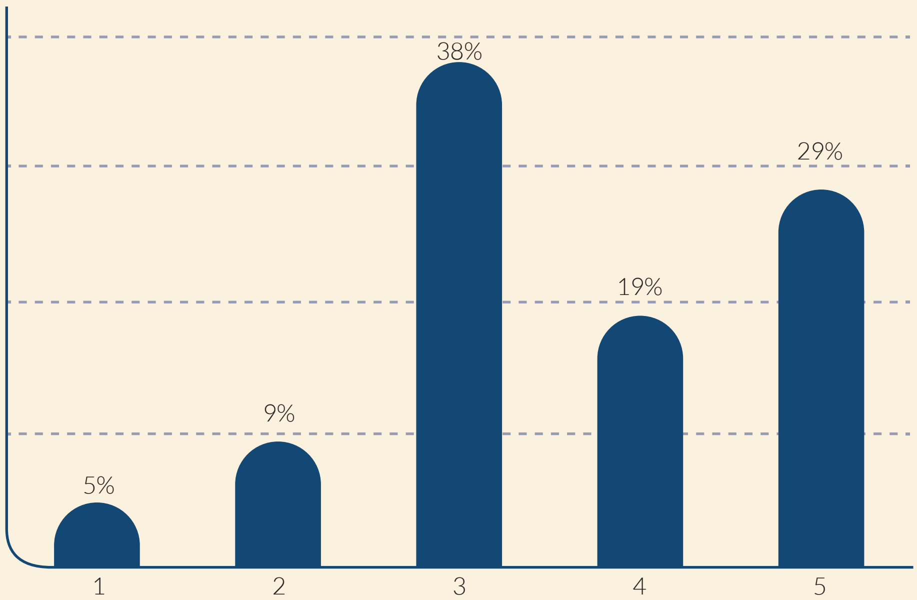
14. Where would you prefer to wear a device?



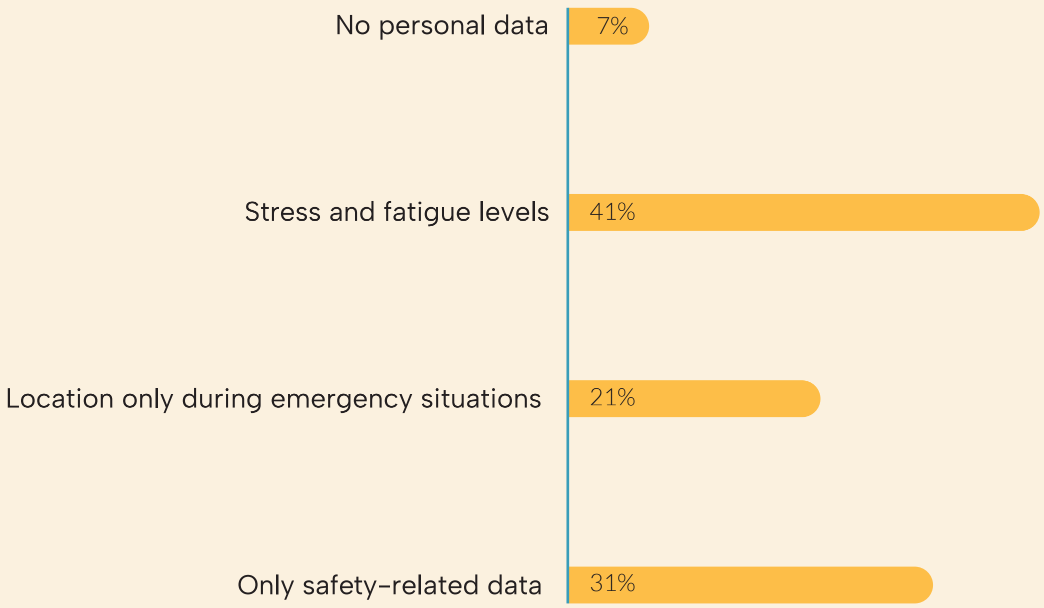
15. Which characteristics are essential for you in a wearable?



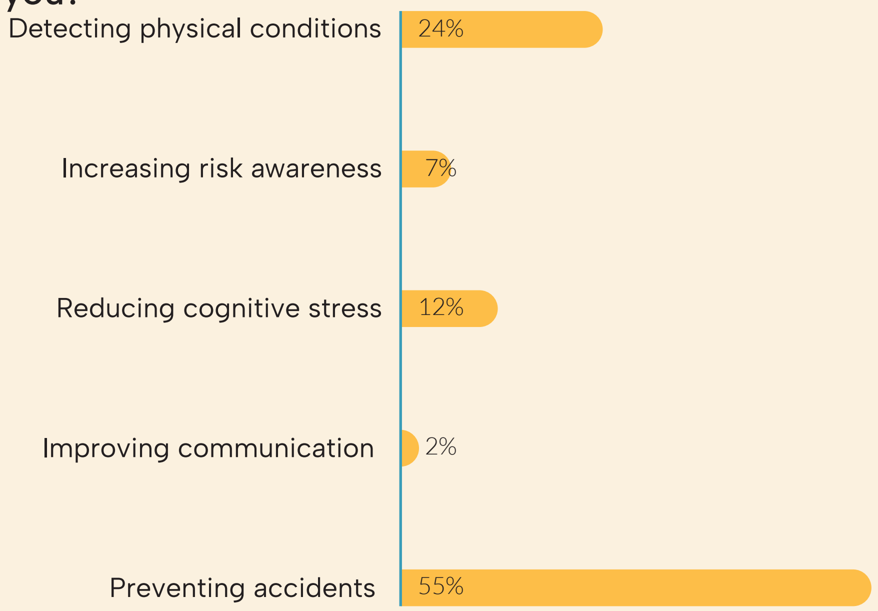
16. Are you concerned about being monitored?



17. Which types of data would you consider acceptable to share?



18. What is the main safety challenge a wearable device should address for you?



19. Any additional comments or suggestions?

It would be very useful to have a smart bracelet that track your position in the working environment and gives you a feedback (sound or vibration) when heavy equipment is close by or when you are entering in a dangerous area (operating machines or similar). The same device should also work as communication device to allow to quickly call your supervisor for any need. It could send a vibration or a small message on the screen if screen is an option.

I believe that ensuring the integration of wearables with existing safety protocols will significantly enhance their effectiveness. Additionally, training workers on how to utilize these devices properly is crucial.

I would suggest a device that can monitor multiple situations. Something non invasive and smart that can help prevent incidents.

During work, it is advisable to be aware of one's situation with respect to the process's statistical data.

6.3 Results analysis

The survey initially had a very low response rate, as during the first two weeks only a few participants completed it. However, over time the number of responses increased, reaching a total of 42 participants. This limited participation can itself be interpreted as a meaningful result, since **many workers are often reluctant to speak openly about workplace safety due to fear, lack of trust, or possible consequences**. This hesitation supports the relevance of this thesis: if working conditions and safety perceptions were completely transparent and unproblematic, workers would likely have no difficulty in sharing their opinions.

As a summary of the survey, to have an overview of the data collected it is possible to say that the majority of the respondents have an age between 25–34 years as we can see in question 1, with a focus on engineering and an experience in the sector between 1 and 5 years. The production line workplace is the most selected and the main feature that goes with that position is to have repetitive movements and risk of falling. Overall, people feel safe in the workplace, as we can see in question 6: 45% declare to feel enough safe. On the other hand, 28% of the workers are concerned about the level of fatigue and stress and the risk of distraction during work with 19%. Only 19% declare that they never use safety devices during work, the remaining 45% say that they wear regular PPE, like glasses, helmets, and gloves. 100% of the people are available to wear a safety device, preferred to wear it on the wrist with 43% and 25% would like to wear it integrated into regular PPE. Very high is the concern about being monitored and this is why 100% said that it would be important to be clear about what you do with the data. With 55%, the most important feature that they would suggest for a smart wearable device for safety is to prevent accidents. A very low number of people answered the last open question; overall, they suggested things aligned with these answers.

Francesco Alleva

Director Corporate Management Education @ ISTUD Business School

«Value is not built by technology alone, but by how humans perceive and trust it.»

6.4 Expert interview

In an organizational context, is it possible to clearly identify cause–effect relationships between actions and outcomes?

In the business environment, it is extremely difficult to identify a clear and univocal cause–effect relationship. There is no direct correlation between individual actions and final results, as the factors that determine a company's success are numerous, interconnected, and highly complex. Outcomes are rarely the result of a single decision, but rather emerge from the interaction of multiple variables over time.

Based on your professional experience, what brings significant value and attractiveness to the company?

In particular, investments that generate tangible touches with the customer work towards attractiveness for the company. This refers to not just products and services but interaction, interface as well as the overall experience. Value is becoming more and more a matter of perception rather than a function.

How reliable are digital metrics in evaluating user behavior and experience?

Social media platforms depend on metrics which may be unreliable if viewed in isolation. A common example is the time spent on a webpage. Although the user's time spent may indicate interest, it may not necessarily be the case. A user can open a page and leave the device alone before returning. Under such situations, the data alone will not be adequate to represent user reality.

How have digital business models changed the relationship between companies and users?

In digital business models, the disintermediation between company and customer has led to the creation of interfaces designed to "trap" users in increasingly seamless and continuous experiences. This has profoundly changed corporate approaches. Today, markets are no longer driven primarily by rational decision-making, but by perceptual and emotional choices shaped by interaction design.

What role do perception and emotion play in decision-making processes?

As demonstrated by Daniel Kahneman's theories on emotional economics, decision-making processes are often guided more by perception than by pure logic. In this sense, User Experience has become a determining factor in shaping a positive perception of a brand and influencing user trust and acceptance.

Can you provide an example of how UX contributes to brand perception?

Amazon represents a clear example. Its Value Proposition and corporate principles are deeply embedded in its UX, which is built around immediacy, trust, and perceived simplicity. Over time, this approach has generated a strong reputational framework, where users intuitively associate the brand with attributes such as ease of use, clarity, and reliability.

How does inclusive or human-centered design influence user trust?

An emblematic case of inclusive design is the introduction of touch interaction with the iPhone. This form of physical UX radically changed how people interact with technology. The more an experience is user-friendly and "anthropic"—that is, modeled on human behavior—the more it succeeds in bringing people closer to technology and generating trust.

How should Value Proposition be understood in contemporary design and business contexts?

The Value Proposition represents the essence of what a company offers to the market. It goes beyond products or services and includes a set of meanings, experiences, and perceived values. Measuring its effectiveness requires specific tools such as surveys, interviews, and direct observation of user behaviors and attitudes.

How important is the reputational dimension of an interface?

The reputational dimension has become increasingly important. For instance, Amazon's UX and UI have created a sort of "reputational library" over time. Users associate the interface with qualities such as intuitiveness and clarity, and this collective perception becomes a competitive asset.

Does ease of use always correspond to simplicity?

Ease of use does not necessarily coincide with simplicity. In industrial machinery, safety systems, and training processes, usability is often the result of complex design work aimed at reducing friction and improving the overall experience. From a corporate perspective, design must occur before implementation, not afterward. Simplicity must be constructed, not improvised.

What role do user behavior and emotional responses play in design processes?

User actions and attitudes are a fundamental part of development. Increasingly detailed studies analyze emotional responses during interaction with interfaces. Even seemingly minor elements, such as emoticons or micro-interactions, provide valuable signals regarding perceived experience and user engagement.

How is user experience evaluated today?

Contemporary research combines narrative, qualitative, and quantitative approaches to measure the impact of digital interactions. The goal is to profile satisfaction levels and understand the relationship between products or services and broader value propositions, including attitudes, expectations, and usage habits.

How are concepts and solutions selected during the design process?

Multiple concepts are typically developed and tested before selecting the most effective solution. However, no proposal can be detached from the market, users, or real customers. Solutions must be generalizable, as innovation often originates in one sector and later finds application in many others.

What factors will determine organizational success in the future?

The success of a company increasingly depends on its strategic capabilities and its ability to understand and anticipate dynamics related to planning, logistics, marketing, and production, which together form the backbone of the value chain.

How do you envision the future role of humans in industrial systems?

Looking ahead, a gradual reduction of direct human involvement is expected, with humanoids and intelligent systems playing a more prominent role. However, the real difference will lie in the ability to train and personalize these systems effectively. Strategic decision-making—the ability to anticipate, design, and create value ahead of competitors—will remain the key determinant of success.

SEVENTH CHAPTER
Design challenge

7.1 Design challenge

The increasing complexity of industrial manufacturing environments and the changing role of the human worker within them give rise to the design challenge discussed in this thesis. Operators on modern assembly lines must mantain high levels of focus, accuracy, ad situational awareness while interacting with automated systems, machinery, and digital interfaces, especially in the heavy manufactoring and metal-mechanical industries. In addition to physical hazards, this environment exposes employees to stress, cognitive overload, and delayed decision-making in crucial circumstances.

In industrial settings, traditional safety solutions are mostly passive and preventive, depending on emergency protocols, personal protective equipment, signage, and procedures that frequently don't take action until a dangerous situation has already arisen. The wearable safety devices that are currently being used in industry are typically designed primarily as **"emergency buttons"** to be activated in dire situations, or they are isolated tools that concentrate on a single parameter. This strategy restricts their ability to effectively handle the systemic, dynamic nature of risk in contemporary production settings.

Therefore, rethinking wearable technology's role for workplace safety and moving from a reactive, device-centered solution to a proactive, **human-centered system is the main design challenge**. The project intends to investigate how a wearable can become a crucial component of a larger ecosystem that continuously supports employees, improving awareness, lowering cognitive strain, and enabling prompt interventions without complicating or diverting daily tasks.

Within this context, the design challenge is approached through a systemic design perspective, which frames workplace safety not as a collection of isolated issues, but as the result of continuous interactions between human operators, technological systems, organizational structures, and the physical environment. In complex industrial settings, risks emerge dynamically from these relationships rather than from single, identifiable causes, making linear and purely reactive solutions insufficient.

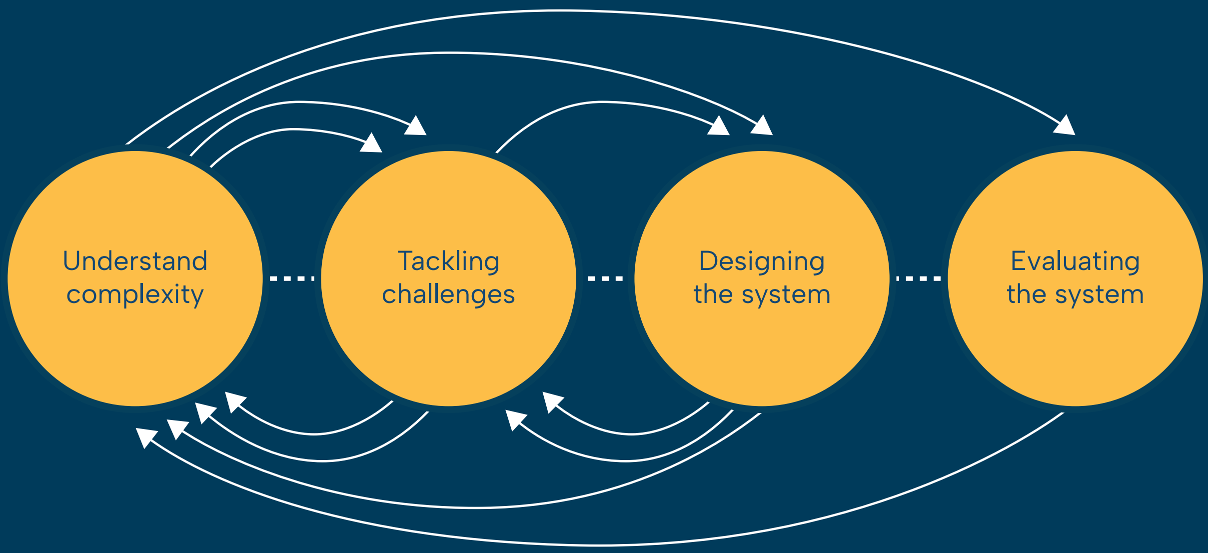


Figure 3. The design challenge is framed at the intersection between understanding complexity and tackling emerging challenges.

7.2 The vision

The vision at the heart of this project entails a **fundamental change in the way safety-worn workplace technology is conceived and experienced**. Instead of a device that is intended to function only in emergencies, the wearable would be an active support mechanism deployed at all times during the worker's daily activities. This creates a constant companion that bolsters safety, awareness and decision-making.

In today's industry uses, wearables work according to a logic of **'red button'**, i.e., they mostly stay invisible but become important under high-stress or emergency situations. In anticipation of an accident or health crisis, reliance on wearable technology to prevent the occurrence of a disaster has been common. While this may avert the danger, it does not assist a worker during the moments before the actual health issue, when emptiness, exhaustion, or changes in surroundings can be observed so as to take necessary measures to avert trouble. The vision put forth encourages the framing of the wearable as a **preventive adaptive presence** that can step in before risk turns to danger.

In this viewpoint, the wearable is not seen as a standalone artifact but as **a node in a human-supporting ecosystem**. The wearable with surrounding industrial ecosystem including machines, digital infrastructures, and supervision, organizational and human factors. This ecosystem is part of a wearable. Via continuous data exchange and contextual interpretation, the system aims to provide meaningful feedback on raw information from individual operators and global safety management.

These forecasts highlight the need for prioritizing the cognitive and experiential needs of individuals. Instead of bombarding workers with additional information, our ecosystem helps them with **reduced cognitive load** alongside filtering, prioritising, and timing feedback considering the context. Shifts in attention in taxicabs have a different characteristic. The driver can readily disengage from the vehicle. In this fashion, technology respects human rhythms and stresses without demanding adaptation on the part of the worker.

At the organizational level, the human-support ecosystem effects a broader understanding of safety as a condition that moves and changes. When supervisors and safety managers know about the aggregated, anonymized data, they will be informed about patterns, trends and emerging risks. Significantly, this entire process focuses on **the ethical framework of transparency, trust and respect for the autonomy of the worker**. Acceptability of the system is sought, avoiding a surveillance-type approach.

The aims of this project are also aligned with the Industry 5.0 principles of integrating technology into industry in a human centric, resilient and sustainable way. The project claims that 'beyond the red button' they propose an invisible yet meaningful wearable which will contribute to a safer, thoughtful and more humane industrial effect.

Wearable as “red button”

Wearable as Heman Support Ecosystem

7.3 Functional and experiential objectives

From the design challenge and the concept of moving from a reactive wearable device to a **human-centric support system**, the project develops a list of **functional-experiential design objectives** that shed light on the design process of the proposed system. The design objectives translate the design vision into design intentions that are aligned with the technical possibilities, human requirements, and context of industrial manufacturing environments.

From the perspective of function, the key purpose is to **facilitate workplace safety on a constant and proactive basis**, as opposed to reacting during emergencies or crisis situations. The system is intended to continuously track various parameters related to the individual as well as the environment and make decisions based on this tracking activity to provide feedback during the identification of potential risks. The purpose of the function is thus **preventive, alerting, or decision support**.

The proposed system is designed to be **non-intrusive, intuitive, and trust-building.** The interaction design for the wearable device should be simple and direct, using subtle feedback like the haptics or visual indicators rather than complex displays or frequent distracting inputs. The worker should feel supported rather than controlled as they work, the role of the wearable device should be seen as an ally rather than a surveillance mechanism.

The other important objective in this category of experiences that this wearable needs to achieve is that it needs to be integrated with existing workflows. The device needs to be compatible with and adjust according to the cycles and constraints of an industrial assembly line without changing behavior too much and adding more training to what already exists.

Finally, at a functional and experiential level, it is a design that emphasizes ethical and human-related concerns. The matter of **transparency concerning data use and collection, autonomy of workers, and trust between workers and management is an important aspect of this design**. The design is not aimed at assessing personal performance but at a collective sense of well-being and improved working conditions.

Taken together, these functional and experience-based objectives enable a systematic approach for subsequent design phases. These objectives help guarantee the alignment of the wearable technological device's developments, as well as the whole ecosystem surrounding it, by being attuned to this project's vision, systemic design's principles, as well as **Industry 5.0's overall objectives**, putting humans in the forefront of technological developments.

Dimension	Objective	Design Intent	Implications
Safety	Support workplace safety in a continuous and proactive manner	Shift from emergency-only logic to early detection and prevention	Continuous monitoring of relevant parameters; contextual interpretation of data
Cognitive ergonomics	Reduce cognitive load during work activities	Deliver only meaningful and timely information	Data filtering, prioritization, and selective activation of feedback
Interaction	Ensure non-intrusive and intuitive interaction	Minimize interruptions and conscious effort	Subtle visual, haptic, or ambient cues; background operationmetry
Workflow integration	Integrate seamlessly into existing industrial processes	Avoid disrupting established routines and productivity	Compatibility with PPE, tasks, and spatial constraints of assembly lines
Human-centered experience	Foster trust and perceived support	Position the wearable as an ally rather than a control tool	Transparent system behavior; clear feedback logic
Organizational support	Enable proactive safety management at system level	Extend safety beyond the individual operator	Aggregated and anonymized data for supervisors and safety managers
Ethics & autonomy	Respect workers' autonomy and privacy	Avoid surveillance-oriented design	Ethical data handling; focus on collective well-being rather than individual performance

Figure 4. Functional and experiential objectives translating the project vision into design guidelines.

7.4 Context presentation: an industrial assembly line

Assembly line is **a production system in which the production of the item is done through a predetermined sequence of workstations** wherein each workstation is designed for performing an activity in the overall production process (Investopedia, 2025). It involves the processing of goods through a sequence of workstations in such a way that the item is eventually produced from raw material/form components to the finished item as it moves through the fixed path. It is possible to divide the complex production jobs into smaller and manageable parts to be processed by humans and/or machines.

The essence of assembly line production is that **the whole process is decomposed into distinct tasks** (Qoblex, 2025). Instead of having one worker build a complete product, the process is divided into discrete steps, with each workstation performing a specific operation. Components move from station to station, often along conveyor belt systems, in continuous and orderly fashion. This kind of sequence logic allows for huge standardization, repeatability, and control of time and quality (Identic solution, 2024).

Importannt features that characterize the assembly line production are **normal work-stations, standardized workflows, and sequential processing of tasks**. In contrast to the slow, often flexible organization of the traditional craft-based manufacturing with high reliance on individuals working on their own, assembly lines depend on coordinating, synchronizing, and a step by step process. Assembling a product no longer means just putting parts together. Over the years, the assembly line concept has expanded to include often the quality checkpoints, inventory systems, and link mechanisms to ensure everything runs smoothly through all levels of production.

However, in modern assembly lines, there is always a lot of synchronization and timing involved. In fact, advanced scheduling programs are used in such assembly lines in order to ensure the timely delivery of materials to every workstation at the right time. But along with this advanced tracking system, it also becomes possible for manufacturers to monitor the current performance level in real time in order to adjust operations according to those requirements (Cerexio, 2025).

In the past, the assembly line was invented in the days of the Industrial Revolution as a reaction to the increasing need for mass production of products and items. Although the division of labor in any form, whether manual or industrial, had been in existence for a long time, the modern form of the assembly line appeared in the late nineteenth and early twentieth centuries through a series of technological and organizational innovations (Aveva, 2025).

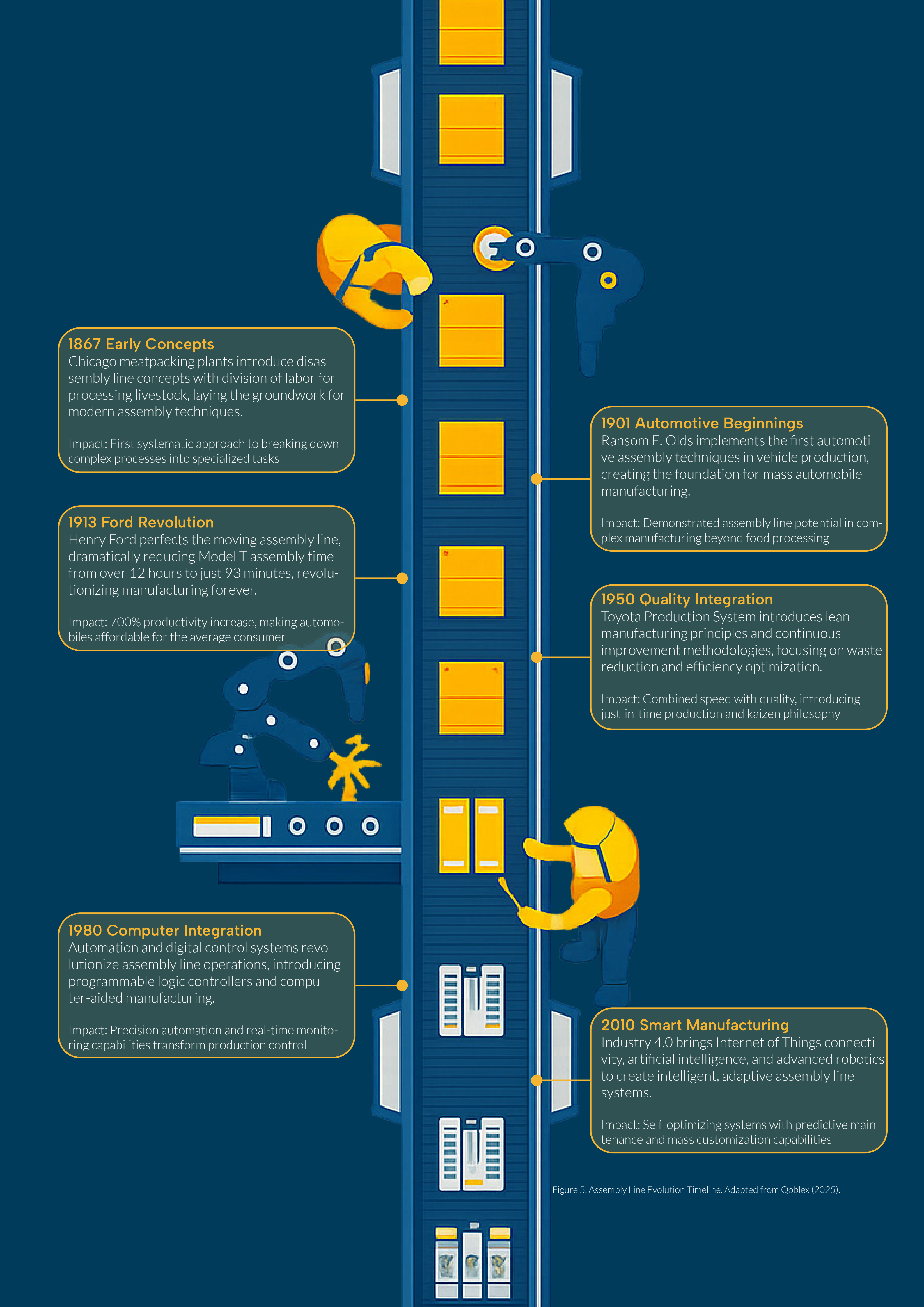


Figure 5. Assembly Line Evolution Timeline. Adapted from Qoblex (2025).

In practice, an assembly line operation follows a clearly structured, step-by-step procedure. Planning and scheduling production involve defining output quantity, materials needed, and workforce deployment. This is a critical stage because at this point, the platform has already been laid for smooth and continuous operations. Materials are prepared, inspected, and staged such that every workstation will have the needed components on tap to avoid delays and mistakes.

The sequential operations at each workstation constitute the very heart of the process. On this account, workers or automated systems add components, carry out assembly tasks, perform inspections, or complete functional checks. Quality control checkpoints are distributed along the line to catch defects early and prevent the propagation of errors downstream. In the final stages, this generally includes inspection, packaging, and preparation for shipment (Investopedia, 2025).

Assembly lines can be of various types depending on the extent of automation involved. Manual assembly lines, which use human labor mostly, are more apt for performing tasks requiring complexity in manipulation, customization, or a high degree of dexterity. An automated assembly line involves machinery and robotics, performing tasks at high speed with great precision; thus, it finds its perfect application in the bulk production of standardized products. A hybrid assembly line falls in between these two extremes, where both manual and automated operations blend; machines are used for repetitive or high-precision tasks, while human involvement is preserved in areas that require judgment and adaptability.

The specifics of the industry also shape the methodology of drawing assembly line design. Car manufacturing deals with heavy, big components and combines complex sub-assemblies. In producing electronics, precision placement and controlled environments become tantamount. Food processing requires strict hygiene and temperature conditions. Even more recently, one finds flexible manufacturing systems that enable the rapid reconstruction of assembly lines to accommodate different products or volumes of production facilitated by modular layouts and programmable automation (Mingo smart factory, 2024).

The selected industrial context is a **heavy manufacturing assembly line environment**; this involves a hybrid configuration, integrating manual operations with automated machinery. This section has been chosen because it represents one of the most complex and risk-prone environments in which both the physical and cognitive demands on workers are extremely high.

The operators in heavy manufacturing assembly lines have to perform repetitive tasks under strong time constraints and stand close to machines, tools, and moving parts. They are continuously exposed to noise, vibrations, and ever-changing environmental conditions. The safety risks are then not limited to sudden accidents but also include fatigue, stress, reduced attention, and delayed decision-making. These characteristics make this context especially relevant for investigating how wearable technology can support workers beyond traditional accident prevention.

Simultaneously, this manufacturing setting essentially represents a transitional phase to Industry 5.0. While automation increases in the setting, the contribution of human operators lies at the core in terms of supervision, intervention, and decision-making. Interlaced with human judgment, the presence of automated systems points to solutions that can bridge the gap between technological complexity and human cognitive capabilities.

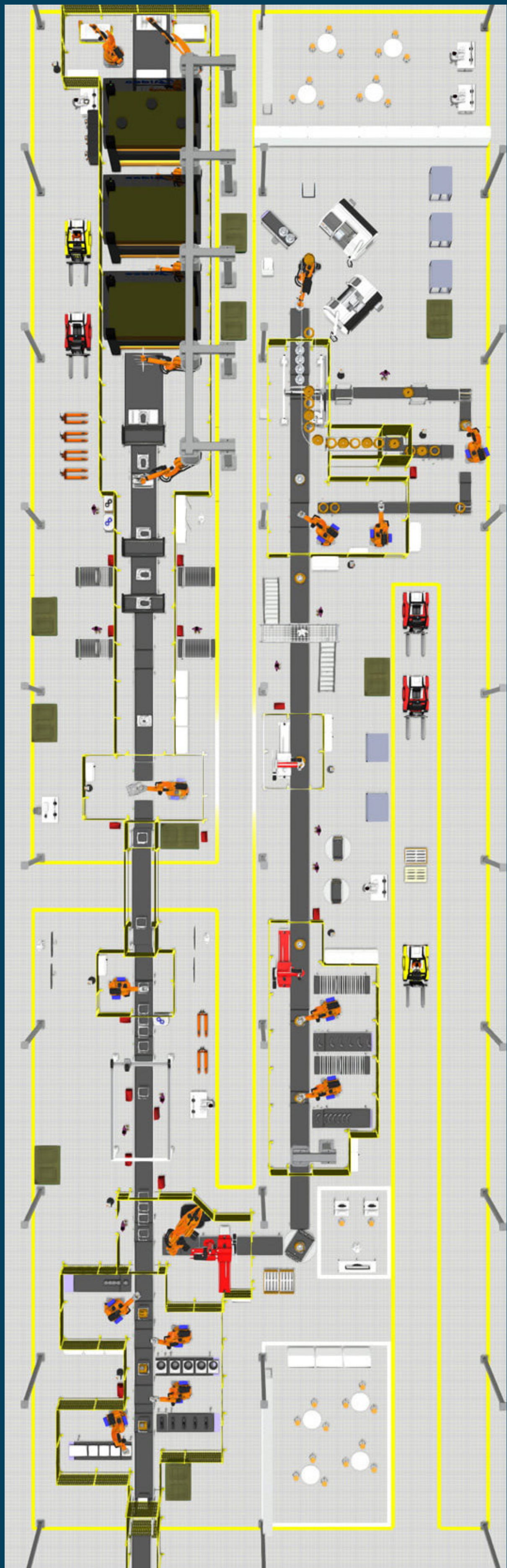
7.5 Reference assembly line for the project

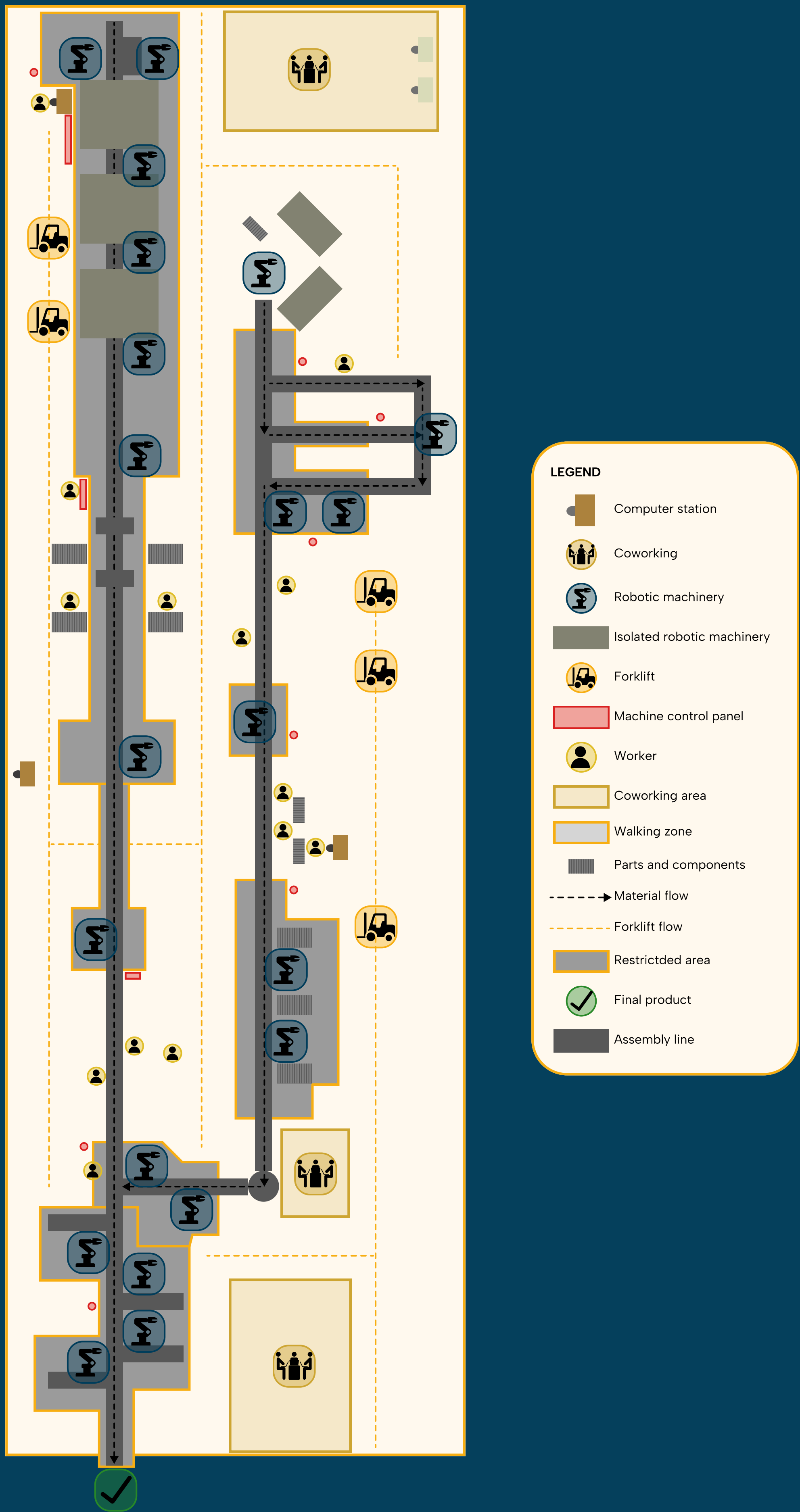
The reference assembly line used for this project is derived from a real industrial case study developed by **Midea Group,** the world's largest producer of major home appliances. In particular, the reference is based on a high-end washing machine assembly line implemented at Midea's Wuxi factory in China, characterized by a high level of automation, flexible production, and the integration of human operators, robotic systems, and internal logistics.

For the purposes of this thesis, **the original assembly line has been intentionally schematized and simplified**. Rather than representing an exact replica of an existing industrial line, the assembly line designed for the project serves as a simplified and realistic illustration of the key characteristics of industrial assembly environments relevant to the design challenge. This abstraction allows the project to focus on spatial organization, operational flows, and human–system interactions, rather than on technical or production-specific details.

The assembly line is conceived as a modular arrangement of workstations, each assigned to a specific stage of the assembly process. The system includes both manually operated stations, where precision tasks are carried out by workers, and semi-automated stations, in which machines assist or regulate certain aspects of the process. Materials and components move through the system via conveyor lines, while operators remain stationed at fixed positions, interacting with machinery and human–computer interfaces.

The entire system relies on continuous coordination among different roles, including line operators, maintenance staff, and supervisors. Effective communication between stations is essential, as delays or errors in one phase directly impact the overall performance of the line. As a result, the assembly line can be understood as a complex socio-technical system, where safety, efficiency, and human performance are deeply interconnected. This context provides a strong rationale for investigating a human-support system based on a wearable-centered ecosystem.




LEGEND
Computer station
Coworking
Robotic machinery
Isolated robotic machinery
Forklift
Machine control panel
Worker
Coworking area
Walking zone
Parts and components
Material flow
Forklift flow
Restrictded area
Final product
Assembly line

EIGHTH CHAPTER
User research

8.1 Proto-personas

age
52 years

city
Brescia

occupation
Assembly line worker

Marco
24 years of experience

Personality

«The wearable must be perceived as protection, not as control.»

Goals:

- To keep a stable routine
- To enjoy quiet time after work
- To stay active without overexerting himself

Needs:

- To feel supported during long, repetitive day
- To sense that potential issues are noticed early
- To avoid unnecessary complications

Behaviors:

- Likes going for evening walks and rides
- Spends weekends fixing things at home
- Prefers familiar tools and habits

Pain points:

- Feeling physically tired at the end of the day
- Losing focus during monotonous tasks
- Discomfort with sudden changes

age
34 years

city
Modena

occupation
Assembly and quality control operator

Sofia

6 years of experience

Personality

«The wearable should reduce cognitive load, not add to it.»

Goals:

- To find time for running in the evening
- To improve work–life balance
- To learn cooking asian food

Needs:

- To feel reassured when things are under control
- To reduce moments of uncertainty
- To receive subtle confirmation rather than constant alerts

Behaviors:

- Listens to podcasts while commuting
- Switches between tasks quickly
- Keeps track of many small details

Pain points:

- Mental fatigue at the end of the shift
- Difficulty staying focused when under pressure
- Feeling overwhelmed by too much information

age
41 years

city
Turin

occupation
Production supervisor

Luca

15 years of experience

Personality

«The system must build trust, not surveillance.»

Goals:

- To maintain order and clarity
- To improve his organizational skills
- To have more time for family and hobbies

Needs:

- To have a general sense of what is happening
- To notice patterns without focusing on individuals
- To feel confident in decisions

Behaviors:

- Plans the day in advance
- Reviews notes and checklists regularly
- Tries to anticipate problems before they arise

Pain points:

- Feeling responsible when something goes wrong
- Difficulty acting before issues become visible
- Balancing oversight with trust

8.2 The concept

To create a **single, integrated system** for managing physical and mental safety within complex contexts such as manufacturing.

The system consists of **two main elements**: a personal wearable device for employees and dedicated data management and analysis software for supervisors.

A key factor of this project is **the link between these two artifacts**, which nowadays are often divided or unplugged from each other in order to ease workers' uptake of the device. Integrating communications into a single solution helps reduce the probability of error from uncoordinated information management.

Transparency and clarity in data management is a fundamental principle of the system: monitoring must be perceived as a tool for support and prevention, and not as a form of control. For this reason, both the wearable device and the software will be highly customizable, leaving the user the option to choose how and what information to view or share.

Although similar systems already exist, the value of the project lies in transferring these functionalities into a **single coherent and integrated solution**. This way, it is possible to reduce the risk of incidents related to suboptimal information management and improve the overall safety experience for workers and supervisors.

8.3 Journey map

Marco

	Start of day	Beginning of shift
Actions	Morning routine	Takes position
Touchpoints	Home	Home
Tasks	1a Wakes up early and follows the same routine every day 1b Has breakfast while mentally preparing for a long shift 1c Gets dressed in work clothes, choosing comfort over style 1d Commutes following a familiar route	2a Enters the plant and heads to the locker room 2b Changes clothes and puts on PPE and safety vest 2c Reaches the workstation and checks tools visually 2d Waits for the line to start
Emotions	Calm	Neutral
Positive perceptions	Sense of routine Familiar start of the day Feeling prepared	Familiar environment Clear expectations Predictable rhythm
Negative perceptions	-	Mild physical discomfort Early stiffness

Mid-shift routine	End of shift	After work
Repetitive work	Wraps up	Returns home
Home	Home	Neighborhood
3a Performs repetitive manual assembly tasks 3b Handles the same tools for long periods of time 3c Maintains a steady rhythm with minimal interruptions 3d Occasionally scans the surroundings without breaking focus	4a Completes the last assigned tasks 4b Cleans the workstation and organizes tools 4c Removes PPE and changes clothes 4d Leaves the production area	5a Commutes back home, often in silence 5b Changes clothes and relaxes 5c Goes for an evening walk 5d Mentally disconnects from work
Automatic	Relief	Relax
Confidence built on experience Feeling “in control” Work flowing smoothly	Satisfaction in finishing Order and closure	Quiet time Balance restored
Physical fatigue Reduced alertness Monotony	Mental tiredness	-

Sofia

	Start of day	Beginning of shift
Actions	Morning routine	Moves between stations
Touchpoints	Smartphone	Assembly stations
Tasks	1a Wakes up and immediately checks messages 1b Has breakfast while planning the day ahead 1c Reviews personal and work commitments 1d Mentally prepares for a busy shift	2a Enters the facility and changes clothes 2b Puts on PPE and safety vest 2c Receives brief instructions 2d Moves to the first workstation
Emotions	Alert	Focused
Positive perceptions	Feeling organized Sense of readiness	Clarity of tasks Engagement
Negative perceptions	Mild anxiety	Information overload

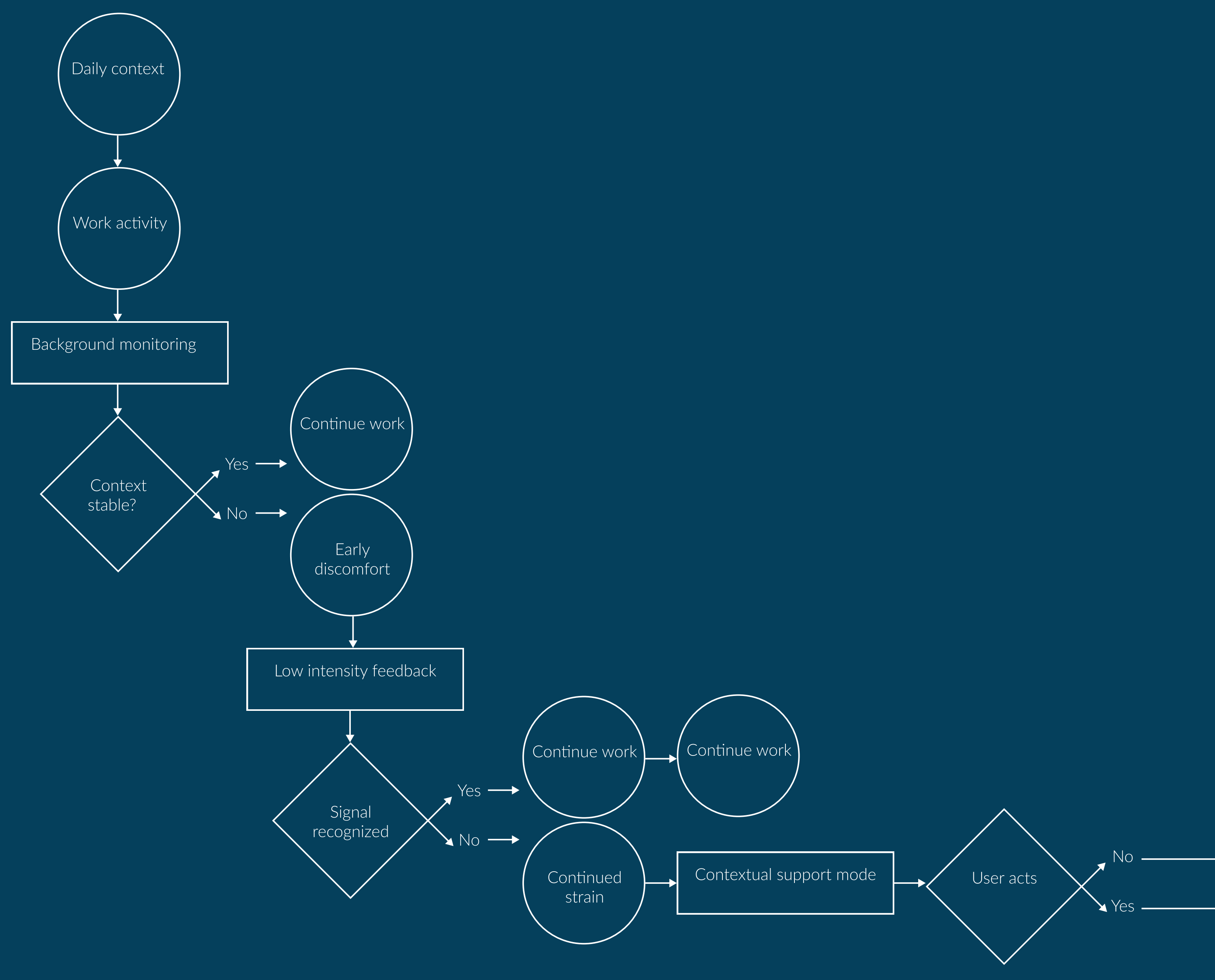
Mid-shift routine	**⚠ End of shift**	**After work**
Multitasking	Final checks	Personal activities
Shared workspaces	Break areas	Outdoor spaces
3a Switches frequently between different tasks 3b Performs assembly and in-spection activities 3c Makes quick decisions under time pressure 3d Manages interruptions and small issues	4a Completes final inspections carefully 4b Slows down pace due to fatigue 4c Double-checks work to avoid mistakes 4d Removes PPE at the end of the shift	5a Leaves the workplace 5b Goes running or exercises 5c Focuses on personal interests 5d Gradually disconnects from work
Pressured	Tired	Relief
Feeling productive Managing complexity	Completion of duties Confidence in accuracy	Freedom Personal time
Cognitive overload Stress peaks	Mental fatigue Reduced concentration	-

Luca

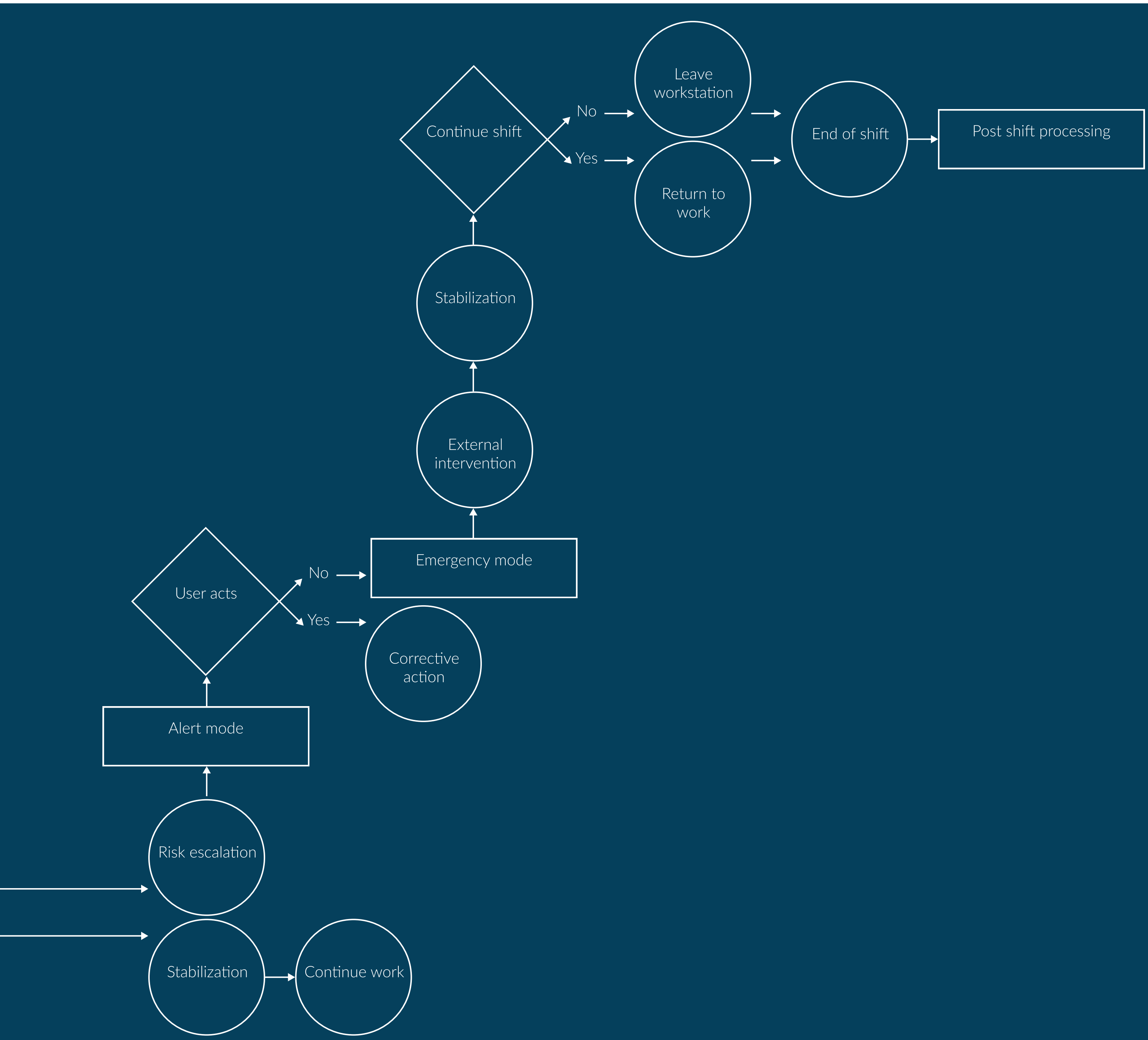
	Start of day	Beginning of shift
Actions	Plans activities	Supervises
Touchpoints	Office desk	Production floor
Tasks	1a Wakes up and reviews the daily schedule 1b Has breakfast while checking emails 1c Mentally prioritizes key issues 1d Commutes to work	2a Enters the plant and reviews reports 2b Walks the production floor 2c Observes ongoing activities 2d Talks briefly with team leaders
Emotions	Focused	Concentrated
Positive perceptions	Sense of control Clarity	Awareness of operations Presence on the floor
Negative perceptions	Responsibility pressure	Constant vigilance

Mid-shift routine	End of shift	After work
Coordinates	Reviews	Family time
Meetings	Reports	Home
3a Coordinates people and resour-ces 3b Addresses emerging issues 3c Adjusts plans and schedules 3d Monitors progress across areas	4a Reviews what happened during the day 4b Notes unresolved issues 4c Plans actions for the following day 4d Leaves the workplace	5a Returns home 5b Spends time with family 5c Reflects on the day 5d Tries to let go of responsibility
Responsible	Tense	Partial relief
Feeling useful Oversight	Confidence in organization	Personal balance
Fear of missing signals	Mental load	Difficulty disconnecting

8.4 User flow



Daily context
Work activity
Background monitoring
Context stable?
Yes
No
Continue work
Early discomfort
Low intensity feedback
Signal recognized
Yes
No
Continue work
Continue work
Continued strain
Contextual support mode
User acts
No
Yes


Continue shift
No
Yes
Leave workstation
Return to work
End of shift
Post shift processing
Stabilization
External intervention
Emergency mode
User acts
No
Yes
Corrective action
Alert mode
Risk escalation
Stabilization
Continue work

NINTH CHAPTER
Selection and analysis of case studies

9.1 Selection criteria

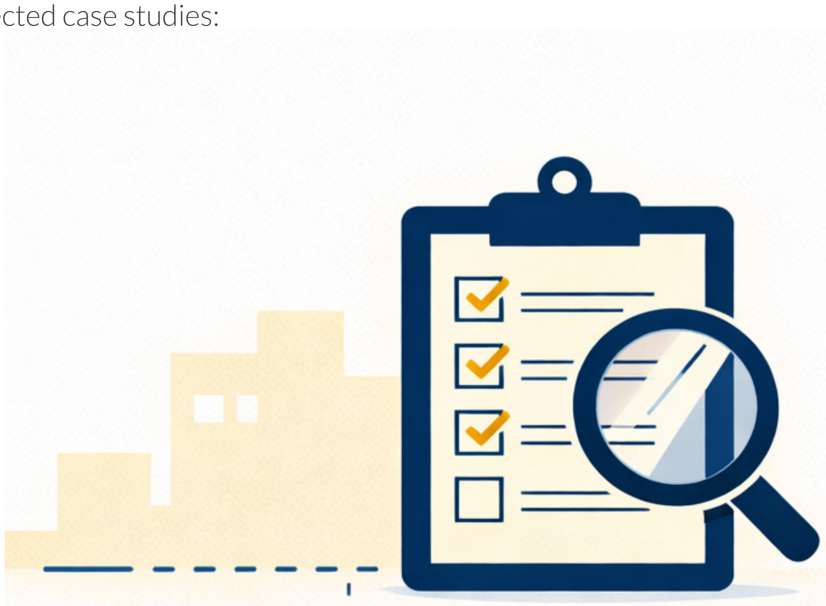
Twenty case studies pertaining to wearable safety technologies were examined in order to start the design and research process. A wide variety of products and solutions that are currently being used or tested in industrial and occupational safety contexts are represented by the chosen cases.

Every case study was examined using a **uniform set of evaluation standards** in order to guarantee both sufficient depth and comparability between the various solutions. In order to frame the context and primary goals of each wearable device, a general description of the product was first given. The focus then shifted to the technologies that underpin the solution, examining the technical components that make it possible for it to function. The analysis then considered the wearable's specific security features, how innovative it was in comparison to existing solutions, and, lastly, the potential users or reference sectors for which it was intended.

Ultimately, the analysis revealed each case's main **advantages and disadvantages,** offering insight into the potential benefits and drawbacks of the wearable safety strategies currently in use. The creation of a **comprehensive overview of the state of the art** in wearable safety technologies was made possible by this methodical analysis, which also provided guidance for later design choices.

9.2 The case studies

Following there are the 20 selected case studies:



RealWear Arc 3

Sector: Industry, maintenance, logistics, energy, field training

Problem: Workers operate in complex or hazardous environments where increased safety, efficiency, and operational accuracy are required

Need: A wearable device that provides hands-free access to visual information and remote collaboration tools, while keeping workers fully aware of their surroundings and safe in the field

Device: AI voice-powered smart glasses for assisted reality

Project objective: Increase productivity, safety, and efficiency through hands-free visual and voice interfaces

Link: https://www.realwear.com/devices/arc-3

Key features:
- Precision display: monocular "double-retina" resolution see-through display for clarity while maintaining environmental awareness
- Dual-camera system: wide-angle + zoom lenses, plus integrated flashlight for low-light environments
- Hands-free workflow & remote collaboration: users can log inspection data, document hazards, and report issues while keeping hands free and eyes on the environment
- "Arc Base" charging dock to keep the device always ready for use

Systemic approach
- Human-technology integration: connected workers that can receive instructions, checklists, and procedures directly in the field of view
- Voice and visual interface that enables fully hands-free operation, improving safety and workflow continuity
- Continuous learning through real-time transfer of expert knowledge (immersive training, immediate feedback)
- Error reduction thanks to AI support and integrated digital workflows

Impact & results
- Enhanced safety (environmental awareness is maintained)
- Reduced downtime and operational interruptions
- Accelerated training for new operators
- Increased productivity thanks to digital workflows and real-time data collection

KEYWORDS
Wearable head-mounted, connected worker, hands-free, remote expert assist, industrial smart glasses, frontline productivity, see-through display, dual-camera system

Smart Track

Sector: Manufacturing, utilities, oil & gas, construction, logistics, and indoor sites with limited GNSS

Problem: It is difficult to detect man-down events, SOS alerts, and collisions in complex or ATEX environments

Need: A wearable device that provides hands-free access to visual information and remote collaboration tools, while keeping workers fully aware of their surroundings and safe in the field

Device: A real-time, compliant safety system that detects critical events and works across sites even with limited connectivity

Project objective: Faster emergency response, better situational awareness, and safer operations through a scalable IoT architecture

Link: https://smarttrack.io/en/products/connected-worker/

Key features:
- WeTAG wearable with man-down detection, waterproof enclosure, nine radio channels, three alarm feedback modes and fast charging
- ATEX-certified version for explosive atmospheres with complete TÜV certification
- Anchors enabling indoor geolocation through star or mesh networks
- Safety Box extending communication using LoRaWAN or satellite channels
- Smart Dialer for fully automatic hands-free answering

Systemic approach
- Integration of devices into one coordinated safety system
- Human-technology interaction enabling immediate alerts and guided emergency response
- Modular architecture adaptable to different plant layouts and risk profiles
- Resilient communication ensured by mesh networks and the Safety Box in low-coverage areas

Impact & results
- Faster emergency response
- Improved risk management in indoor and ATEX environments
- Increased regulatory compliance
- Stronger data-based decision processes
- Enhanced worker protection without invasive monitoring

KEYWORDS
Connected worker, wearable safety, indoor geolocation, ATEX wearable, IoT safety, man-down detection, industrial risk management

MākuSafe

Sector: High-volume manufacturing, logistics, energy, construction, and other industrial environments

Problem: Lagging indicators and manual reporting miss real-time hazards like noise, heat, and ergonomic overload

Need: A proactive, scalable safety solution that detects hazards in real time and delivers actionable exposure data

Device: AMākuSafe’s Ally multifunction wearable paired with the MākuSmart cloud analytics platform

Project objective: Prevent incidents through real-time hazard detection and data-driven insights, while improving efficiency, reducing claims, and enabling connected-worker safety

Link: https://makusafe.com/wearable-safety-technology-why-now-and-why-makusafe/

Key features:
- Multifunction wearable for motion analysis, ergonomic risk detection, environmental hazards, noise monitoring, and forklift proximity alerts
- Privacy-respectful design with no biometrics or continuous tracking
- MākuSmart analytics for patterns, trends, and root-cause insights
- MyVoice push-to-talk for reporting hazards and near misses
- Modular, scalable deployment from single sites to global operations

Systemic approach
- Unified ecosystem connecting wearable data, cloud analytics, and safety workflows
- Human-technology collaboration that boosts awareness while preserving privacy
- Real-time exposure data supporting safety programs, connected-worker initiatives, and Industry 4.0
- Scalable architecture enabling smooth expansion from pilot to enterprise rollout
- Predictive insights and automated trend analysis driving continuous improvement

Impact & results
- Lower incident frequency and severity
- Reduced claims and workers’ compensation costs, with documented cases of premium reductions up to 60%
- Decreased downtime and improved operational efficiency
- Stronger safety culture and higher worker engagement
- Reduction in certain incident categories exceeding 80%

KEYWORDS
Wearable safety, connected worker, ergonomic risk detection, environmental exposure monitoring, real-time hazard identification, privacy-respectful wearable, Industry 4.0 safety

SlateSafety

Sector: Industries with high heat exposure and physically demanding work

Problem: Rising temperatures increase risks of heat exhaustion, heatstroke, and exertion injuries, causing many incidents with major human and financial impacts

Need: A reliable, non-invasive system that detects heat stress and exertion risk in real time to enable early intervention and protect large, distributed workforces

Device: SlateSafety BAND V2, a rugged wearable monitoring exertion, core temperature, heart rate, movement, and location, with cloud connectivity

Project objective: Prevent heat- and exertion-related incidents through real-time monitoring, early alerts, and data-driven decision making across diverse teams

Link: https://slatesafety.com/

Key features:
- Continuous monitoring of exertion, core temperature, heart rate and movement
- Real-time alerts using vibration and LEDs
- Rugged waterproof design with long battery life
- GPS and indoor location options with on-body detection
- Cellular, satellite, Wi-Fi and offline data capability
- Web and mobile platforms for live and historical data with SOC 2 security

Systemic approach
- Integration of wearable sensing, communication infrastructure and cloud analytics
- Real-time alerts connecting workers and supervisors
- Configurable thresholds aligned with safety programs
- Scientific validation supporting reliable decision making
- Scalable deployment for small or large operations

Impact & results
- Earlier detection of heat stress and exertion risk
- Reduced heat-related injuries
- Improved productivity and reduced fatigue-related errors
- Faster emergency response
- Enhanced safety preparedness for extreme temperatures
- Increased trust through validated non-invasive monitoring

KEYWORDS
Heat stress monitoring, connected worker, physiological safety, core temperature estimation, industrial wearable, exertion monitoring

Mercari

Sector: Lone workers, maintenance, field technicians, transport, and construction

Problem: Workers operating alone face physical and emergency risks without the ability to signal danger or be located quickly

Need: A reliable system that enables rapid intervention and real-time location, even if the worker is unconscious or out of sight

Device: Lone worker safety device available as pendant, wristband, belt clip, or lanyard, with fall detection, GPS, two-way voice, check-ins, and global coverage

Project objective: Improve lone-worker protection through automatic alerts, instant GPS localization, and two-way communication for faster, coordinated emergency response

Link: https://loneworkerdevices.com/lone-worker-safety-devices/

Key features:
- SOS / Panic Button: instant alarm and GPS location sent to multiple contacts or emergency services
- Man-Down & Fall Detection: detects falls, immobility, and loss of consciousness
- Motion / No-Motion Alerts: custom activity and inactivity alerts
- Automatic Check-ins: configurable periodic safety timers
- Two-Way Voice Communication: hands-free calls with contacts or emergency responders
- GPS Tracking & Geofencing: real-time location and safe-zone alerts

Systemic approach
- Integrated safety network: device acts as a smart node connecting worker, technology, and environment
- Proactive protection: automatic emergency detection without user action
- Coordinated response: simultaneous alerts to multiple contacts for faster intervention

Impact & results
- Faster response in case of an accident or medical emergency
- Increased confidence and sense of protection for lone workers
- Reduced risk in remote or high-hazard environments
- Easy adoption thanks to a lightweight, intuitive, ready-to-use design

KEYWORDS
Lone worker safety, wearable technology, GPS tracking, fall detection, geofencing, voice communication, emergency response, human-centered design, proactivity, connected safety

Elitac

Sector: Field service, utilities, maintenance, and other lone-worker environments

Problem: Service engineers often work alone in remote or low-light areas where emergencies, falls, or loss of consciousness can go unnoticed, delaying rescue

Need: A reliable safety solution that enables rapid assistance, improves visibility, and protects workers without restricting movement

Device: SmartShoulder is a smart vest with an integrated panic button, man-down detection, automatic LED lighting, and waterproof electronics

Project objective: Improve lone-worker safety through immediate alerts, automatic fall detection, and hands-free lighting for safer field operations

Link: https://elitacwearables.com/industrial-safety-wearables/

Key features:
- Panic Button sending immediate alerts to HQ
- Man-Down Detection for falls, immobility, or loss of consciousness
- Automatic LED lighting activated in low-light environments
- 3 adaptive LED lights that adjust brightness to maintain clear visibility
- Waterproof, washable design built for all-day comfort
- Continuous-wear electronics tested for full-day field operations
- Waterproof hardware suitable for harsh and outdoor environments

Systemic approach
- Integrated ecosystem connecting the wearable, HQ monitoring, and emergency response workflows
- Proactive protection through automatic detection of falls and danger signals
- Human-centered design that enhances trust and comfort during long shifts
- Hands-free operation enabling users to focus fully on their tasks

Impact & results
- Faster emergency response thanks to instant alerts
- Improved protection for lone workers in remote or hazardous environments
- Higher situational awareness through adaptive lighting
- Increased confidence and sense of security for field technicians
- Reduced incident severity due to quicker intervention

KEYWORDS
Lone worker safety, fall detection, man-down detection, GPS location, smart PPE, connected safety, field service operations, human-centered design, worker protection

Bee

Sector: Personal and professional environments where wearable AI assistance is useful

Problem: Traditional voice assistants or devices don't fit naturally on the wrist and lack battery life or optimized acoustic performance in noisy environments

Need: A compact wearable that enables continuous voice-based personal AI assistance with strong audio recognition, long battery life, and privacy protection

Device: Wrist-wearable device with dual microphones, action button, USB-C charging, wristband or clip options

Project objective: Provide a wearable personal AI companion that is always on the wrist, able to listen and respond in noisy or dynamic environments, with minimal charging and strong data privacy

Link: https://www.bee.computer/

Key features:
- Up to 160+ hours (about 7 days) of battery life on a single charge
- Dual-microphone setup with advanced noise filtering
- Supports 40 languages for global usability
- USB-C fast and universal charging
- Modular design with two wristbands (yellow and black) plus a clip attachment

Systemic approach
- Always-on wearable + AI ecosystem: the device works as a continuous voice interface, capturing spoken inputs and providing real-time assistance through the connected app and cloud AI
- Noise-aware interaction: dual microphones and filtering algorithms ensure accurate recognition even in busy or noisy environments
- Human-centered design: small, lightweight form factor available as a wristband or clip, blending naturally into daily routines
- Privacy by design: audio is processed in real time with no storage, giving users transparency and control over their information

Impact & results
- Empowered hands-free interaction with personal AI using a single device
- Reduced need for frequent charging with week-long battery life
- Enhanced user trust thanks to transparent privacy controls and device design

KEYWORDS
Wearable AI, personal AI assistant, voice-first device, dual microphones, long battery life, wrist wearable, intelligent wearable, voice commands, data privacy, multilingual support

Amazon smart glasses

Sector: Last-mile delivery, logistics, transportation

Problem: Drivers juggle navigation, package handling, and hazard awareness while relying on phones, increasing distraction and safety risks

Need: A hands-free, AI-guided system that improves navigation, hazard detection, and delivery accuracy without reducing situational awareness

Device: AI and computer-vision smart glasses with heads-up delivery guidance, package scanning, hazard cues, and an all-day swappable battery

Project objective: Make deliveries safer, faster, and more accurate through real-time, hands-free navigation and package guidance

Link: https://www.aboutamazon.com/news/transportation/smart-glasses-amazon-delivery-drivers

Key features:

- Heads-up display showing navigation, hazards, tasks, and delivery details
- Automatic activation when the vehicle is safely parked
- Turn-by-turn walking navigation using Amazon geospatial technology
- Package scanning and proof-of-delivery capture directly through the glasses
- Hazard guidance in complex environments (gates, stairs, apartments, etc.)
- Emergency button to reach support services along the delivery route
- Supports prescription lenses and adaptive light-adjusting lenses

Systemic approach

- Integrated wearable + geospatial navigation + package data + delivery workflows
- Computer vision and AI generate context-aware prompts at each delivery step
- Designed with driver feedback to optimize usability, comfort, and display clarity
- Real-time data flow creating a full end-to-end delivery ecosystem
- Forms part of Amazon's broader last-mile innovation strategy with AI tools and safety programs

Impact & results

- Increased safety from reduced phone dependence and forward-focused visibility
- Faster, more intuitive navigation in neighborhoods and apartment complexes
- Improved accuracy in package identification and proof-of-delivery
- Enhanced driver confidence and reduced cognitive load

KEYWORDS
Smart glasses, delivery innovation, last-mile technology, AI sensing, computer vision, heads-up display, hazard detection, geospatial navigation, hands-free delivery, wearable technology

Spacebands

Sector: Construction, manufacturing, logistics

Problem: Workers face real-time risks like vibration exposure, loud noise, machine collisions, PPE issues, and restricted-area access without immediate warning

Need: A rugged wearable that detects these hazards in real time, alerts workers instantly, and captures data for safety teams

Device: Waterproof, multi-sensor device monitoring vibration, noise, proximity risks, PPE compliance, and access violations, with automatic cloud upload via charging dock

Project objective: Reduce incidents and exposure by giving workers instant alerts and giving companies actionable safety data to build a proactive safety culture

Link: https://www.spacebands.com/technology/wearable

Key features:
- Monitors hand-arm vibration and loud noise levels in real time
- Alerts wearers for proximity to machinery, restricted zones, unauthorised access and PPE non-compliance
- Data stored on device then automatically uploaded when placed in charging dock
- Waterproof design for extreme weather, adjustable strap for comfort
- Focus on real-time alerts to prevent workplace injuries, reduce days lost, insurance premiums, fines and claims

Systemic approach
- The wearable device acts as a smart node in a connected safety ecosystem
- Worker-focused design integrates seamlessly into daily wear without being intrusive
- Deployable across large industrial sites (construction yards, manufacturing floors, logistics hubs) creating a unified hazard-monitoring network

Impact & results
- Workers receive immediate alerts about hazardous conditions, increasing situational awareness
- Safety managers can access aggregated exposure and incident data, improving decision-making
- Real-world testimonial: “In just a year of use we have reduced exposure by close to 80%” (senior H&S manager)

KEYWORDS
Wearable safety device, hand-arm vibration monitoring, noise exposure alerts, machine-collision warning, real-time worker alerting, industrial safety technology, connected worker

viAct Smart Helmet

Sector: Construction, oil & gas, mining, manufacturing, facility management

Problem: Workers face real-time hazards such as unsafe conditions, falls, access to restricted zones, lack of PPE compliance, and delayed incident responses

Need: A device that integrates AI, IoT and location tracking to monitor worker health and environment, provide hands-free safety alerts, enable precise tracking and support proactive hazard management

Device: AI-powered safety helmet featuring augmented reality overlays, proactive safety alerts, precision GPS location tracking, and hands-free voice communication

Project objective: To transform worker safety

Link: https://www.viact.ai/iot/smart-helmet

Key features:

- Augmented reality overlays to enhance situational awareness
- Proactive safety alerts triggered automatically for hazards and unsafe conditions
- Data-analytics dashboard to track safety trends and deliver actionable insights
- Voice-activated hands-free operation to keep workflows uninterrupted
- Precision GPS tracking for location monitoring and faster emergency response
- Durable, lightweight design built for comfort and extended use in tough environments

Systemic approach

- Wearable helmet + AI analytics + IoT sensor network form a unified connected safety ecosystem
- Real-time worker health, environment and location data feed into analytics for proactive hazard detection
- Hands-free communication and automatic alerts keep workers focused on tasks, not devices

Impact & results

- Enhanced worker awareness and immediate hazard detection
- Faster interventions and improved emergency response times
- Stronger compliance with safety standards and fewer incidents
- Data-driven insights enabling better site safety management and preventative action

KEYWORDS
Smart helmet, worker safety, IoT safety wearable, AI safety analytics, augmented reality PPE, hands-free communication, location tracking, industrial wearable, proactive hazard detection

ZaafDesign Smart Helmet

Sector: Construction, manufacturing, industrial maintenance and remote technical operations

Problem: Field technicians working in remote or industrial settings often face operational delays, lack of live remote support, limited visibility into complex environments and risk of errors or safety incidents without immediate assistance

Need: A wearable device that enables remote support, live operational oversight, and hands-free communication

Device: IoT wearable helmet designed for remote technical operations and industrial environments

Project objective: Improve worker performance and safety

Link: https://zaafdesign.com/it/portfolio/dispositivo-wearable-smart-helmet/

Key features:

- Remote streaming and expert support via the helmet's connectivity
- Sensors for environment monitoring and hazard detection
- Robust industrial build suitable for remote or harsh sites
- Designed for seamless integration into technical operations with field engineers
- Supports improved operational efficiency, worker autonomy and safety

Systemic approach

- Live data from field technicians is sent to supervisors and experts, enabling remote support and faster resolution of technical issues
- Hands-free design allows field workers to stay focused on tasks while receiving remote guidance or alerts
- Deployed across distributed industrial sites and operations, creating a unified infrastructure for remote operations and worker performance

Impact & results

- Operational efficiency increases thanks to real-time connectivity and faster problem resolution
- Safety is enhanced by enabling oversight and support in remote, complex or hazardous work environments
- Worker autonomy improves, and remote operations become more scalable with less onsite supervision

KEYWORDS
Smart helmet, wearable IoT, remote operations, field engineer support, industrial wearable, hands-free communication, IoT safety device, connected worker, remote assistance

Univet VisionAR

Sector: Industrial and field operations such as manufacturing, logistics, maintenance, and technical support

Problem: Workers need real-time information and guidance while keeping hands free; traditional eyewear offers no digital overlays, causing slowdowns and safety risks

Need: Certified AR safety glasses that deliver hands-free instructions, workflow support, alerts, and remote assistance directly in the user's field of view

Device: EN166 F and ANSI Z87.1+ certified AR safety glasses

Project objective: Improve productivity, safety, and accuracy by giving workers real-time visual guidance, reducing errors and downtime, and enabling remote diagnostics and training

Link: https://www.univetar.com/it/

Key features:
- Transparent waveguide AR display with real-time overlays
- Industrial certifications (EN166 F, ANSI Z87.1+)
- Compatible with PPE and prescription glasses
- Ergonomic frame with side shields for comfort and protection
- Works with Windows, Linux, and Android control units

Systemic approach
- Integrates AR display, PPE-certified eyewear, and digital workflows into a unified tool
- Supports remote guidance, visual instructions, and on-site data capture
- Hands-free operation keeps workers focused on the task
- Deployable across diverse industrial environments for consistent digital workflows

Impact & results
- Faster task execution with real-time step-by-step guidance
- Reduced errors and rework thanks to AR overlays
- Enhanced worker safety and compliance with certified protective design
- Improved training, inspections, and remote troubleshooting

KEYWORDS
Augmented reality glasses, industrial AR, safety eyewear, hands-free guidance, workflow assistance, remote support, connected worker, digital instructions

StrongArm

Sector: Warehousing, manufacturing, logistics, construction, healthcare

Problem: Workers face high rates of musculoskeletal and over-exertion injuries; many safety programs rely on retrospective audits instead of real-time feedback

Need: A proactive wearable system that monitors movement risk in real time, alerts workers instantly, and provides data for targeted training and early intervention

Device: Lightweight wearable sensor with haptic alerts and the SafeWork analytics platform delivering risk insights, personalized coaching and workforce-level safety intelligence

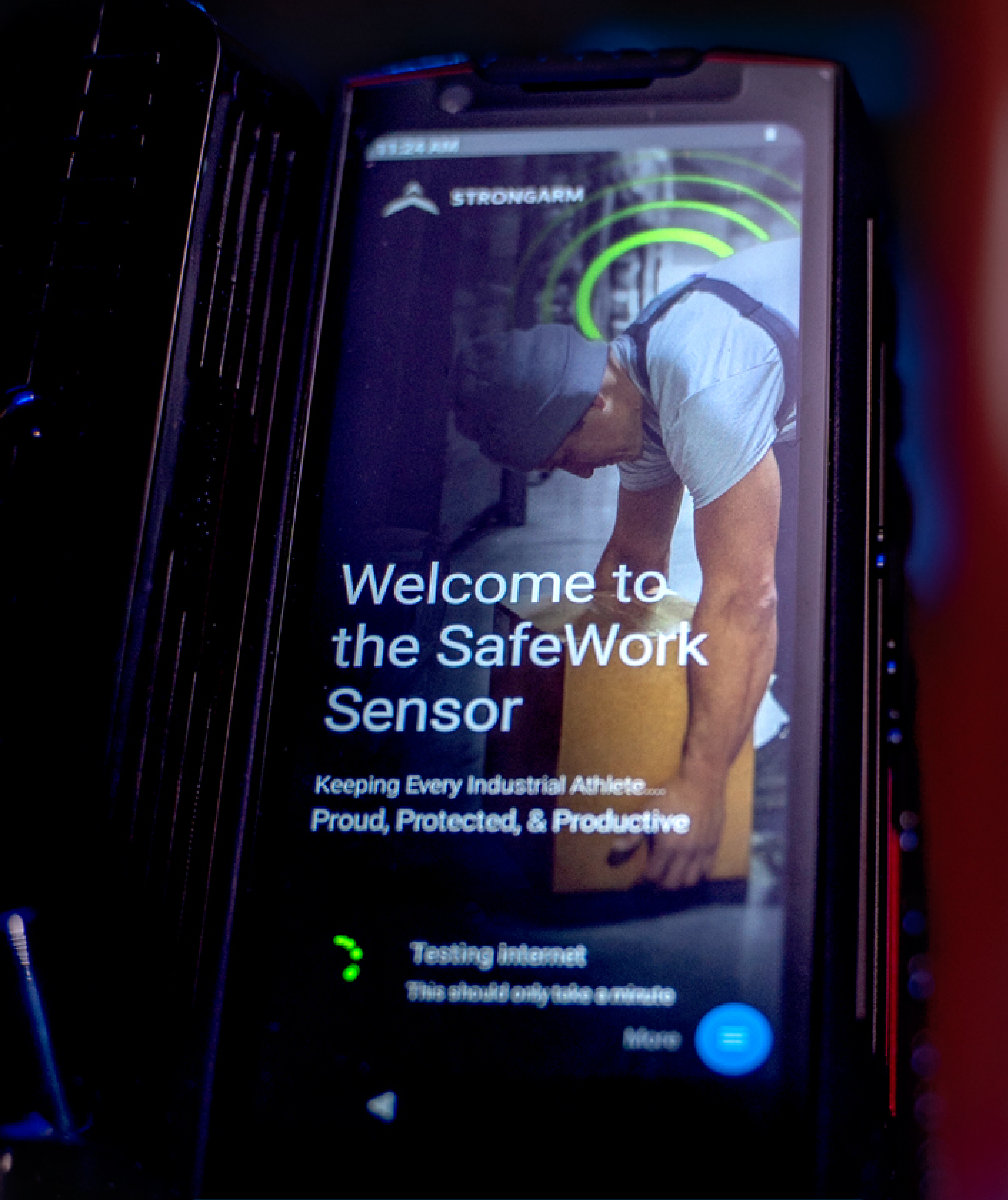
Project objective: Reduce injuries and claims by improving posture and movement behaviour

Link: https://strongarmtech.com/solutions/

Key features:
- Haptic & vibration alerts when movement or posture is risky
- Real-time sensor tracking of body motion throughout the shift
- AI-driven analytics identifying individual and workforce-level risk patterns
- Industrial ruggedness (wearable sensor, all-day battery)
- Personalized micro-learning delivered based on real-time data
- Deployable across warehouse, manufacturing, healthcare, and construction settings

Systemic approach
- Wearable sensor worn on the body captures continuous movement data
- Data is uploaded and analysed via the SafeWork Platform to generate risk insights
- Alerts and personalized training are delivered back to the worker and safety team
- Real-time feedback changes behaviour immediately, analytics inform full workforce improvement
- Scalable deployment across sites builds unified safety culture and data ecosystem

Impact & results
- Typical reductions in soft-tissue injuries up to ~35% year-over-year, and up to ~89% in best-in-class SafeWork programs
- Case study: ~60% reduction in injury rates, > $5M in gross savings, and ~78% reduction in margin of error when evaluating injury risk
- ROI reported at 250%+ at scale
- Greater worker engagement, improved posture/motion behaviour and stronger safety culture



KEYWORDS
Wearable sensor, injury prevention, ergonomic risk monitoring,, AI analytics platform, connected worker, musculoskeletal injury reduction, proactive safety, workplace health analytics

Modjoul

Sector: Manufacturing, warehousing and other industrial-production environments

Problem: Injuries from musculoskeletal strain and collisions with vehicles remain a major issue

Need: Technologies that deliver real-time alerts for ergonomic risk

Device: Suite including the "SmartBelt" wearable, "HaloGuard" forklift-collision avoidance system, and "Watchdog" location/trace system

Project objective: Enable manufacturing operations to reduce injury rates and improve operator safety for ergonomics and vehicle interactions

Link: https://modjoul.com/industry-solutions/manufacturing-safety-solutions/

Key features:
- SmartBelt wearable that detects unsafe bending, twisting, overexertion and near-miss events and gives haptic feedback
- HaloGuard system for forklift and vehicle proximity alerts to both drivers and pedestrians
- Watchdog location and trace capability to understand people and asset movement patterns
- Real-time dashboards and analytics showing risk trends, high-risk tasks and areas
- Configurable alerts and reporting to support targeted coaching and safety interventions

Systemic approach
- SmartBelt, HaloGuard and Watchdog operate together as a unified safety ecosystem
- Wearable sensors and proximity beacons provide real-time alerts for posture risk and vehicle interactions
- Continuous data flows into the Modjoul platform for risk scoring, trends and targeted coaching
- Scales easily across sites to standardize safety processes and reduce operational variability

Impact & results
- Significant reductions in musculoskeletal-injury risk (e.g., one manufacturer reported a 30% reduction in sprains/strains and a 40% reduction in total bends after SmartBelt deployment)
- Reduced forklift and equipment collision risks
- Faster detection of high-risk tasks and improved training effectiveness

KEYWORDS
Wearable safety system, ergonomic risk detection, forklift proximity alert, worker movement monitoring, connected worker platform, injury prevention, industrial safety intelligence

ViSafe+

Sector: Manufacturing, logistics, construction, healthcare

Problem: Workers performing lifting, bending, twisting, repetitive postures or machine-operated tasks are exposed to musculoskeletal injuries

Need: A wearable system that captures objective movement and muscle-activity data in real time, identifies high-risk tasks, enables targeted interventions, and improves safety outcomes through analytics

Device: Wearable sensor-based platform combining body-worn sensors (movement, EMG), video synchronisation and cloud analytics

Project objective: Reduce injury rates and manual handling costs by providing safety teams with precise data to intervene early

Link: https://dorsavi.com/visafe-plus/#how-it-works

Key features:

- Wearable sensors tracking movement, posture, muscle activity and vibration
- Video synchronised with sensor data to visualise risky motion and sustained postures
- Real-time feedback to workers and safety teams for early intervention
- Data dashboards showing range of motion, time in risk zones, repetition counts and muscle strain
- Scalable system design with options for 1, 3 or 5 sensor configurations

Systemic approach

- Sensor-wearable + video capture + analytics platform form a unified safety ecosystem
- Workers wear sensors during tasks, data flows automatically to dashboards for safety professionals
- Alerts and insights feed into training, workstation design, process improvement and behaviour change
- Enables proactive risk management across sites rather than reactive reporting

Impact & results

- Up to a 30–40% reduction in manual handling costs reported in some clients
- Notable reductions in work-related injury frequency through targeted risk identification
- Enabled productivity gains without sacrificing worker safety by optimising safer movement behaviours

KEYWORDS
Wearable safety system, ergonomic monitoring, musculoskeletal injury prevention, real-time movement analytics, manual handling risk, connected worker, industrial wearable sensors

Blackline G7

Sector: Industries with isolated or high-risk workers

Problem: Workers operating alone or in remote locations often lack immediate help in cases of falls, medical emergencies, collisions or no-motion events

Need: A wearable system that captures objective movement and muscle-activity data in real time, identifies high-risk tasks, enables targeted interventions, and improves safety outcomes through analytics

Device: Dependable, always-connected wearable that provides real-time location, automatic fall/no-motion detection, emergency SOS, voice communication and monitoring

Project objective: Ensure that no call goes unanswered and no incident goes undetected

Link: https://www.blacklinesafety.com/solutions/lone-worker/g7-lone-worker

Key features:
- Direct-to-cloud cellular connectivity with GPS location and real-time visibility
- Emergency SOS latch for manual distress alerts; automatic alerts for falls and no-motion
- Two-way voice communication, text and push-to-talk options for isolated field workers
- Optional satellite connectivity for remote or off-grid locations; cloud data streaming for incident review and analytics

Systemic approach
- Wearable device + cloud platform + optional live monitoring service form a complete lone-worker safety ecosystem
- Real-time sensor and location data feed into dashboards and emergency monitoring centres for immediate action
- Scalable deployment across sites with device reassignment, over-the-air updates and integration of gas detection or other hazard sensors as needed

Impact & results
- Improved worker confidence and safety in isolated work environments thanks to consistent connectivity and alerting
- Faster emergency response and better oversight of lone-worker scenarios, reducing risk of undetected incidents
- Enhanced operational visibility through time- and location-stamped data, enabling patterns of risk to be identified and mitigated

KEYWORDS
Lone worker safety, wearable monitor, fall detection, no-motion detection, SOS emergency device, real-time connectivity, cloud-connected safety, GPS location tracking

Smart shoes

Sector: Construction work and other jobs where workers walk on uneven surfaces, climb stairs and risk falling

Problem: Falls, trips and stair accidents are common on construction sites, and it is hard to monitor workers' movements in real time using traditional methods

Need: Simple, low-cost wearable that can track how workers move, warn about unsafe steps or balance issues and help prevent falls before they happen

Device: Smart insole placed inside a worker's shoe

Project objective: Understand how workers move and use this information to reduce falls and improve safety

Link: Wang, C., Kim, Y., Lee, S. H., Sung, N. J., Min, S. D., & Choi, M. H. (2020). Activity and safety recognition using smart work shoes for construction worksite. KSII Transactions on Internet and Information Systems, 14(2), 654–670. https://doi.org/10.3837/tiis.2020.02.010

Key features:

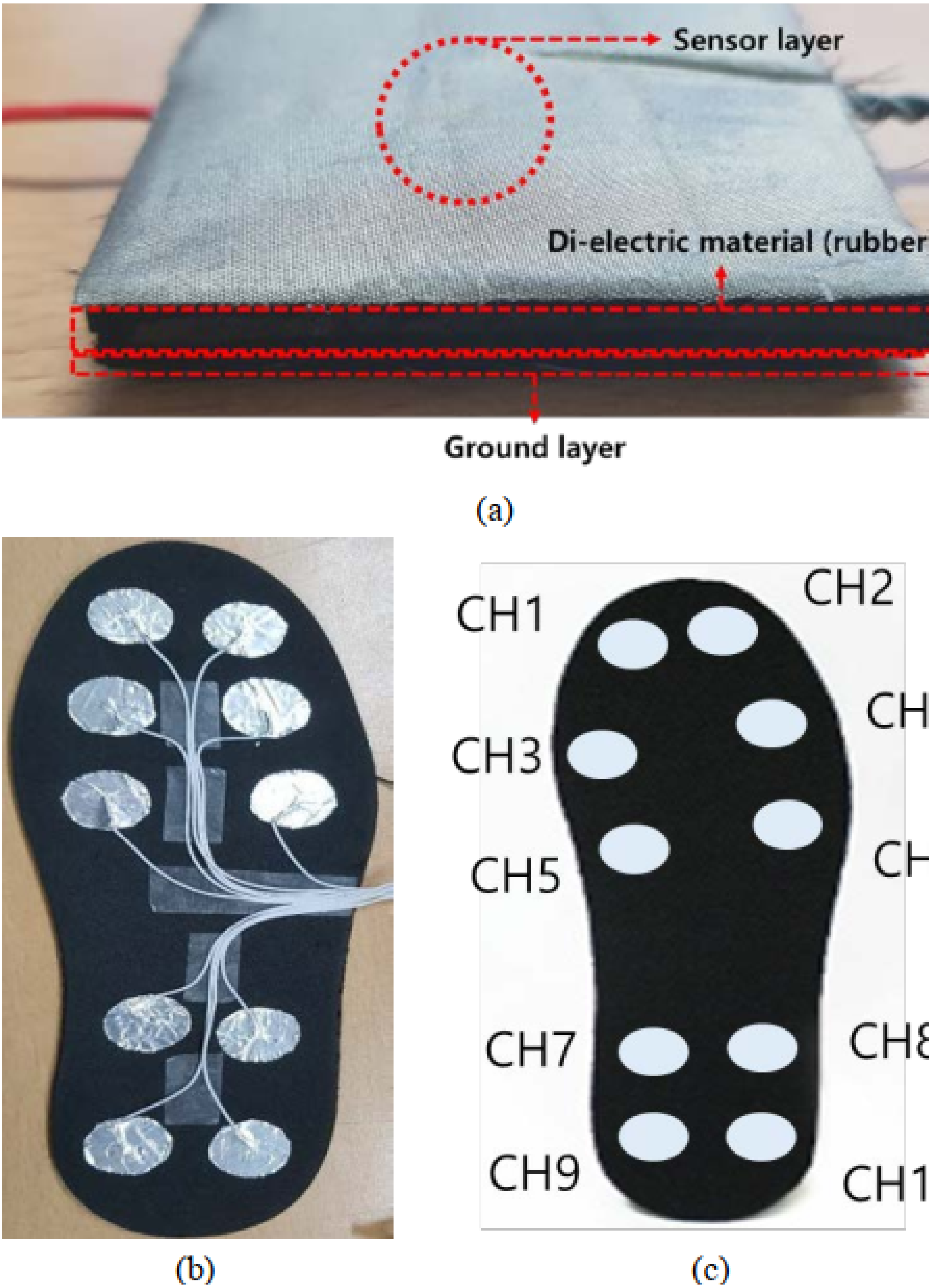
- Light, flexible insole that measures foot pressure
- Wireless connection sending data in real time
- Software that shows how the worker steps or shifts weight
- Detects walking, going up stairs and going down stairs
- Uses simple machine learning to recognize different movements

Systemic approach

- The insole collects movement data
- The data is sent to a computer or phone
- The system identifies the type of movement
- Safety teams can use this information to spot risky behaviour and prevent accidents

Impact & results

- Insole readings stayed accurate even after many uses
- Correctly recognized a worker's movement (walking, climbing up, climbing down) about 90% of the time
- Shows clear differences in the way people move on stairs, helping identify fall risks earlier



KEYWORDS
Smart insole, worker safety, fall prevention, construction work, movement tracking, stair detection, wearable sensor, safety monitoring

TELUS

Sector: Utilities, construction, manufacturing, transportation, logistics

Problem: ontline and lone workers face hazards such as falls, isolation, equipment misuse, fatigue, regulatory non-compliance and slow emergency response

Need: Unified safety ecosystem that monitors workers in real time, integrates devices, data and workflows, and enables early alerts for risk

Device: IoT platform combining wearables/devices, cloud data analytics, real-time monitoring and alerts

Project objective: Keep workers protected, productive and proactive by enabling real-time visibility into safety hazards, automating controls, and supporting compliance

Link: https://www.telus.com/en/business/medium-large/iot/connected-worker

Key features:

- Monitoring for lone workers, employee tracking and person-down detection via devices and alerts
- Real-time gas hazard and worker safety monitoring through connected sensors and alerts
- Integrated platform combining worker location, behavior, telematics and third-party apps for unified visibility
- Fitness-for-duty features including fatigue, substance use and impairment monitoring where applicable
- Field workflow and process automation: digital tasks, cloud access, real-time info to workers in motion

Systemic approach

- Devices worn by workers feed real-time data into a central platform that supports monitoring, alerting and analytics
- Worker safety, operational productivity and compliance workflows are digitized and connected, creating one unified system
- Proactive hazard detection combined with streamlined communication and data-driven decision-making
- Scalable across sites and workflows to support remote, mobile and high-risk field operations

Impact & results

- Improved real-time visibility into worker risk and hazard conditions
- Faster response to lone-worker emergencies, hazards and compliance events
- Streamlined frontline operations through automation and better data integration, boosting productivity while enhancing safety

KEYWORDS
Connected worker, frontline safety, IoT safety platform, lone worker monitoring, real-time alerts, wearable devices, hazard sensing, operational productivity, safety compliance

iSmarch

Sector: Construction sites

Problem: Workers on construction sites face risks such as falls, entering restricted zones accidentally, long periods of inactivity, and lack of real-time visibility for site managers

Need: Wearable safety ecosystem that tracks worker location, inactivity, restricted zone entry, alerts both worker and supervisor in real time, and fits into industrial-site workflows with minimal disruption

Device: Smart helmets, smart bracelets, smart watches

Project objective: Enhance safety, reduce unmonitored risks and enable supervisors to respond faster by turning wearable data into actionable alerts and insights on a construction site

Link: https://ismarch.com/ismarch-iot-wearable-devices-for-construction/

Key features:
- Smart helmets, wristbands, watches and tags with GPS, LoRaWAN and Bluetooth
- Real-time worker location tracking across the entire jobsite
- Restricted-zone alerts when workers enter dangerous or unauthorized areas
- Fall detection and inactivity monitoring with instant notifications
- SOS button for emergencies
- Rugged, waterproof designs built for harsh construction environments
- Central dashboard showing worker status, movement, alerts and site activity

Systemic approach
- Wearables collect movement, location and activity data during work
- Data is sent through wireless networks (LoRaWAN, BLE, GPS) to a cloud platform
- Supervisors see live dashboards and receive alerts when risks occur
- The system connects workers, devices and site operations into one safety ecosystem
- Designed to scale across multiple sites and integrate with broader IoT infrastructure

Impact & results
- Improved situational awareness for supervisors across large or complex sites
- Better protection for lone workers or those operating out of sight
- Enhanced operational efficiency thanks to clear visibility of worker movement and activity patterns

KEYWORDS
Construction wearable, connected worker, fall detection, restricted-zone alert, worker tracking, LoRaWAN wearable, GPS safety device, real-time monitoring, site safety IoT, smart helmet

Reflex

Sector: Industrial and high-movement environments

Problem: Workers who frequently bend, twist or lift are at high risk of sprains, strains and musculoskeletal injuries; many safety programs rely on retrospective audits instead of real-time feedback

Need: System that monitors employee posture and motion in real time, gives immediate feedback when high-risk movements occur, and provides data for safety teams to coach behaviour and reduce injuries

Device: Clip-on, pager-sized wearable that employees attach to their belt

Project objective: Reduce injury rates, decrease lost work days and cut claims costs by improving worker mechanics, increasing awareness of unsafe motion, and supporting a data-driven safety culture

Link: https://kineticcomp.com/reflex-wearable

Key features:

- Real-time feedback with vibration alerts when high-risk movements happen
- Tracks bending, twisting and other poor posture actions
- Logs data automatically and generates reports for supervisors
- Rugged, drop-proof, water-resistant and designed for frontline use
- Easy to deploy just clip it on and go

Systemic approach

- Wearable is part of a broader injury-reduction ecosystem: device + analytics platform + coaching programs
- Motion data is collected continuously, sent to dashboards and used for targeted intervention by job function, shift or site
- Real-time alerts change worker behaviour on the spot while analytics drive longer-term safety improvements
- Scalable across clients and integrated with workers' compensation and safety teams to align technology with business outcomes

Impact & results

- Some clients have reported injury-rate reductions around 58%, lost work days reductions up to 88%, and claims cost reduction of around 54%
- By giving workers instant feedback on posture, the system helps reduce risky movements and builds safer habits
- Safety managers gain visibility into individual and team motion patterns behaviours

KEYWORDS
Wearable safety device, real-time posture monitoring, ergonomic risk reduction, injury-prevention wearable, connected worker sensor, industrial safety analytics

9.3 Competitive matrix

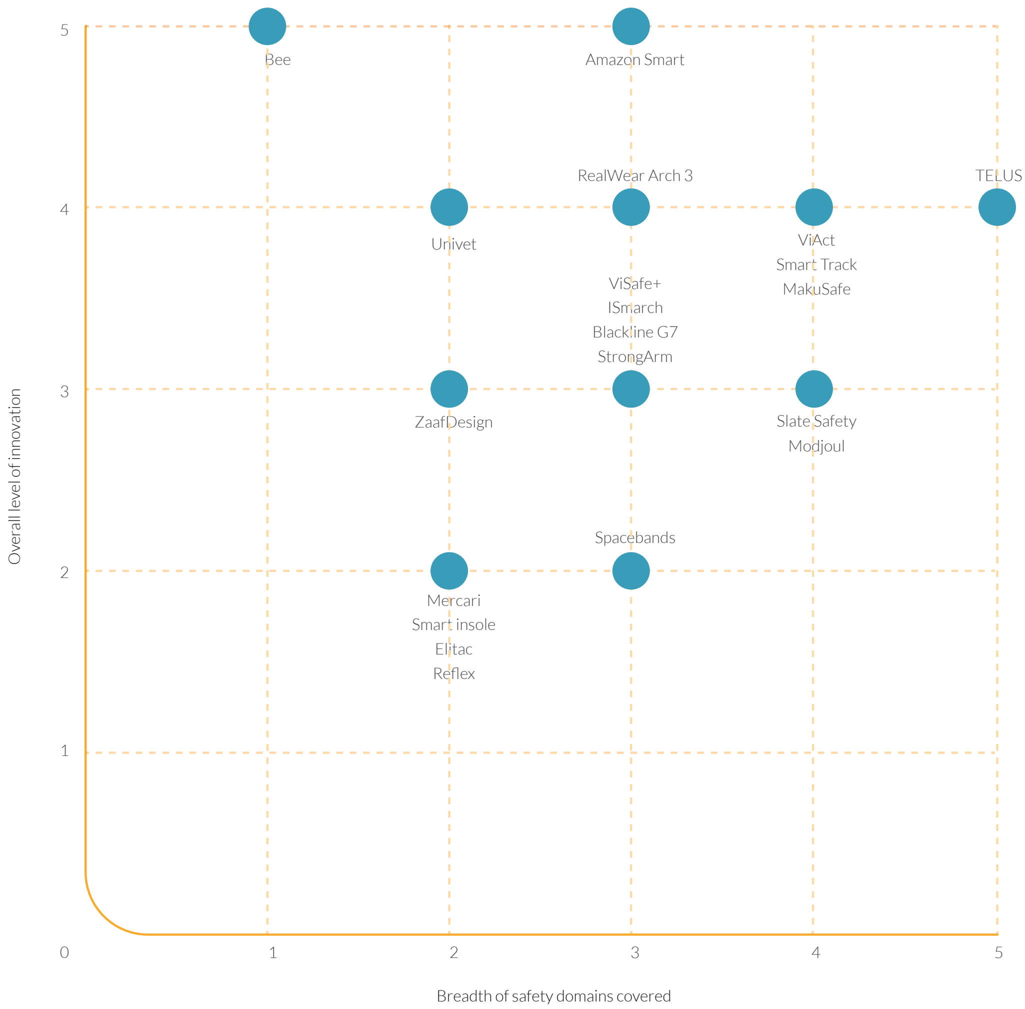
To provide a more **synthetic and comparative overview** of the twenty analyzed case studies, a comparison matrix was developed. This visual tool was designed to condense the results of the previous qualitative analysis into a clear and interpretable framework, allowing relationships and patterns among the different wearable safety solutions to emerge more easily. For each case study, two quantitative values ranging from 0 to 5 were assigned based on the information collected during the analysis.

The horizontal axis represents **the breadth of the safety areas covered**, indicating the number and variety of safety functions offered by each wearable device. These include, for example, physical protection, health monitoring, detection of environmental conditions, cognitive support and emergency management.

The vertical axis, on the other hand, e**xpresses the overall level of innovation**, taking into account the degree to which each solution introduces new technologies, alternative modes of interaction, or systemic approaches different from the proposals currently present on the market. Representing case studies along these two dimensions allows for a concise comparison of different solutions in terms of functional scope and innovative value, facilitating the identification of recurring clusters, design gaps, and potential opportunities in the industrial safety wearable landscape.

The analysis of the comparative matrix shows that most of the analyzed devices fall within a **medium-high range in terms of both security coverage and level of innovation**. These data suggest a general trend towards multifunctional solutions that introduce gradual technological improvements, rather than truly disruptive approaches. Only a limited number of cases are found in the upper right area of the matrix, where broad coverage of security functions combines with a high degree of innovation, indicating that truly holistic and advanced solutions are still relatively rare. At the same time, the presence of different devices concentrated in the central and lower areas highlights the existence of more specialized wearable devices, designed to respond to specific needs or individual safety functions.

Overall, the matrix highlights **a gap between comprehensive safety coverage and high innovation**, pointing to opportunities for future wearable solutions that better integrate multiple safety functions within more advanced and human-centered systems.



Case study	X	Y
RealWear Arc 3	3	4
Amazon Smart Glasses	3	5
Univet VisionAR	2	4
viAct Smart	4	4
ZaafDesign	2	3
Mercari	2	2
Elitac	2	2
Blackline G7	3	3
Smart Track	4	4
TELUS	5	4

Case study	X	Y
iSmarch	3	3
SlateSafety	4	3
MakuSafe	4	4
Spacebands	3	2
Smart Insole	2	2
StrongArm	3	3
Modjoul	4	3
Reflex	2	2
ViSafe+	3	3
Bee	1	4

Figure 6. Matrix based on the 20 selected case studies, comparing the Breadth of Safety Domains Covered and the Overall Level of Innovation.

AR / Smart Glasses / Smart Helmets

Solution	Purpose	Form factor	Input
RealWear Arc 3	Hands-free guidance, remote expert support	Smart glasses	Camera, voice, display
Amazon Smart Glasses	Safer delivery navigation, hazard identification	Glasses + controller	Camera, CV, navigation
Univet VisionAR	AR overlays for tasks and workflows	AR safety glasses	Waveguide display
viAct Smart Helmet	Hazard detection, AR awareness	Smart helmet	AR cam, GPS, sensors
ZaafDesign Smart Helmet	Remote support & monitoring	IoT helmet	Camera, env. sensors

Lone Worker / Emergency Response Systems

Solution	Purpose	Form factor	Input
Mercari Lone Worker Device	SOS, man-down, tracking	Pendant/wrist/clip	Accelerometer, GPS
Elitac SmartShoulder	Man-down + visibility	Smart vest	Fall detection, light sensor
Blackline G7	Full lone worker safety	Clip-on	Fall, no-motion, gas (opt.), GPS
Smart Track WeTAG	ATEX indoor/outdoor emergency	Werable tag + anchors	Man-down, location
TELUS Connected Worker	Unified safety + compliance	Multi-device ecosystem	Location, gas, motion
iSmarch	Construction site visibility	Helmets, bands	GPS, BLE, LoRa, accelerometers

Feedback	Device/Platform	Connectivity	Target	Limitations
Visual overlays, voice	Device + platform	Wi-Fi, BT	Maintenance, field ops	No situational sensing (heat, noise, posture)
Heads-up display	Device + Amazon delivery ecosystem	Wi-Fi, BT	Logistics, delivery	Not for heavy industry; limited ergonomics
Visual guidance	Device only (needs external unit)	Cable/BLE depending	Manufacturing, logistics	No environmental/ physiological sensing
Visual + voice	Device + AI platform	4G/5G, GPS	Construction, mining	Heavy; limited ergonomics sensing
Video + alerts	Device + remote interface	Wi-Fi/BT	Remote technical ops	Limited analytics

Feedback	Device/Platform	Connectivity	Target	Limitations
Audio, SMS, dispatch	Device + cloud	Cellular, GPS	Lone workers	Limited environmental sensing
LEDs, alerts	Device + app	BT, LTE (via phone)	Field maintenance	No advanced telemetry
Voice, SOS,monitoring	Device + 24/7 platform	Cellular, satelliteg	Oil & gas, remote	Expensive; bulky
Vibration, LEDs	Full platform	LoRa, BLE, Sat	ATEX plants, logistics	No physiology sensing
Alerts via app/devices	Full platform	LTE, IoT, GPS	Utilities, construction	Complex ecosystem
Haptic, visual	Device + dashboard	LoRa, GPS, BLE	Construction	Limited physiology/AR

Physiological & Environmental Monitoring

Solution	Purpose	Form factor	Input
SlateSafety BAND V2	Heat + exertion safety	Arm/wrist band	HR, temp, accel, location
MakuSafe Ally	Hazard exposure monitoring	Wearable pod	Vibration, motion, gasses (opt)
Spacebands	Noise, vibration, PPE compliance	Wristband	Noise, vibration, proximity
Smart Insole	Movement + fall/stair safety	Insole	Pressure sensors

Ergonomics / Musculoskeletal Reduction

Solution	Purpose	Form factor	Input
StrongArm SafeWork	Reduce MSD injuries	Back module	Motion, posture
Modjoul SmartBelt	Ergonomics + forklift safety	Belt	Motion, proximity
Reflex (kinetic)	Real-time posture alerting	Belt clip	Motion
ViSafe	Deep ergonomics + EMG	Body sensor	EMG + motion

AI Assistant / Cognitive Support

Solution	Purpose	Form factor	Input
Bee Wrist AI	Continuous voice AI	Wrist device	Dual mics

Feedback	Device/Platform	Connectivity	Target	Limitations
LED, vibration	Device + cloud	Cellular, Sat, Wi-Fi	Extreme heat, utilities	No AR / navigation
Haptic, data alerts	Full platform	BLE, LoRa	Manufacturing	No real-time AR cues
Vibration, tone	Device + data sync	BLE	Logistics, manufacturing	Not continuous connectivity
Software-level alerts	Device + analytics	BLE	Construction	Not for heavy PPE use

Feedback	Device/Platform	Connectivity	Target	Limitations
Haptic	Device + platform	BLE	Logistics, warehouse	No environment sensing
Vibration	Device + cloud	BLE, RFID, UW8	Manufactoring	Multi-component system
Haptic	Device + dashboard	BLE	High-motion jobs	No environment or physiology
Dashboard	Device + platform	BLE, video sync	Clinical + industry	Not practical for daily use

Feedback	Device/Platform	Connectivity	Target	Limitations
Voice	Device + app	BT	Everyday wor	No safety sensing

9.4 Summary analysis and key insights

An examination of the summary table of the 20 case studies allowed the identification of recurring patterns and major limitations across the analyzed technologies. This analysis was a crucial step in developing a comprehensive understanding of the current state of the art of market-available solutions.

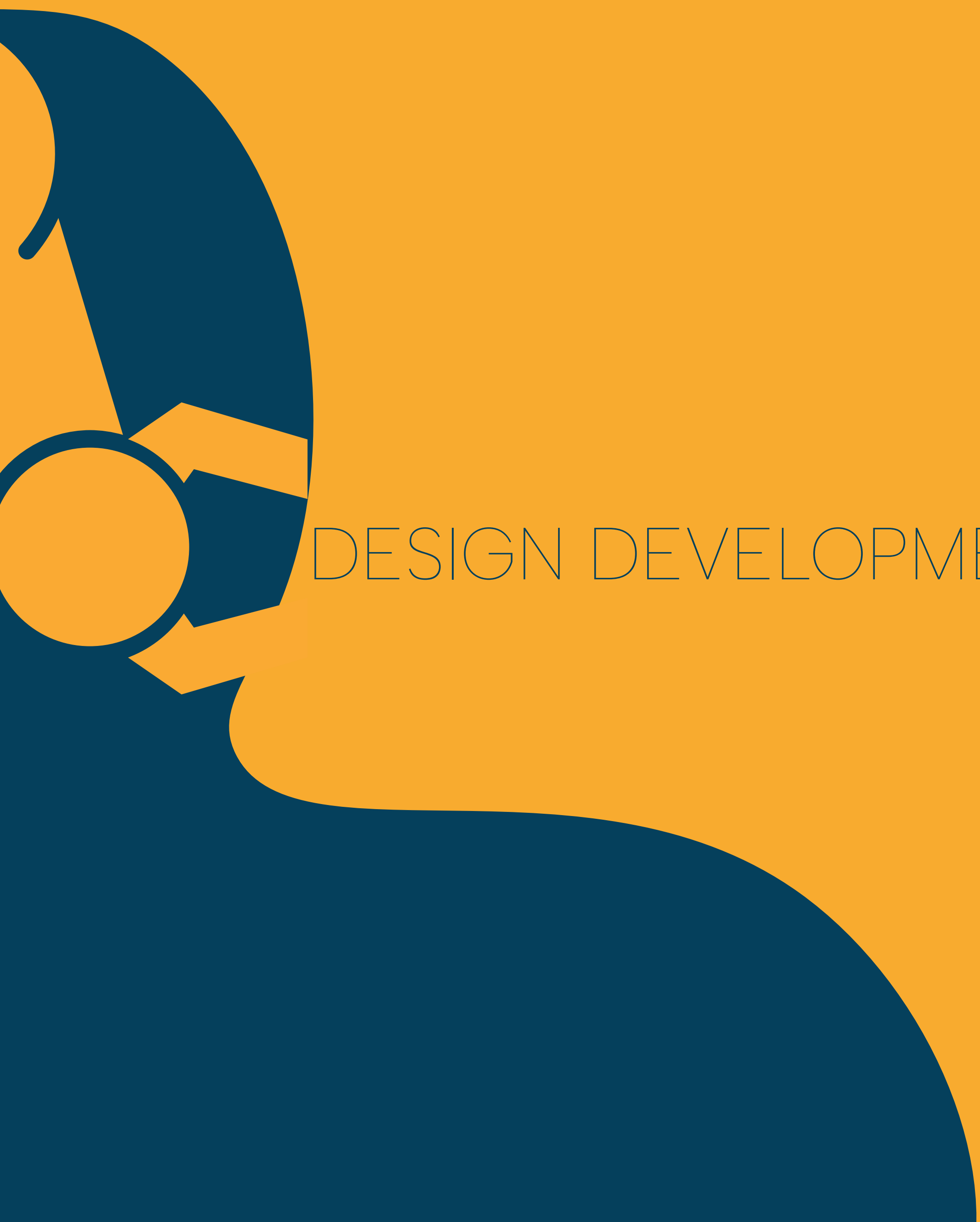
Common patterns:

- All solutions target workers operating in **high-risk and complex industrial environments.**
- Each case is based on a **wearable device integrated with sensors, connectivity, and a backend platform** for real-time alerts and data visualization.
- A shared objective is the shift from reactive safety **practices to proactive risk detection and prevention.**
- Most solutions combine two main value propositions: **improved safety outcomes and operational efficiency gains.**

Identified limitations:

- Solutions are **predominantly specialized**, addressing isolated safety domains rather than providing a holistic safety perspective.
- **Cognitive load, stress, and mental fatigue are largely overlooked.**
- Alert systems are mostly **non-adaptive** and risk overwhelming workers in complex contexts.
- **Data remains fragmented** across vendor-specific platforms, limiting integration and systemic safety insights.
- **Worker agency and transparency in data use are weakly addressed.**

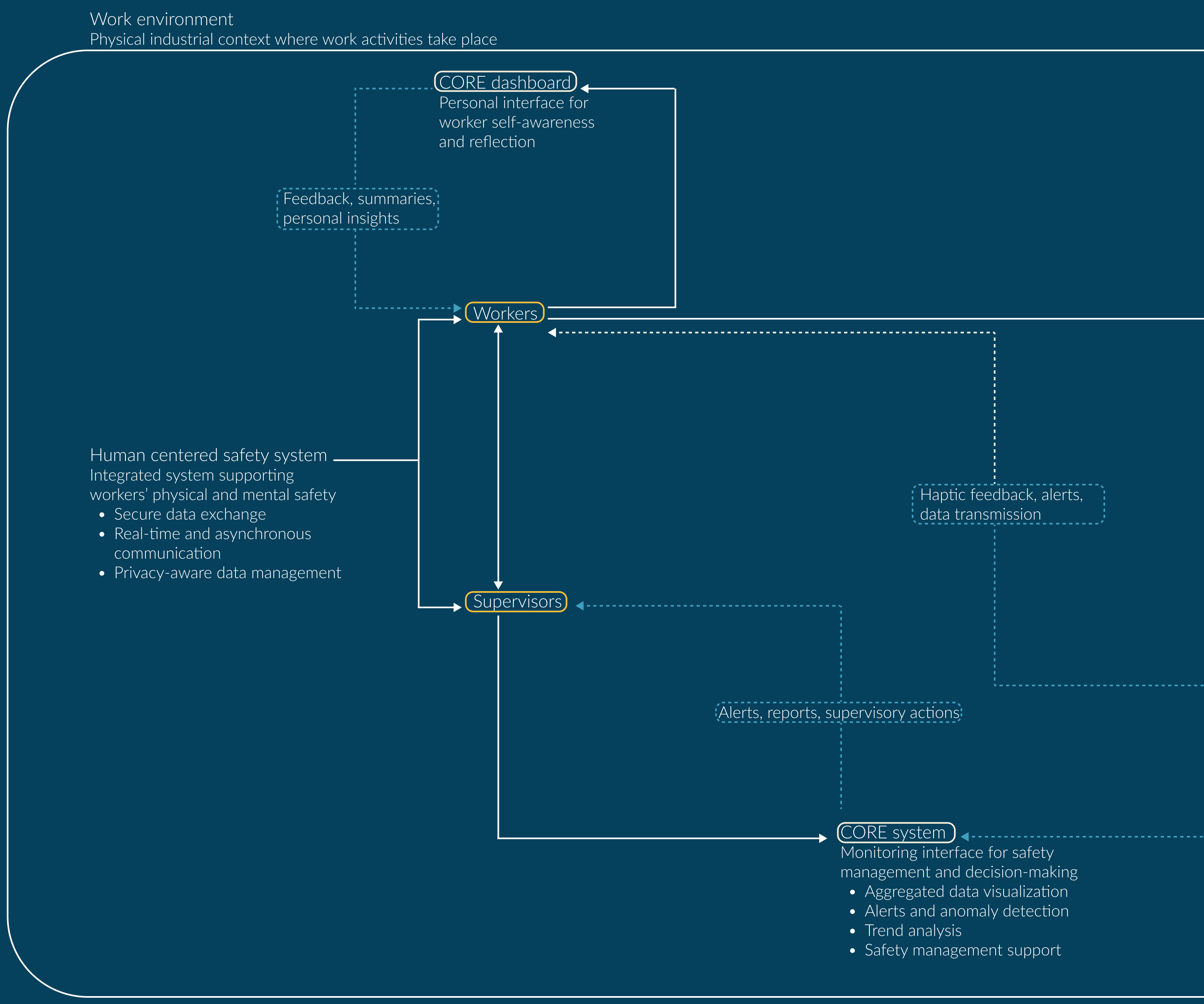
PART IV

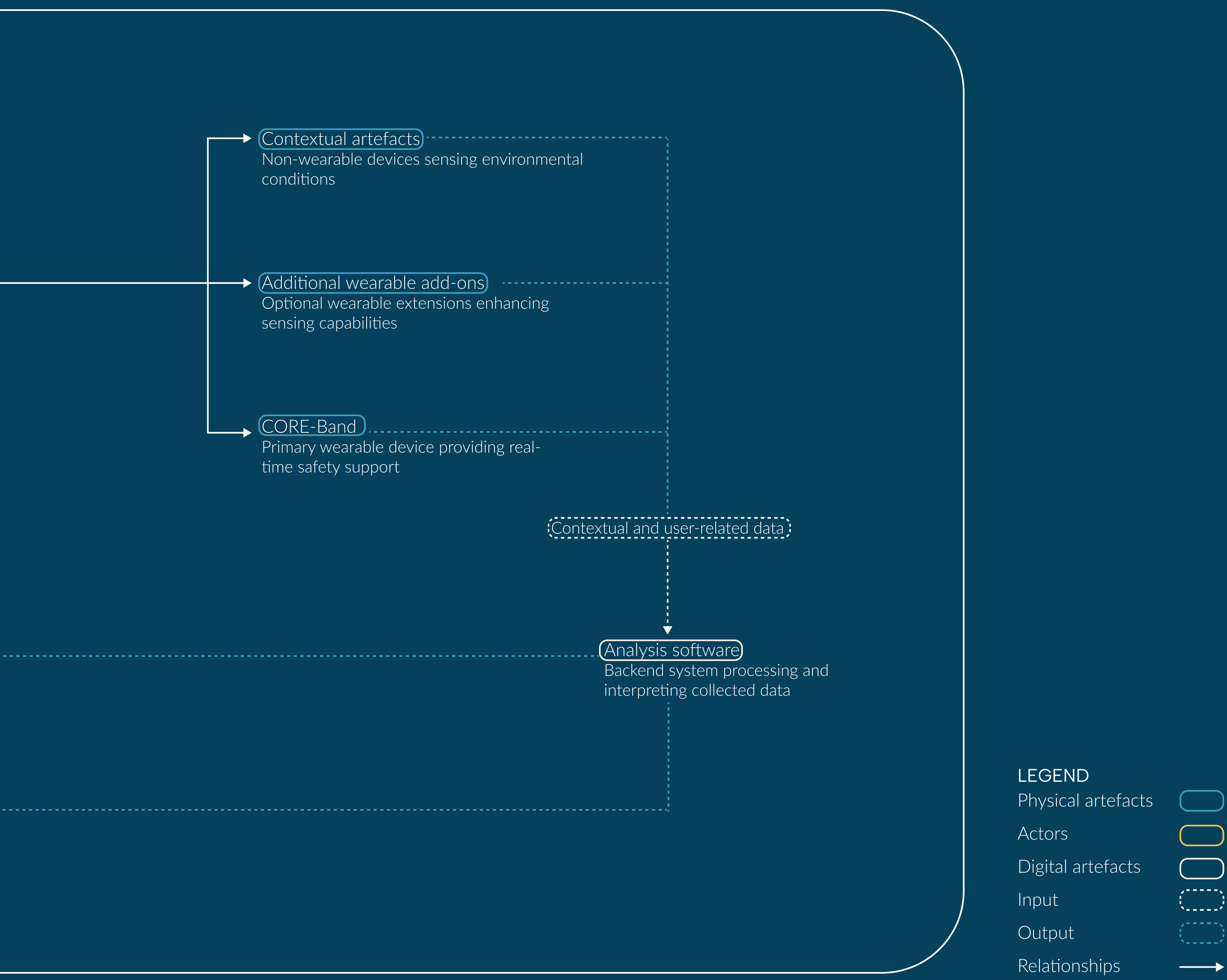


DESIGN DEVELOPMENT

TENTH CHAPTER
The project

10.1 System Artefact Map





Contextual artefacts
Non-wearable devices sensing environmental conditions
Additional wearable add-ons
Optional wearable extensions enhancing sensing capabilities
CORE-Band
Primary wearable device providing real-time safety support
Contextual and user-related data
Analysis software
Backend system processing and interpreting collected data
LEGEND
Physical artefacts
Actors
Digital artefacts
Input
Output
Relationships

The project is developed in a work context where **safety and well-being** are two essential aspects of the activities. The beginning of this ecosystem is the **human-centered security system**, which is integrated with everything important in the system in one place. The project is divided into one part for workers and another for supervisors.

The main interface with which the worker can access the system is based on interaction with the **CORE-band** wrist-worn device during work activities. The worker could potentially use additional other devices placed on different parts of the human body to supplement their interaction with the wearable device. In addition, some artifacts could likely be placed in the environment to facilitate obtaining physical, physiological, and environmental information to support analysis for information translation for worker safety purposes.

In addition to real-time feedback, workers will also be able to use a **personal dashboard** that has both desktop and mobile views where they can access, view their data, past trends, summaries, among many other things. It is a personal and supportive element that helps workers gain a greater understanding of conditions and reflect on how to improve them, among many other aspects.

Supervisors can interact with this system via data **management/analysis software,** where they will obtain aggregated/interpreted output results to help them monitor the overall state of the factory or manage safety issues.

The core of this ecosystem is a strong dual relationship between workers and supervisors. Workers enjoy direct and immediate support, while their supervisors benefit from having a comprehensive framework to assist in decision-making, **addressing safety at both the personal and organizational levels.**

10.2 Visual Identity

#F7AD1A

#9FE7F5

#419EBD

#063F5C

INTER

Aa Bb

Aa Bb Cc Dd Ee Ff Gg Hh Ii Jj Kk Ll Mm Nn Oo Pp Qq Rr Ss Tt Uu Vv Ww Xx Yy Zz

0 1 2 3 4 5 6 7 8 9

INTER

Aa Bb

Aa Bb Cc Dd Ee Ff Gg Hh Ii Jj Kk Ll Mm Nn Oo Pp Qq Rr Ss Tt Uu Vv Ww Xx Yy Zz

0 1 2 3 4 5 6 7 8 9

10.3 The wearable

The **CORE-Band**, representing the main wearable of the CORE system, is the most immediate point of human interaction between workers and human-centered safety ecosystem. The CORE-Band is a wrist-worn wearable device designed to be worn by the worker throughout the entire working day. This aids in the integration of the device into daily routine without focussing on it or wearing it while on work. The primary goal is not a performance or productivity measure, but to help support safety, awareness, and wellbeing in a seamless and unobtrusive way.

The worker wears the CORE-Band at the start of their shift as they would a normal watch. When the device is worn, the CORE system is automatically activated and linked without any need for configuration or complicated interactions. From now on, the CORE-Band operates mainly in the background. It continually monitors physical and situational circumstances, while allowing the operator to concentrate on their job. This passive behaviour is a key design decision to mitigate cognitive load and avoid distracting users during work activities.

The CORE-Band adapts to working phases and situations throughout the day. During normal activity, the device remains virtually invisible, signalling its presence only through subtle indications. The CORE-Band sends a signal whenever a serious situation occurs. For instance, when the exertion level is too high, or when the worker is in a bad environment for too long. The feedback is meant to be read or touched at a quick glance so that the worker can respond quickly without disrupting their work.

The CORE-Band also has an important role outside real-time interaction. At the end of the working day, it synchronizes with the CORE system the collected data so that it can be consulted later. The workers can now review their data on the dashboard making the CORE-Band transform from a just “moment-to-moment” safety device to a **long-term self-awareness and reflection device**.


CORE

Wearable content inventory

Category	Content Element	Description	Type	Frequency
System Status	Device on/off status	Indicates whether the device is active	Informational	Persistent
	Connectivity status	Shows connection to central system	Informational	Persistent
	Battery level	Remaining battery percentage	Informational	Periodic
	System error state	Indicates malfunction or failure	Alert	Event-based
Physiological Data	Heart rate	Continuous physiological monitoring	Data	Continuous
	Physical load indicator	Estimated physical strain level	Data	Continuous
	Stress level indicator	Derived cognitive or physiological stress signal	Data	Persistent
	Fatigue trend	Accumulated workload over time	Data	Shift-based
Movement & Activity	Motion detection	Basic movement and activity recognition	Data	Continuous
	Posture anomaly	Detection of non-neutral postures	Data	Event-based
	Repetitive movement detection	Identification of repeated motions	Data	Periodic
Environmental Awareness	Environmental exposure status	Indicates potentially unsafe conditions	Data	Event-based
	Combined risk level	Synthesis of body and environmental data	Data	Dynamic
Feedback & Alerts	Low-level alert	Non-critical warning feedback	Alert	Event-based

Category	Content Element	Description	Type	Frequency
	High-priority alert	Critical safety-related notification	Alert	Event-based
	Haptic feedback pattern	Vibration-based alert communication	Feedback	Event-based
	Visual alert signal	Light or screen-based warning	Feedback	Event-based
User Interaction	Alert acknowledgment	User confirms reception of alert	Interaction	On-demand
	Manual interaction input	Simple gesture or touch input	Interaction	On-demand
	Emergency activation	Immediate emergency signal	Interaction	Rare / Critical
Temporal Awareness	Activity duration	Time spent in current task or condition	Informational	Continuous
	Exposure duration	Time exposed to critical conditions	Informational	Event-based
	Shift phase indicator	Awareness of work phase	Informational	Shift-based
Data Management	Data logging	Records sensor data and events	System	Continuous
	Event timestamping	Time reference for alerts and interactions	System	Event-based
	Data synchronization	Transmission to analysis system	System	Periodic
Privacy & Control	Data abstraction level	Raw vs processed data handling	System	Persistent
	User data boundaries	Separation between personal and organizational	System	Persistent

10.4 Device components and sensors

The CORE-Band consists of a **thoughtfully chosen set of sensors** to enable the CORE system to gather meaningful information regarding the worker's body's state and movement and surrounding environment. These components are specifically selected utilizing **a trade-off between the accuracy of the data, comfort and reliability**, which are all necessary in industrial environments where devices have to work 24/7 and not interfere with others' operations.

The CORE-Band is equipped with **physiological sensors** that allow it to monitor signals such as heart rate and overall physical activation. These indicators show the energy used by the worker and the stress experienced throughout the day. This system does not only look at single values but looks at trends and variations over time as these are more useful for fatigue/long repetitiveness.

Movement patterns and **physical behavior** are detected through motion sensors like accelerometers and gyroscopes. Using these sensors, the CORE-Band can detect repeated movements, sudden movements or non-neutral postures that may lead to injuries. In industrial assembly environments, it is common to work in constrained postures while doing repetitive tasks.

In addition to body-related data, the CORE-Band can communicate with **contextual artefacts placed in the work environment** and additional wearable add-ons. This collection allows the system to sense other elements, like monitoring noise, measuring temperature, or assessing the quality of the air. The CORE analysis system receives all collected data for further combination and interpretation. The system takes the raw data generated by the sensors and turns them into results that can be converted into feedback for workers and actionable information for supervisors.

CORE-Band has a **modular structure** that enables further future development of additional add-ons. These add-ons can be customized to serve certain assignments or objectives, thus making the system quite scalable and adaptable to industrial setups. This will allow the CORE to evolve through time without needing to redesign the whole wearable device itself.

Physiological Sensors:
Heart Rate Sensor
Physiological Activation Sensors
Contextual Sensors:
Digital Thermometer
Noise Detection
Gas Sensor
Motion Sensors:
3-Axis Accelerometer
3-Axis Gyroscope

10.5 Materials, ergonomics, and form factor

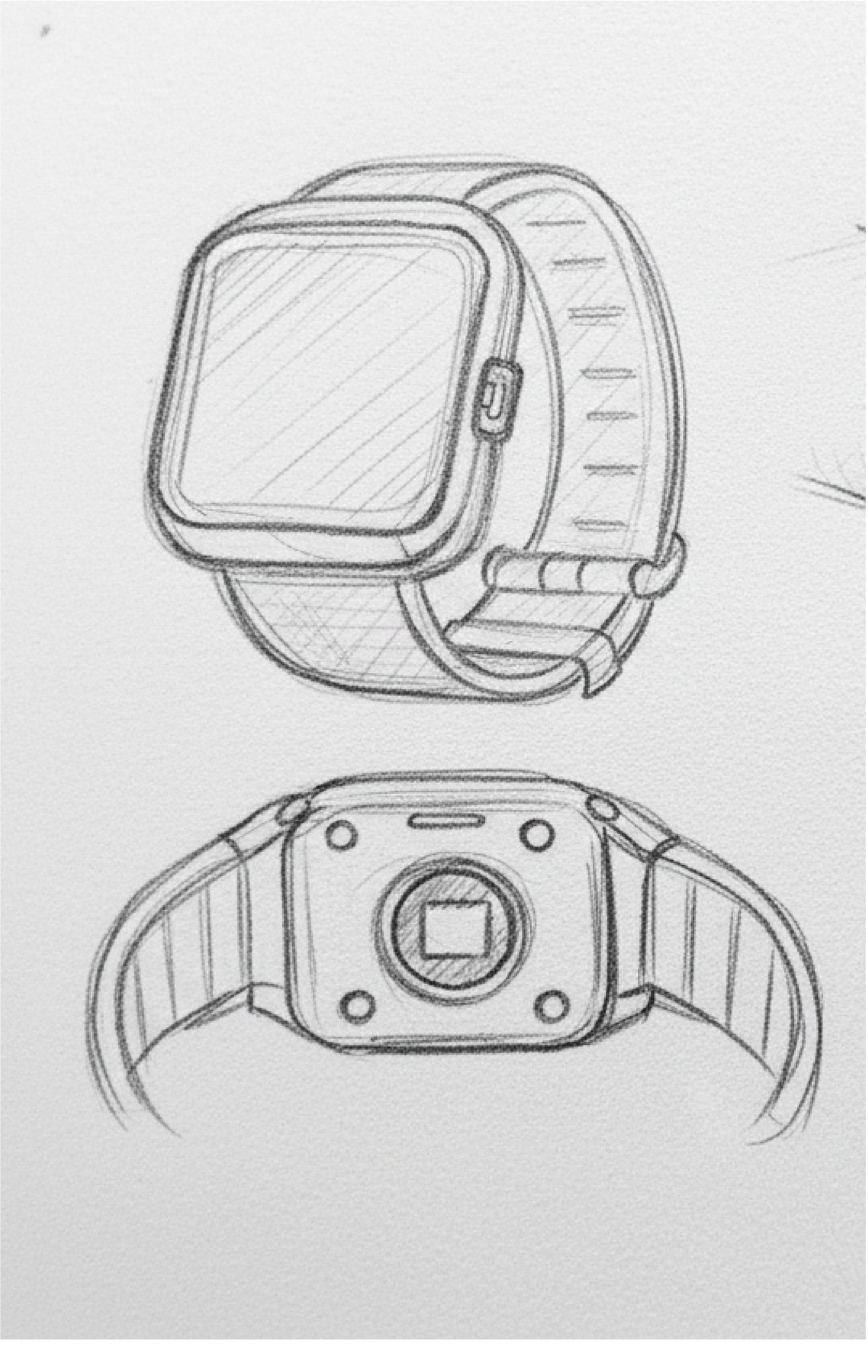
The CORE-Band's form factor was purposefully influenced by **commercial smartwatches that are already popular and well-known**. The functional and as well the psychological factors influence this design decision. By relying on established interaction habits, adopting a recognizable form promotes user acceptance and lowers the risk of rejection associated with unfamiliar wearable technologies.

The CORE-Band strap is made of **materials like silicone and fluoroelastomer** that are frequently found in consumer smartwatches. These materials can be used for extended periods of time in industrial settings because they are strong, flexible, and resistant to moisture, dust, and perspiration. Long work shifts are made comfortable by the strap's adjustable design and stability during physical activity.

The CORE-Band's outer shell, which is made to withstand daily wear and impacts, protects the main body of the device. Tempered glass or reinforced polymer are used to cover the display area; these materials are comparable to those found in commercial wearable technology. These materials ensure that **visual feedback is clear even in difficult lighting conditions** by striking a balance between protection and visibility.

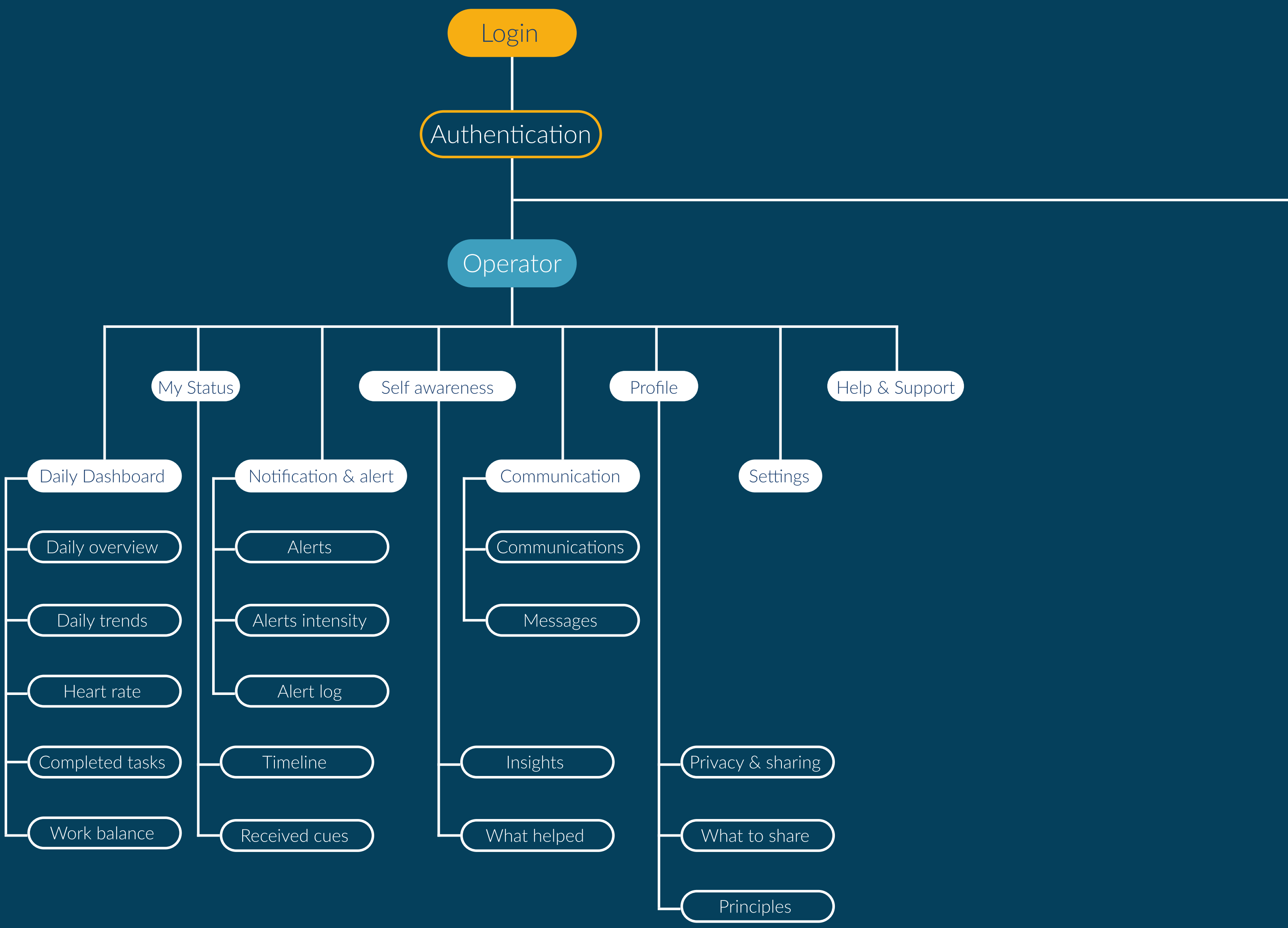
From an ergonomic standpoint, the CORE-Band is **lightweight, small, and designed to fit the wrist's natural curve.** A special focus is placed on avoiding excessive thickness or sharp edges that could interfere with other protective equipment or manual tasks. Instead of making the device feel like an external or intrusive object, the overall design seeks to make it feel like a natural extension of the worker.

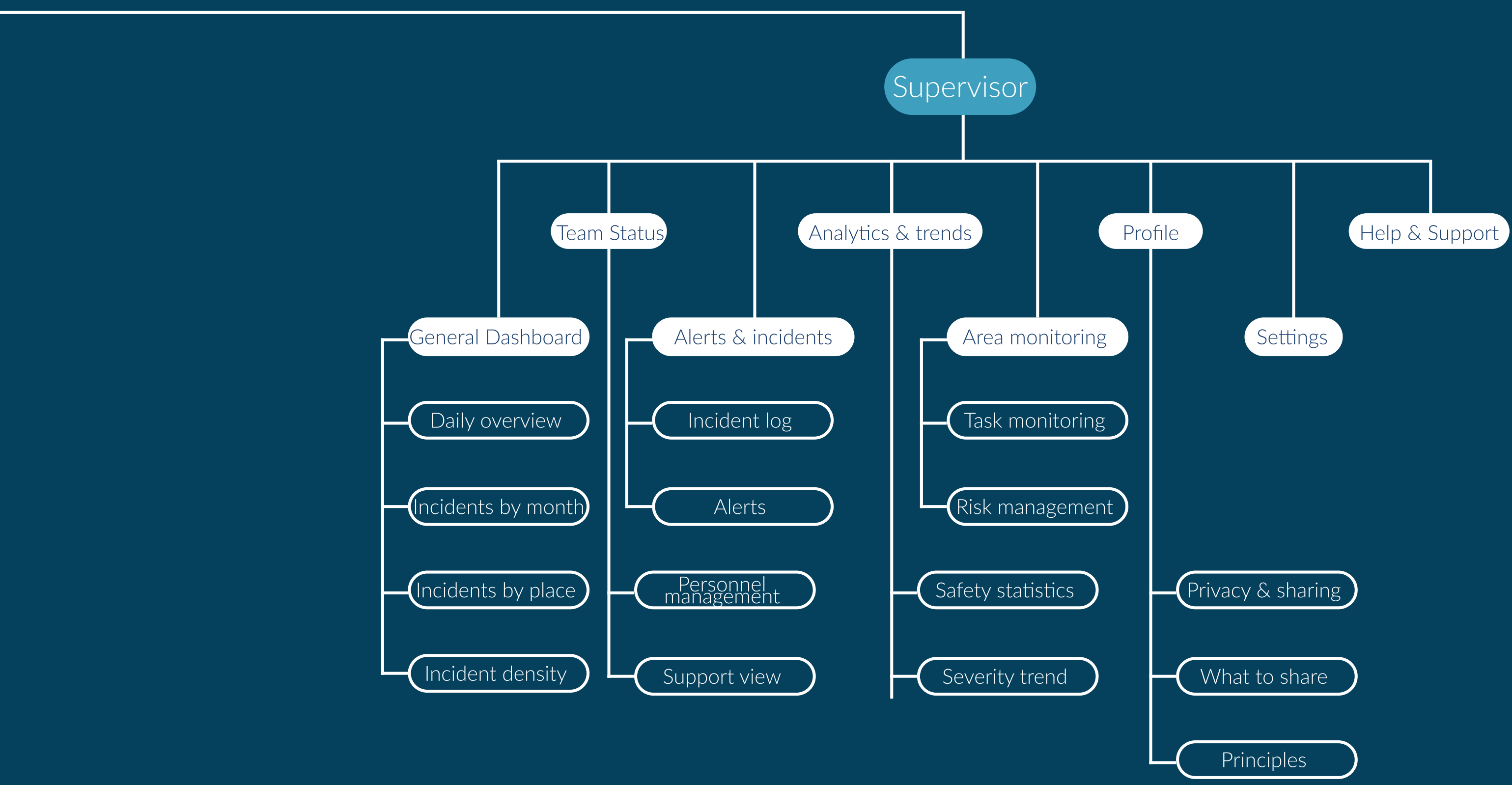
The CORE-Band embodies the CORE system's human-centered philosophy through the use of well-known materials, meticulous ergonomics, and an established form factor. It reinforces the notion that safety technology can support employees discreetly and efficiently without interfering with their daily routines because it is made to be **trusted, accepted, and worn on a daily basis.**



ELEVENTH CHAPTER
The system

11.1 Sitemap




Supervisor
Team Status
Analytics & trends
Profile
Help & Support
General Dashboard
Daily overview
Incidents by month
Incidents by place
Incident density
Alerts & incidents
Incident log
Alerts
Personnel management
Support view
Area monitoring
Task monitoring
Risk management
Safety statistics
Severity trend
Settings
Privacy & sharing
What to share
Principles

11.2 The interaction

The interaction principles of CORE system are based on the human-centred design approach. Technology is seen as a support system, rather than an occupying or overpowering force. The CORE-Band and digital dashboards are designed to respect the organizational, cognitive and physical constraints of the work environment while creating synergies with industrial work routines. Users and the context use the system, which means that system adapts but not users.

One primary aspect of interaction design is unobtrusiveness. While working together, the contact is limited to what is absolutely necessary. Passive observing and unobtrusive feedback are the main working modes of the CORE-band. The worker is not even required to keep a constant check on data or on the device. Instead, communication would happen only when there is, say, a dangerous situation that is likely or has to be rectified immediately and so on. One technique to help employees focus on the task is to reduce distraction.

Not entirely unrelated to this is the principle of progressive disclosure of information. The CORE system spreads information across artefacts and layers of interaction. The CORE-Band self-consciously offers only the most necessary and immediate feedback, which should be quickly perceivable through haptic signals or simple visual hints. More detailed information, explanations, and historical data are on purpose moved to the digital dashboards. This keeps complex data from interfering with real-time activities while still being available for later stages of reflection, analysis, and decision-making.

Another relevant principle is role-based interaction. Workers and supervisors interact with the CORE system through different interfaces, each tailored to meet their needs and responsibilities. Workers will only have contact with the CORE-Band and the personal dashboard. These are oriented to individual safety, self-awareness, and reflection; therefore, feedback must be delivered to support understanding and not judgment. The personal dashboard enables workers to browse data over time and discover patterns, which they might use to understand how their physical and mental conditions change during work.

Supervisors interact with the CORE system through a dedicated dashboard designed for management and coordination. This interface gives an overview of factory status, active alerts, environmental conditions, and aggregated data with regards to teams and work areas. The interaction design will support monitoring and prioritization. In this line, the interaction supports supervisors in intervening if necessary, and in managing safety at an organizational level. Importantly, aggregated and contextual information is emphasized in the supervisor dashboard, avoiding the unnecessary exposition of individual-level data.

One crucial concept that defines an interactive design is the consistency and clarity delivered across all interfaces. There is consistency and clarity between visual language, interactions, and feedback logic for both CORE-Band and dashboards. With all these factors, it becomes easy for an individual to develop both familiarity and comfort with the system. Consistent cause-and- effect relationships also enhance an individual's confidence in reliability and consistency.

The role of trust proves to be especially critical in relation to the interaction design of CORE. For this reason, it has been treated as one of the basic aspects by considering it in terms of transparency. The user has prior information about what kinds of data are being processed, in what manner, and to what extent they will be used. No attempt has been made to provide ambiguous kinds of feedback, which can only prove to be confusing.

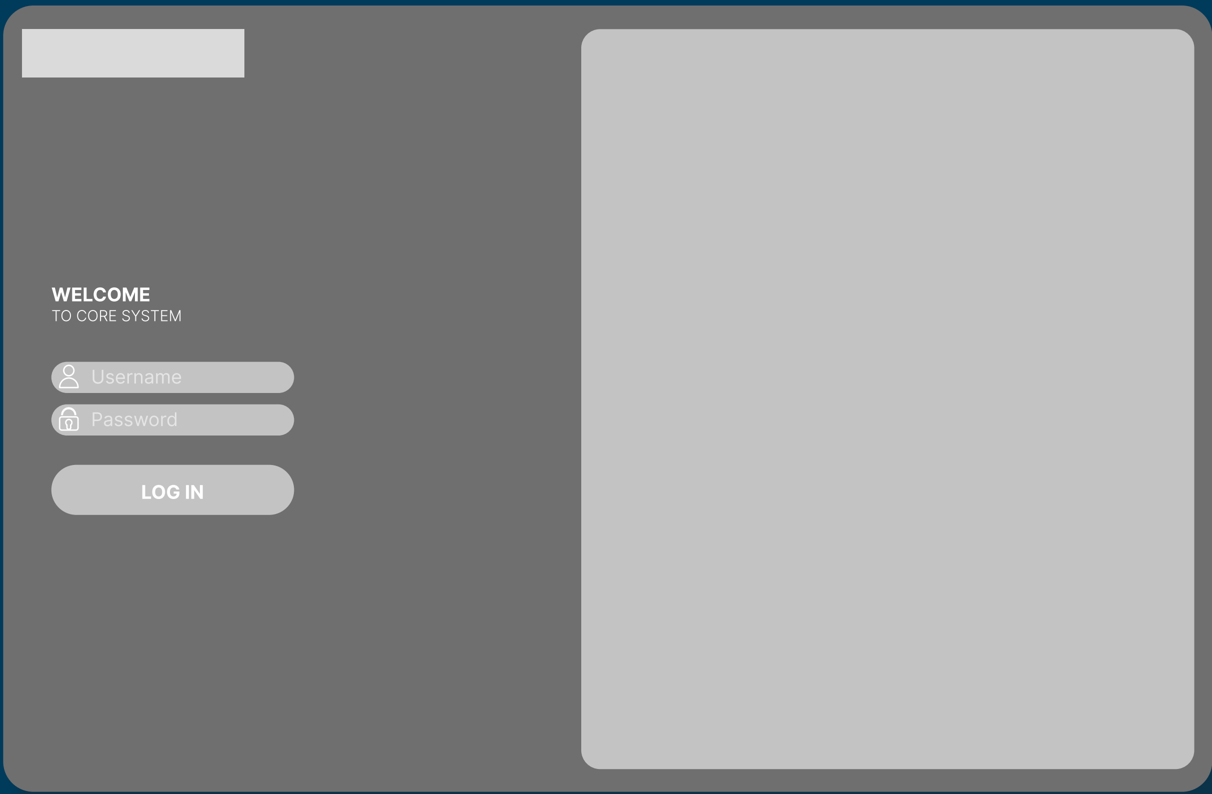
Moreover, one can argue that the approach of the CORE system in relation to interacting principles is actually in line with an increasing understanding of industrial systems that is dominated by an increasing need for technology to complement human abilities, rather than replacing them in any way. Thus, it is clearly in line with an understanding of what is currently required in relation to providing enhanced support in relation to human understanding in decision-making processes or otherwise.

By doing this, the CORE system addresses safety on both an individual and organizational level, offering a well-balanced interaction model for safety. The discussion also strengthens the idea of technology as a silent collaborator in the workplace, fostering a secure and long-lasting workplace while taking into account the human element of work.

11.3 Wireframe

This stage marks the transition from the project's conceptual level to the first physical manifestation of the user experience. Research results, functional specifications, and design guidelines are mapped onto an organized interface, and wireframes are used as a design and analysis aid. Wireframes are meant to determine information structure, interaction, and user flow within the system, not aesthetics.

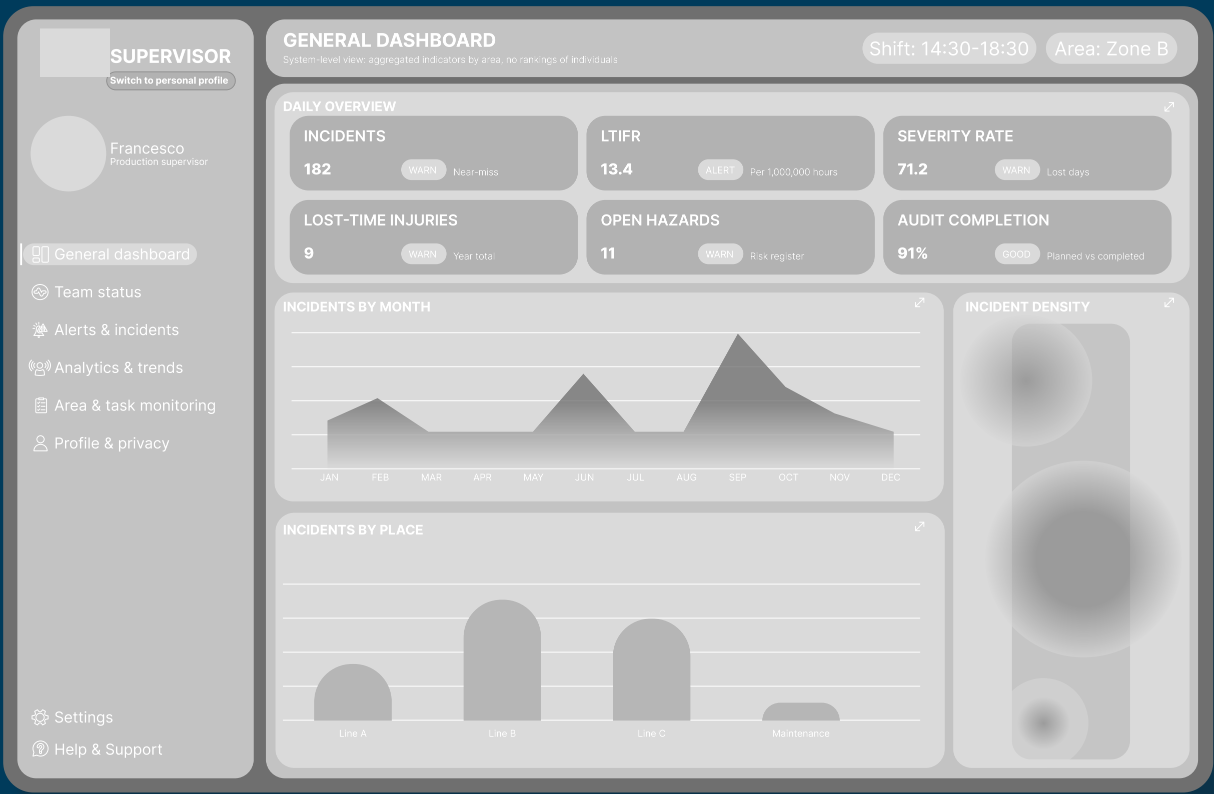
Investigating the way the user interacts with the system throughout the workday, the way information is revealed, and the way decisions and actions are supported in various contexts is made possible through the creation of wireframes. Before proceeding to visual design and high-fidelity prototyping, this step enables the identification of possible critical points, risks of cognitive overload, and opportunities to simplify interactions. In this way, wireframes facilitate an iterative, human-centered approach to the overall experience's design by serving as a link between research and implementation.

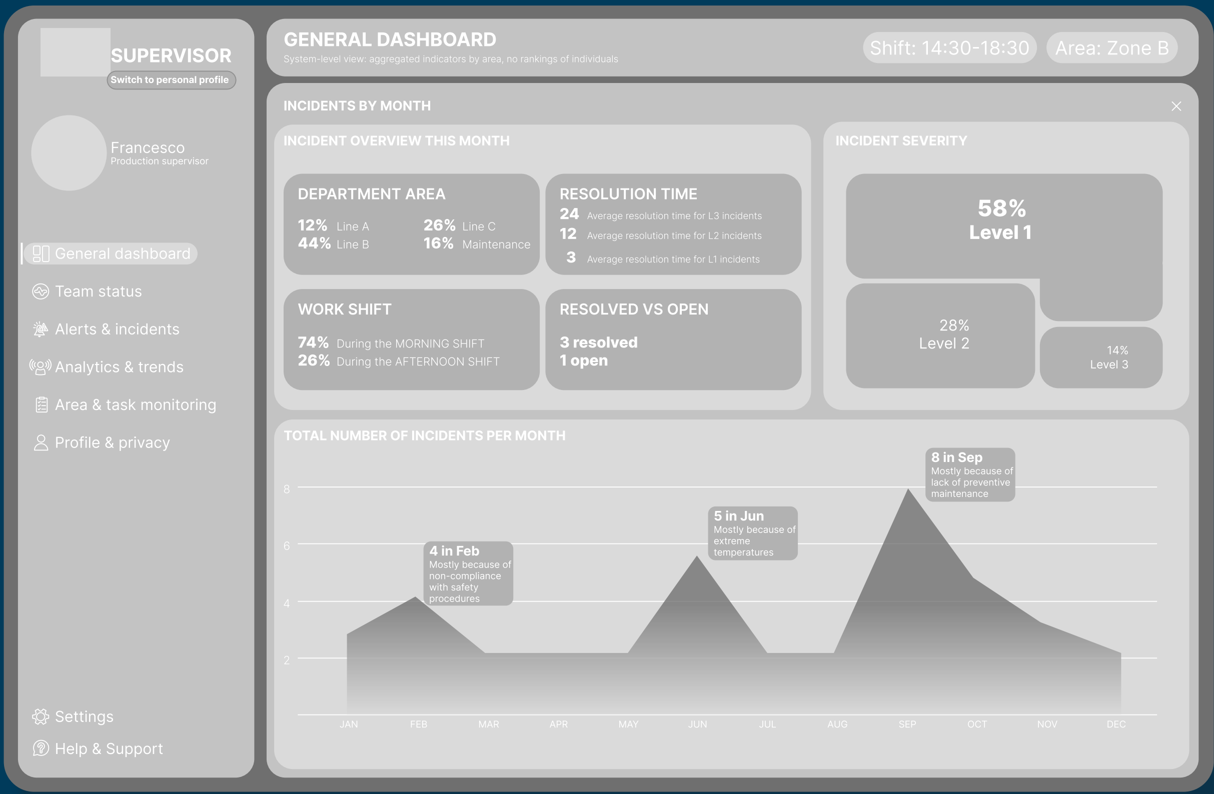


Users enter their username and password to gain access to the system. Following authentication, the employee is taken to the daily dashboard, which offers a straightforward and customized summary of the workday. It is made to be easily readable and to promote awareness without being distracting.

To ensure visual clarity, each section includes an expandable arrow in the upper-right corner, allowing users to access detailed contextual information via pop-up windows. This hierarchical navigation leads to the 'My Status' dashboard, which displays a timeline of the workday highlighting pertinent events and feedback.

The Notifications and Alerts view is designed to centralize all system communications. It offers a clear visual breakdown of alert categories, ensuring that the nature and frequency of each notification are immediately identifiable. Supervisors, who log in with their own credentials and are taken straight to the general dashboard, are subject to the same access logic.





The supervisor's view replicates the personal dashboard's architecture, utilizing pop-up expansions for in-depth data exploration. The 'Team Status' page applies this logic to the whole group, providing a clear overview of the psycho-physical conditions of individual workers. This dual-layered approach ensures that collective safety management remains as intuitive and detailed as individual self-monitoring.

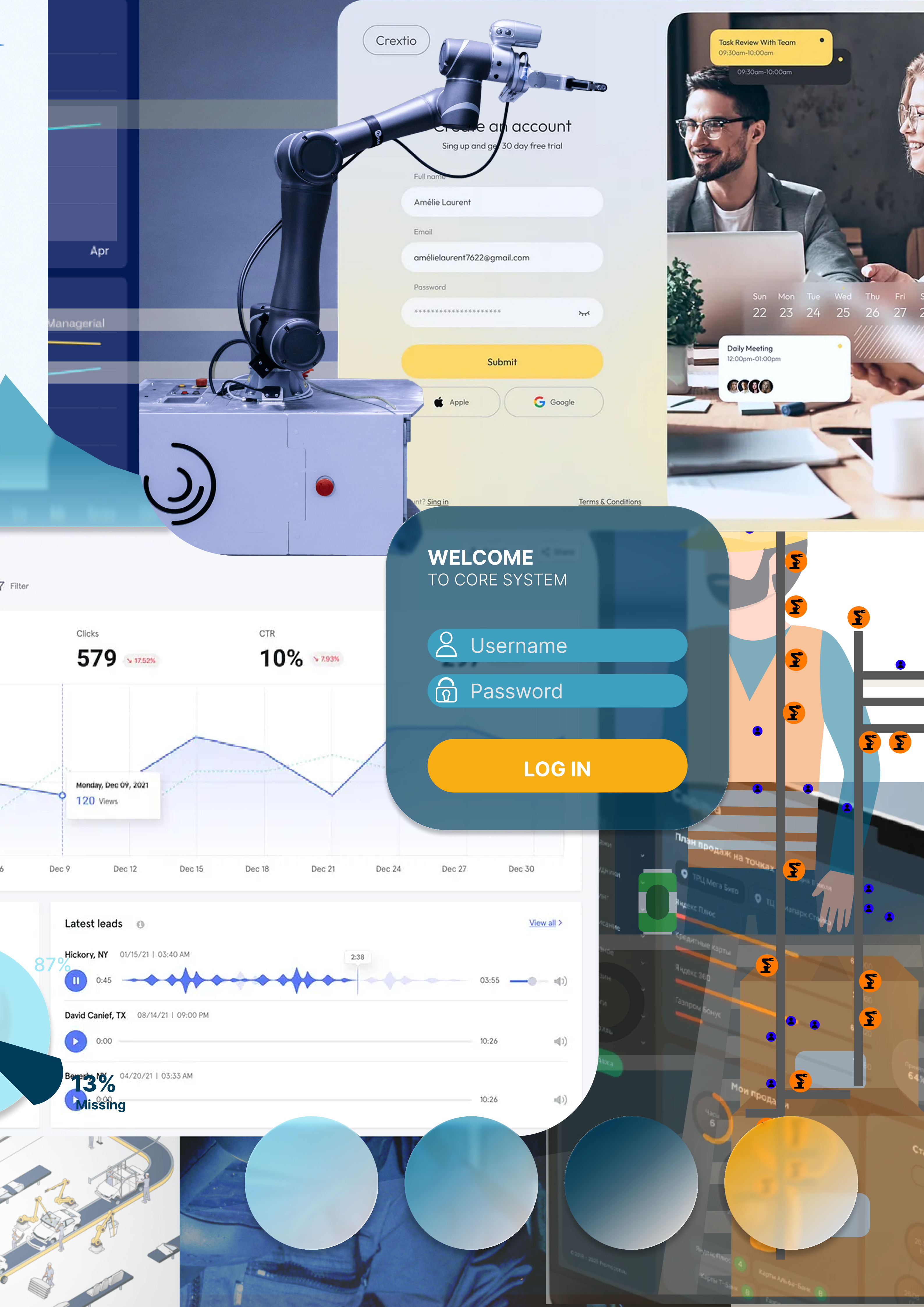
Supervisors can keep an eye on the status of all alerts sent to employees in the Alerts & Incidents section, which gives them a summary of both unresolved and ongoing problems. Additional sections are available for both user profiles to facilitate a better comprehension of safety performance and areas for improvement. Lastly, users can manage their personal information and preferences and get help when they need it through shared areas like Profile, Settings, and Help & Support.

11.4 Moodboard

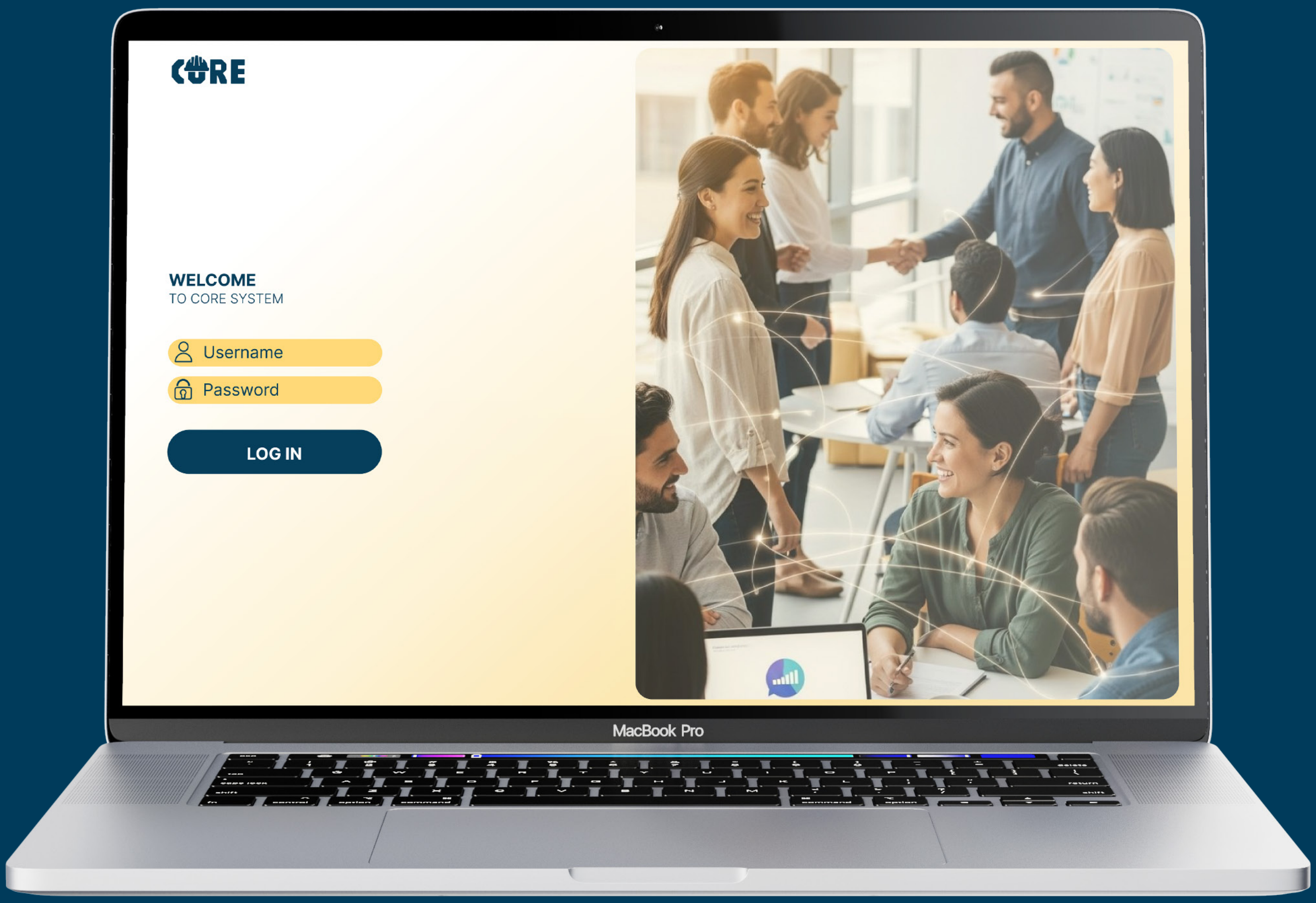
A crucial stage in the creation of the user interface is the moodboard, which defines the system's overall style both conceptually and visually. In order to ensure consistency across all interfaces and devices, it is used to investigate and align visual elements like color palette, typography, iconography, and overall atmosphere. Beyond aesthetics, the moodboard assists in translating the project's values such as trust, clarity, and non-invasiveness into visual selections that promote usability and lessen cognitive load.

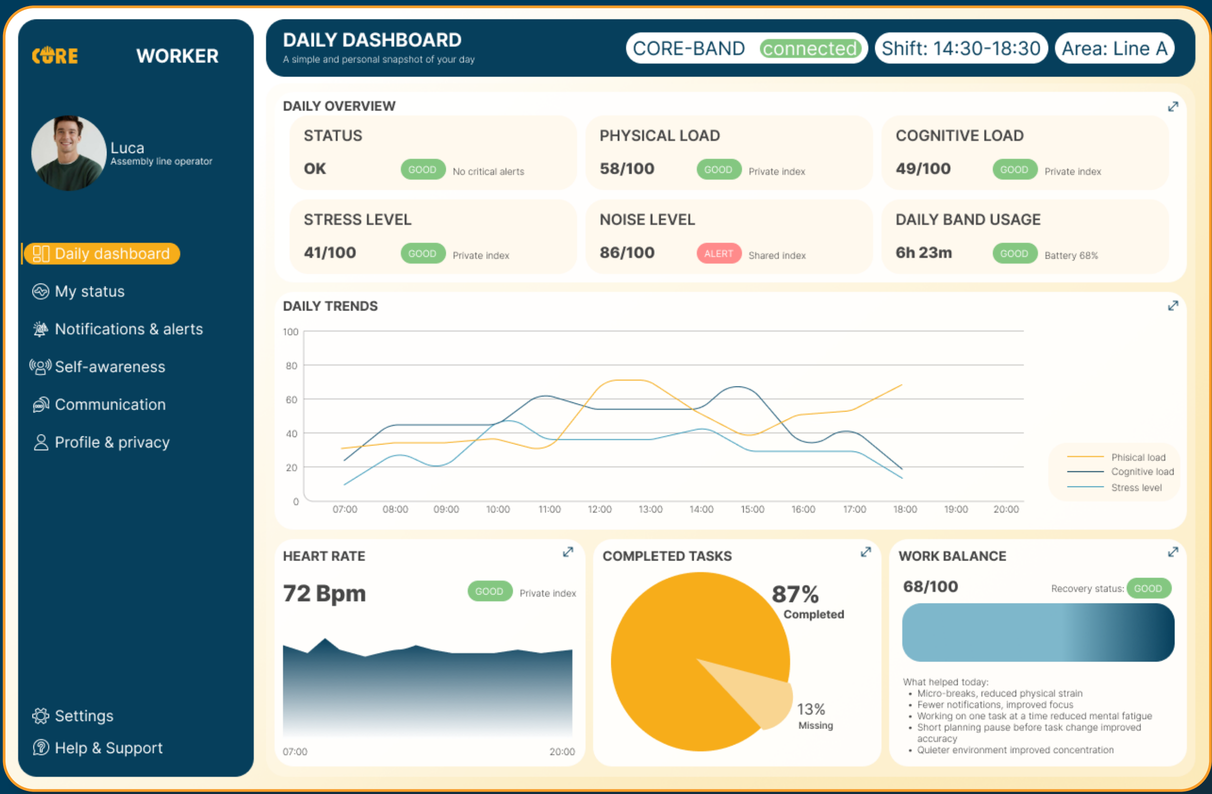
By bringing all these references, visual cues, and stylistic intentions together, the moodboard acts as a bridge to facilitate the move from wireframing to visual design. In this project, it is instrumental in ensuring that there is a unified look and feel between the worker interface and the supervisor interface, while at the same time ensuring that there is a clear information hierarchy and a professional, serene look that is appropriate for industrial settings.

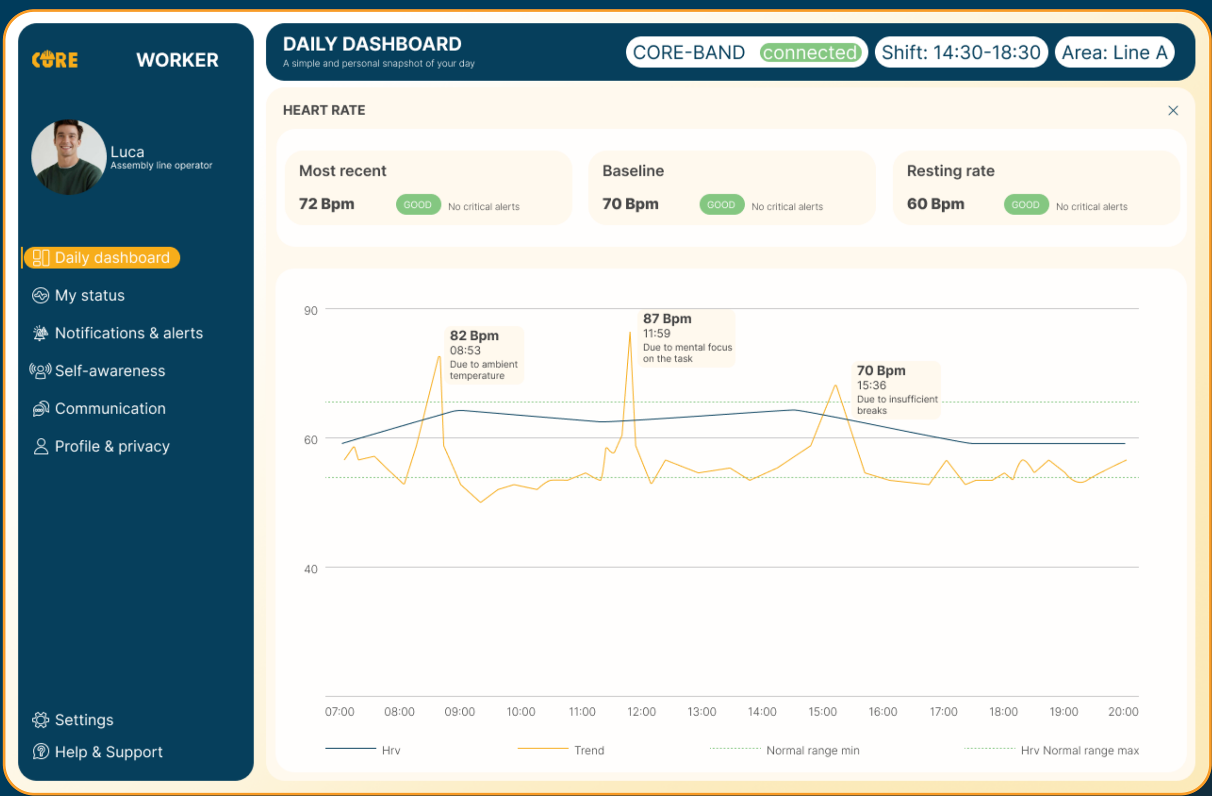
Incidents this year
Jan
Feb
Mar
Incident location
Office
Warehouse
workshop
Offsite
74
Staff overdue
12
pending approval
16
overdue > 45 days
ADS
Dashboard
Opportunities
Ads Settings
Boost Zones
Boosted Service
Ads Dashboard
12 Aug 2021 - 19 Aug 2021
Views
3,769
12.90%
Opportunity type
Crextio
Dashboard
People
Hiring
Devices
Apps
Salary
Calendar
Reviews
Setting
Welcome in, Nixtio
Interviews
Hired
Project time
15%
15%
60%
ACTIVE WORKERS
45
GOOD
Wearable connected
Lora Piterson
UX/UI Designer
$1,200
6.1 h
Work Time this week
5h 23m
02:35
Work Time
Task
Onboarding Task
2/8
Interview
Team Meeting
Project Update
Discuss Q3 Goals
HR Policy Review
Pension contributions
Devices
MacBook Air
Version M1
Compensation Summary
Employee Benefits
August
September 2024
October
Weekly Team Sync
Discuss progress on projects
Onboarding Session
Introduction for new hires

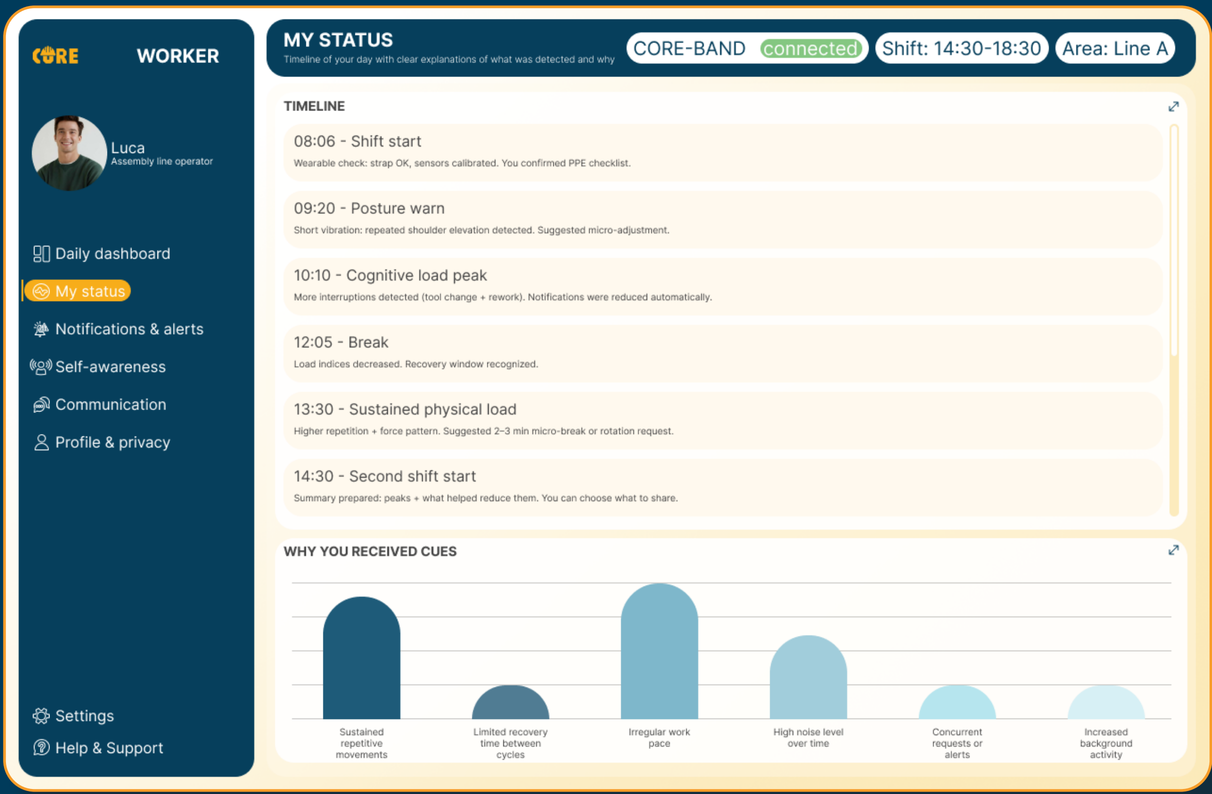

Apr
Managerial
Crextio
Create an account
Sing up and get 30 day free trial
Full name
Amélie Laurent
Email
amélielaurent7622@gmail.com
Password
Submit
Apple
Google
Terms & Conditions
Task Review With Team
09:30am-10:00am
Sun Mon Tue Wed Thu Fri
22 23 24 25 26 27
Daily Meeting
12:00pm-01:00pm
WELCOME
TO CORE SYSTEM
Username
Password
LOG IN
Filter
Clicks
579
CTR
10%
Monday, Dec 09, 2021
120 Views
Dec 9 Dec 12 Dec 15 Dec 18 Dec 21 Dec 24 Dec 27 Dec 30
Latest leads
View all
Hickory, NY 01/15/21 | 03:40 AM
0:45 03:55
David Caniel, TX 08/14/21 | 09:00 PM
0:00 10:26
04/20/21 | 03:33 AM
10:26
87%
13%
Missing
План продаж на точках
Мои продажи

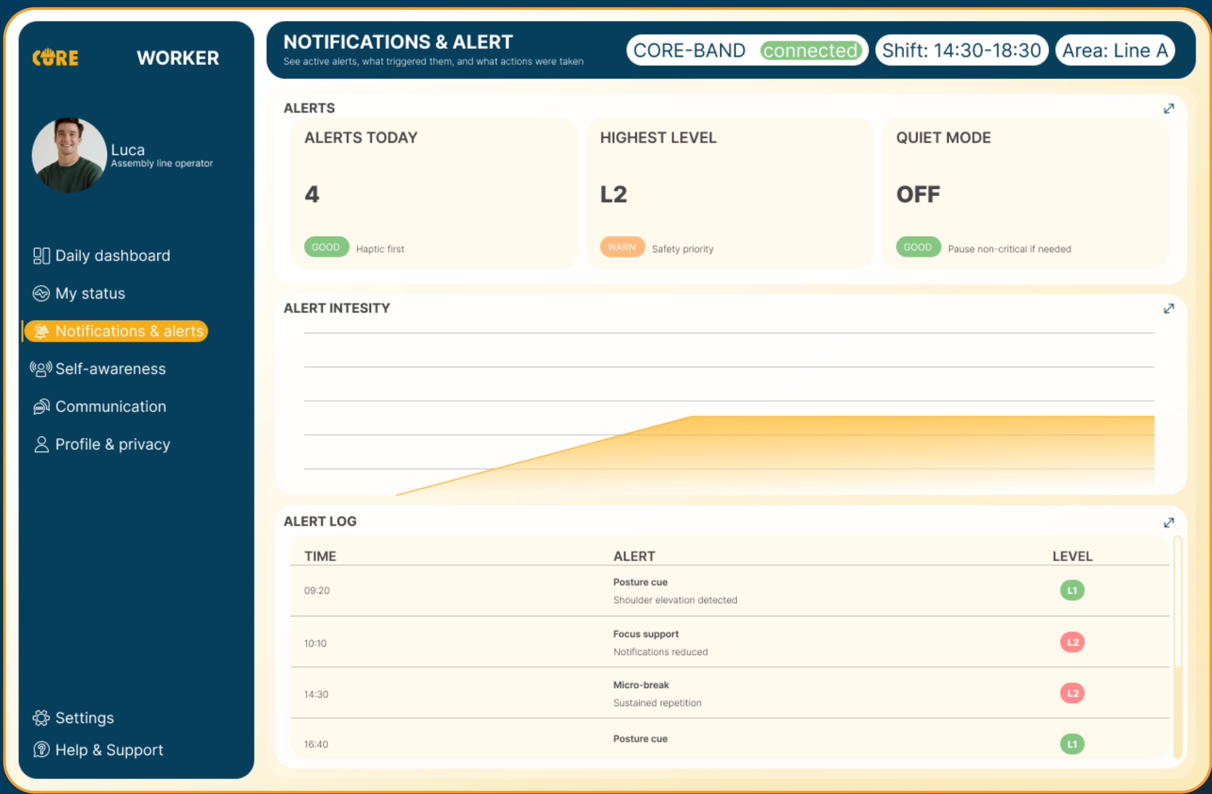
11.5The prototype



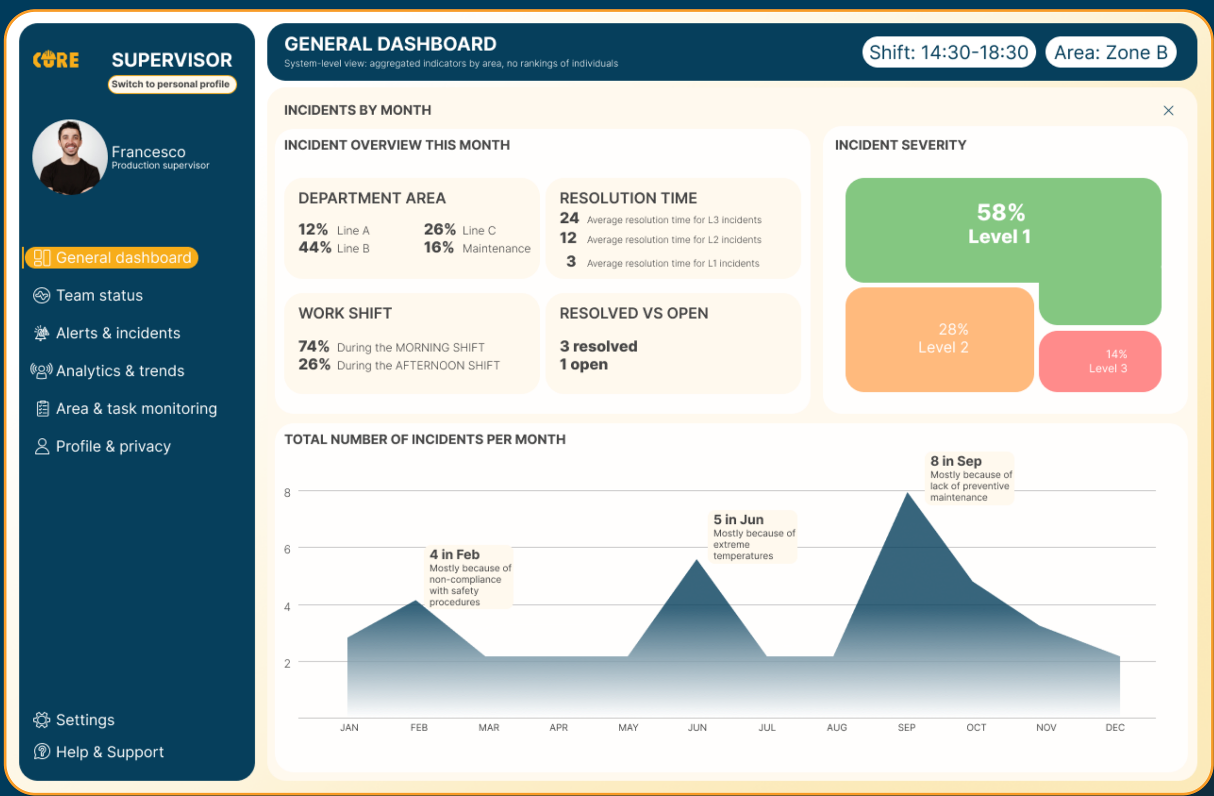

CORE
WORKER
Luca
Assembly line operator
Daily dashboard
My status
Notifications & alerts
Self-awareness
Communication
Profile & privacy
Settings
Help & Support
DAILY DASHBOARD
A simple and personal snapshot of your day
CORE-BAND connected
Shift: 14:30-18:30
Area: Line A
DAILY OVERVIEW
STATUS
OK
GOOD
No critical alerts
PHYSICAL LOAD
58/100
GOOD
Private index
COGNITIVE LOAD
49/100
GOOD
Private index
STRESS LEVEL
41/100
GOOD
Private index
NOISE LEVEL
86/100
ALERT
Shared index
DAILY BAND USAGE
6h 23m
GOOD
Battery 68%
DAILY TRENDS
Phisical load
Cognitive load
Stress level
HEART RATE
72 Bpm
GOOD
Private index
07:00
20:00
COMPLETED TASKS
87%
Completed
13%
Missing
WORK BALANCE
68/100
Recovery status: GOOD
What helped today:
Micro-breaks, reduced physical strain
Fewer notifications, improved focus
Working on one task at a time reduced mental fatigue
Short planning pause before task change improved accuracy
Quieter environment improved concentration

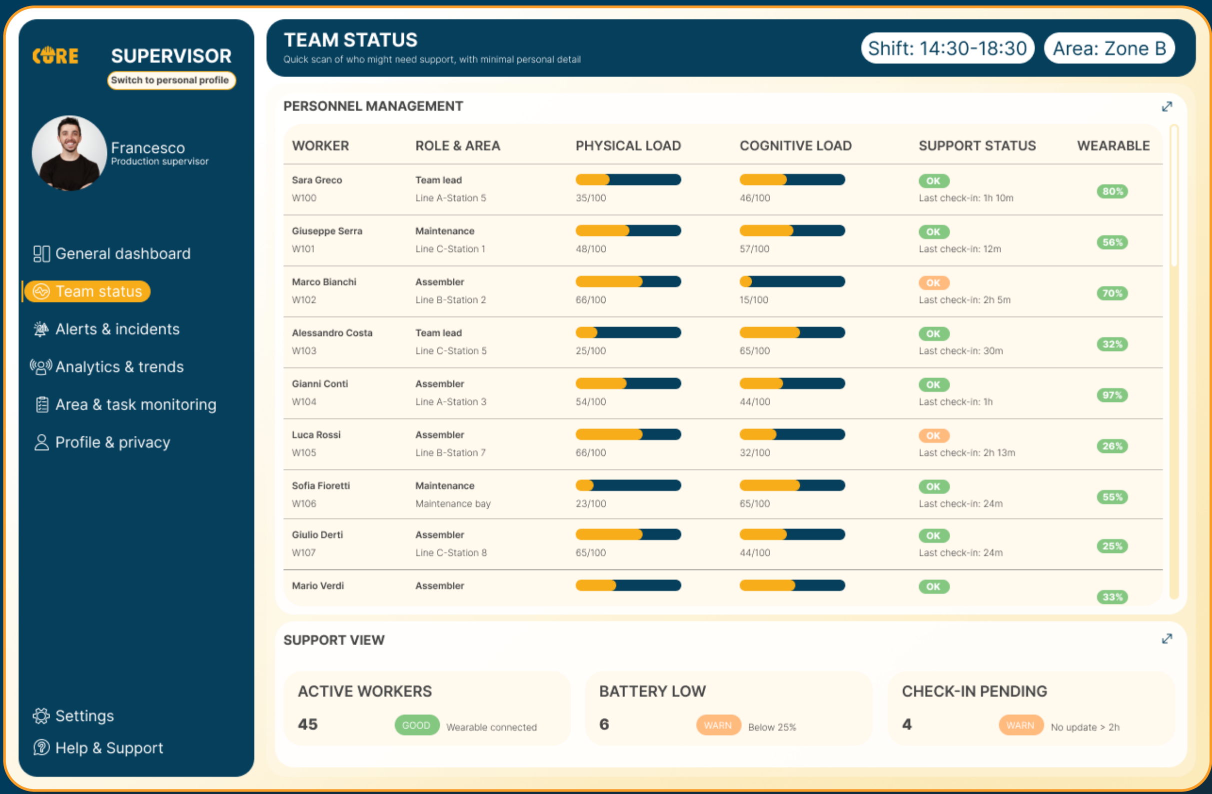

CORE
WORKER
Luca
Assembly line operator
Daily dashboard
My status
Notifications & alerts
Self-awareness
Communication
Profile & privacy
Settings
Help & Support
DAILY DASHBOARD
A simple and personal snapshot of your day
CORE-BAND connected
Shift: 14:30-18:30
Area: Line A
HEART RATE
Most recent
72 Bpm
GOOD
No critical alerts
Baseline
70 Bpm
GOOD
No critical alerts
Resting rate
60 Bpm
GOOD
No critical alerts
82 Bpm
08:53
Due to ambient temperature
87 Bpm
11:59
Due to mental focus on the task
70 Bpm
15:36
Due to insufficient breaks
Hrv
Trend
Normal range min
Hrv Normal range max

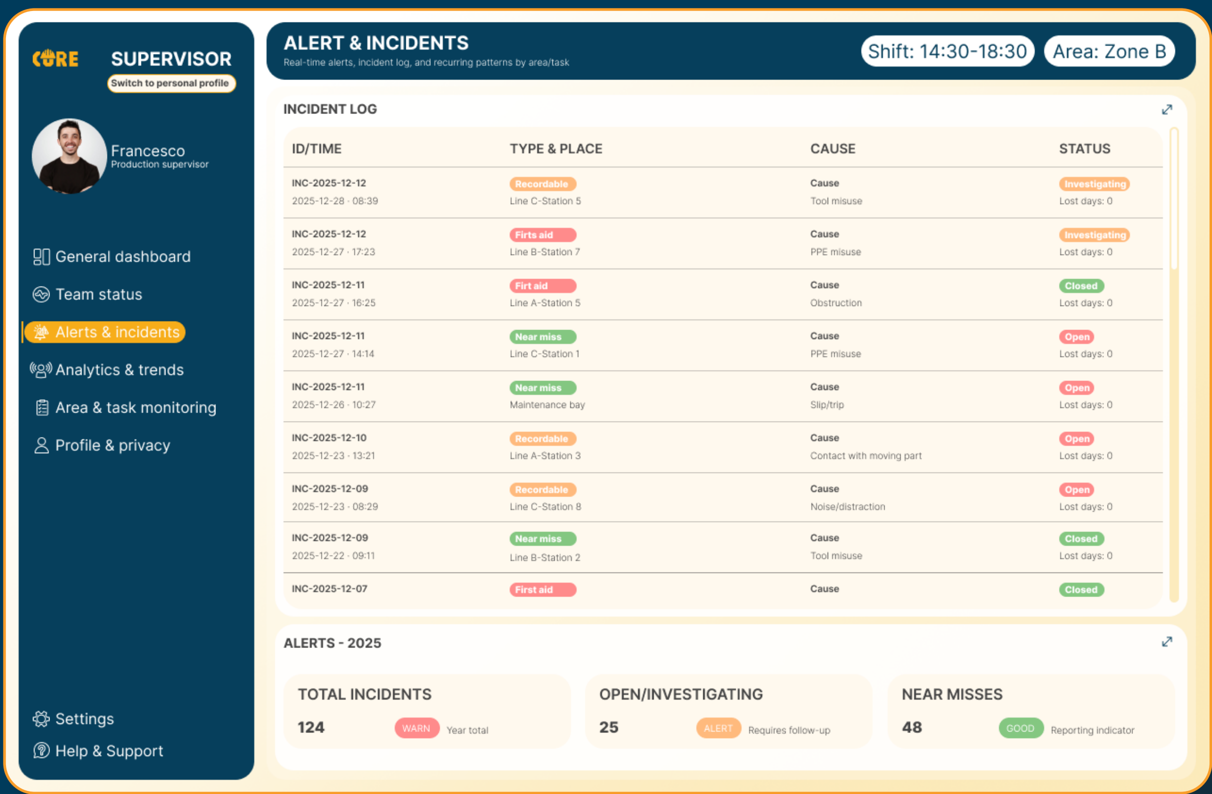

CORE
WORKER
Luca
Assembly line operator
Daily dashboard
My status
Notifications & alerts
Self-awareness
Communication
Profile & privacy
Settings
Help & Support
MY STATUS
Timeline of your day with clear explanations of what was detected and why
CORE-BAND connected
Shift: 14:30-18:30
Area: Line A
TIMELINE
08:06 - Shift start
Wearable check: strap OK, sensors calibrated. You confirmed PPE checklist.
09:20 - Posture warn
Short vibration: repeated shoulder elevation detected. Suggested micro-adjustment.
10:10 - Cognitive load peak
More interruptions detected (tool change + rework). Notifications were reduced automatically.
12:05 - Break
Load indices decreased. Recovery window recognized.
13:30 - Sustained physical load
Higher repetition + force pattern. Suggested 2–3 min micro-break or rotation request.
14:30 - Second shift start
Summary prepared: peaks + what helped reduce them. You can choose what to share.
WHY YOU RECEIVED CUES
Sustained repetitive movements
Limited recovery time between cycles
Irregular work pace
High noise level over time
Concurrent requests or alerts
Increased background activity


CORE
WORKER
Luca
Assembly line operator
Daily dashboard
My status
Notifications & alerts
Self-awareness
Communication
Profile & privacy
Settings
Help & Support
NOTIFICATIONS & ALERT
See active alerts, what triggered them, and what actions were taken
CORE-BAND connected
Shift: 14:30-18:30
Area: Line A
ALERTS
ALERTS TODAY
4
GOOD
Haptic first
HIGHEST LEVEL
L2
WARN
Safety priority
QUIET MODE
OFF
GOOD
Pause non-critical if needed
ALERT INTESITY
ALERT LOG
TIME
ALERT
LEVEL
09:20
Posture cue
Shoulder elevation detected
L1
10:10
Focus support
Notifications reduced
L2
14:30
Micro-break
Sustained repetition
L2
16:40
Posture cue
L1

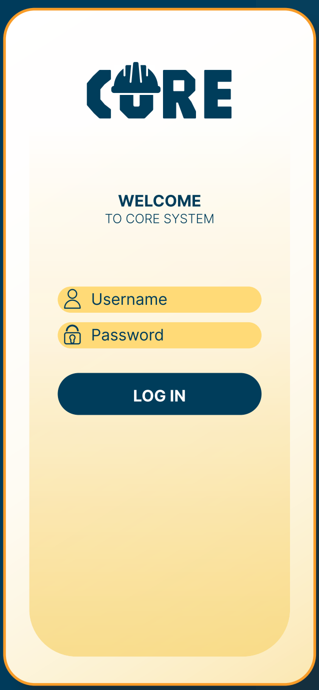

CORE
SUPERVISOR
Switch to personal profile
Francesco
Production supervisor
General dashboard
Team status
Alerts & incidents
Analytics & trends
Area & task monitoring
Profile & privacy
Settings
Help & Support
GENERAL DASHBOARD
System-level view: aggregated indicators by area, no rankings of individuals
Shift: 14:30-18:30
Area: Zone B
DAILY OVERVIEW
INCIDENTS
182
WARN
Near-miss
LTIFR
13.4
ALERT
Per 1,000,000 hours
SEVERITY RATE
71.2
WARN
Lost days
LOST-TIME INJURIES
9
WARN
Year total
OPEN HAZARDS
11
WARN
Risk register
AUDIT COMPLETION
91%
GOOD
Planned vs completed
INCIDENTS BY MONTH
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
INCIDENT DENSITY
INCIDENTS BY PLACE
Line A
Line B
Line C
Maintenance

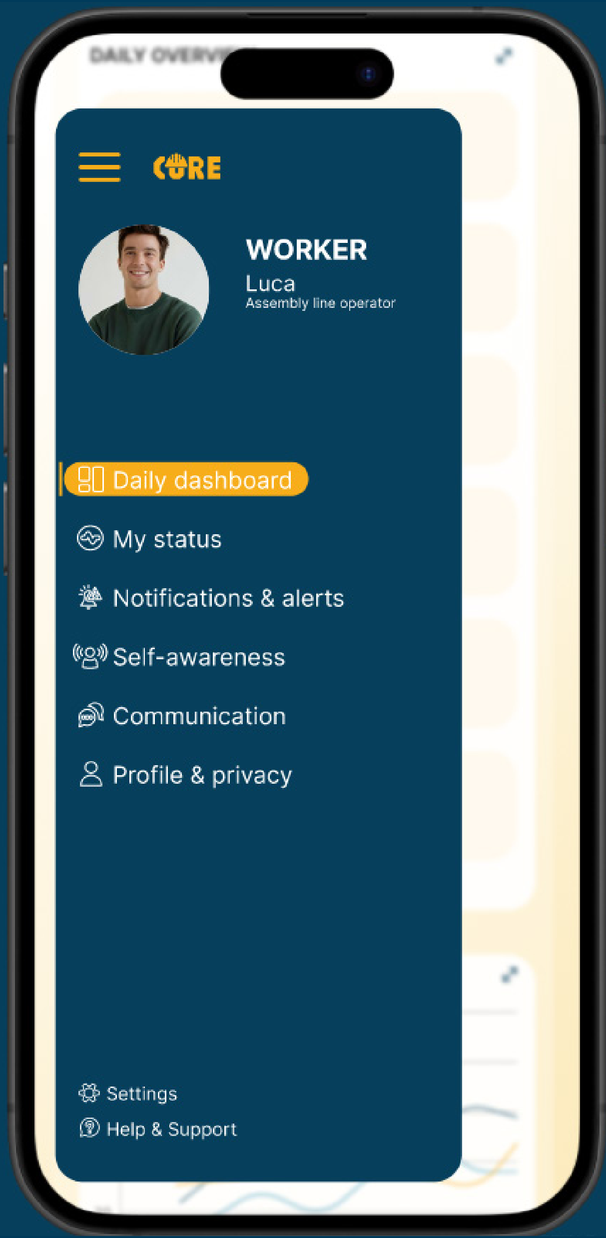

CORE
SUPERVISOR
Switch to personal profile
Francesco
Production supervisor
General dashboard
Team status
Alerts & incidents
Analytics & trends
Area & task monitoring
Profile & privacy
Settings
Help & Support
GENERAL DASHBOARD
System-level view: aggregated indicators by area, no rankings of individuals
Shift: 14:30-18:30
Area: Zone B
INCIDENTS BY MONTH
INCIDENT OVERVIEW THIS MONTH
DEPARTMENT AREA
12% Line A
26% Line C
44% Line B
16% Maintenance
RESOLUTION TIME
24 Average resolution time for L3 incidents
12 Average resolution time for L2 incidents
3 Average resolution time for L1 incidents
WORK SHIFT
74% During the MORNING SHIFT
26% During the AFTERNOON SHIFT
RESOLVED VS OPEN
3 resolved
1 open
INCIDENT SEVERITY
58%
Level 1
28%
Level 2
14%
Level 3
TOTAL NUMBER OF INCIDENTS PER MONTH
8
6
4
2
4 in Feb
Mostly because of non-compliance with safety procedures
5 in Jun
Mostly because of extreme temperatures
8 in Sep
Mostly because of lack of preventive maintenance
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

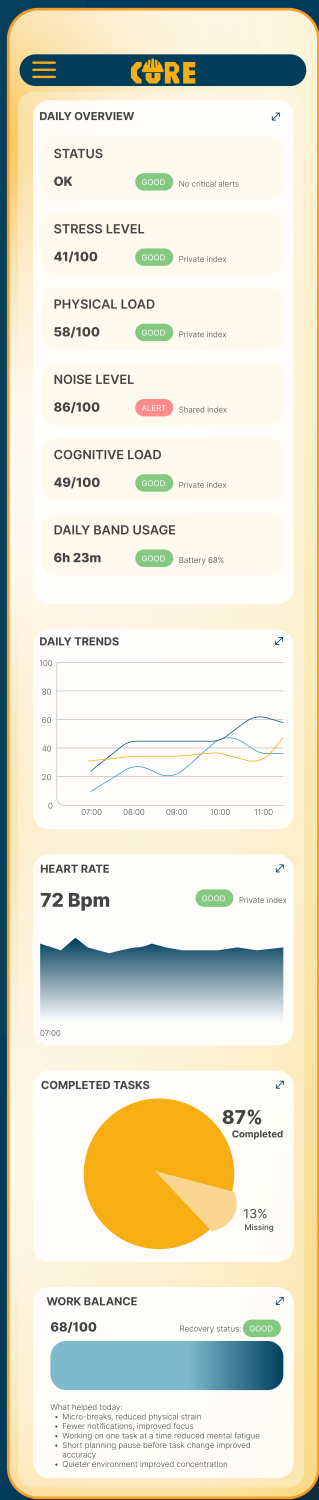

CORE
SUPERVISOR
Switch to personal profile
Francesco
Production supervisor
General dashboard
Team status
Alerts & incidents
Analytics & trends
Area & task monitoring
Profile & privacy
Settings
Help & Support
TEAM STATUS
Quick scan of who might need support, with minimal personal detail
Shift: 14:30-18:30
Area: Zone B
PERSONNEL MANAGEMENT
WORKER
ROLE & AREA
PHYSICAL LOAD
COGNITIVE LOAD
SUPPORT STATUS
WEARABLE
Sara Greco W100 | Team lead Line A-Station 5 | 35/100 | 46/100 | OK Last check-in: 1h 10m | 80%
Giuseppe Serra W101 | Maintenance Line C-Station 1 | 48/100 | 57/100 | OK Last check-in: 12m | 56%
Marco Bianchi W102 | Assembler Line B-Station 2 | 66/100 | 15/100 | OK Last check-in: 2h 5m | 70%
Alessandro Costa W103 | Team lead Line C-Station 5 | 25/100 | 65/100 | OK Last check-in: 30m | 32%
Gianni Conti W104 | Assembler Line A-Station 3 | 54/100 | 44/100 | OK Last check-in: 1h | 97%
Luca Rossi W105 | Assembler Line B-Station 7 | 66/100 | 32/100 | OK Last check-in: 2h 13m | 26%
Sofia Fioretti W106 | Maintenance Maintenance bay | 23/100 | 65/100 | OK Last check-in: 24m | 55%
Giulio Derti W107 | Assembler Line C-Station 8 | 65/100 | 44/100 | OK Last check-in: 24m | 25%
Mario Verdi | Assembler | OK | 33%
SUPPORT VIEW
ACTIVE WORKERS 45 GOOD Wearable connected
BATTERY LOW 6 WARN Below 25%
CHECK-IN PENDING 4 WARN No update > 2h


CORE
SUPERVISOR
Switch to personal profile
Francesco
Production supervisor
General dashboard
Team status
Alerts & incidents
Analytics & trends
Area & task monitoring
Profile & privacy
Settings
Help & Support
ALERT & INCIDENTS
Real-time alerts, incident log, and recurring patterns by area/task
Shift: 14:30-18:30
Area: Zone B
INCIDENT LOG
ID/TIME
TYPE & PLACE
CAUSE
STATUS
INC-2025-12-12 2025-12-28 · 08:39 | Recordable Line C-Station 5 | Cause Tool misuse | Investigating Lost days: 0
INC-2025-12-12 2025-12-27 · 17:23 | Firts aid Line B-Station 7 | Cause PPE misuse | Investigating Lost days: 0
INC-2025-12-11 2025-12-27 · 16:25 | Firt aid Line A-Station 5 | Cause Obstruction | Closed Lost days: 0
INC-2025-12-11 2025-12-27 · 14:14 | Near miss Line C-Station 1 | Cause PPE misuse | Open Lost days: 0
INC-2025-12-11 2025-12-26 · 10:27 | Near miss Maintenance bay | Cause Slip/trip | Open Lost days: 0
INC-2025-12-10 2025-12-23 · 13:21 | Recordable Line A-Station 3 | Cause Contact with moving part | Open Lost days: 0
INC-2025-12-09 2025-12-23 · 08:29 | Recordable Line C-Station 8 | Cause Noise/distraction | Open Lost days: 0
INC-2025-12-09 2025-12-22 · 09:11 | Near miss Line B-Station 2 | Cause Tool misuse | Caused Lost days: 0
INC-2025-12-07 | First aid | Cause | Closed
ALERTS - 2025
TOTAL INCIDENTS 124 WARN Year total
OPEN/INVESTIGATING 25 ALERT Requires follow-up
NEAR MISSES 48 GOOD Reporting indicator

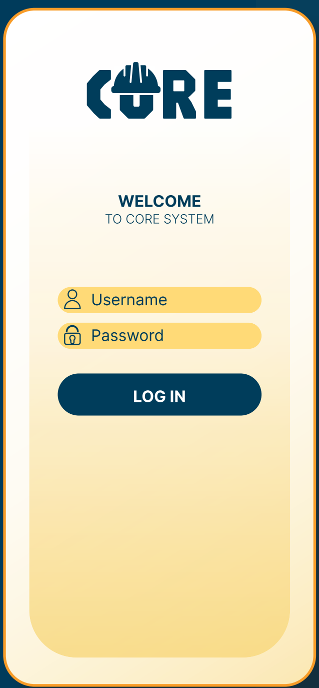

SUPERVISOR
Francesco
General dashboard
Team status
Alerts & incidents
Analytics & trends
Area & task monitoring
Profile & privacy
Settings
Help & Support
GENERAL DASHBOARD
Shift: 14:30-18:30
Area: Zone B
DAILY OVERVIEW
INCIDENTS
182
LTIFR
13.4
SEVERITY RATE
71.2
LOST-TIME INJURIES
9
OPEN HAZARDS
11
AUDIT COMPLETION
91%
INCIDENTS BY MONTH
INCIDENT DENSITY
INCIDENTS BY PLACE
WORKER
Luca
My status
Notifications & alerts
Self-awareness
Communication
Profile & privacy

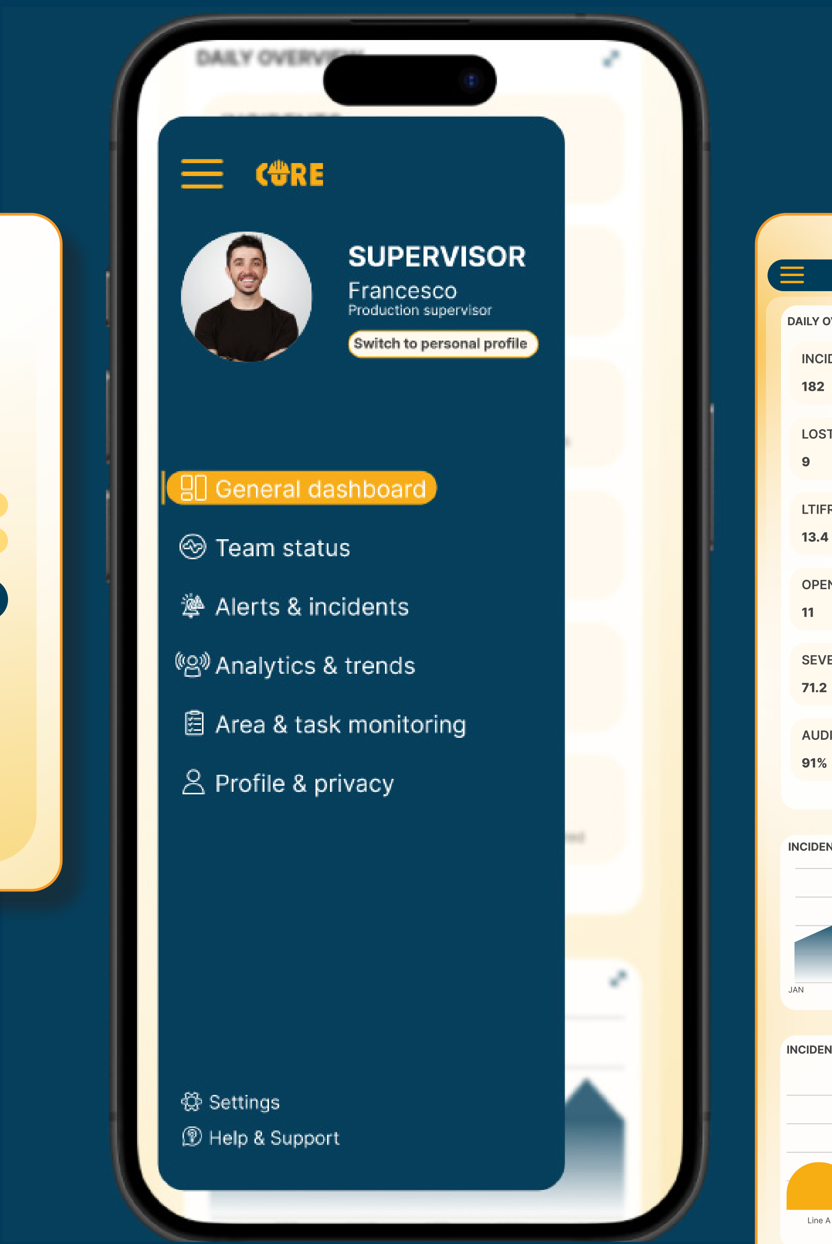

CORE
WELCOME
TO CORE SYSTEM
Username
Password
LOG IN

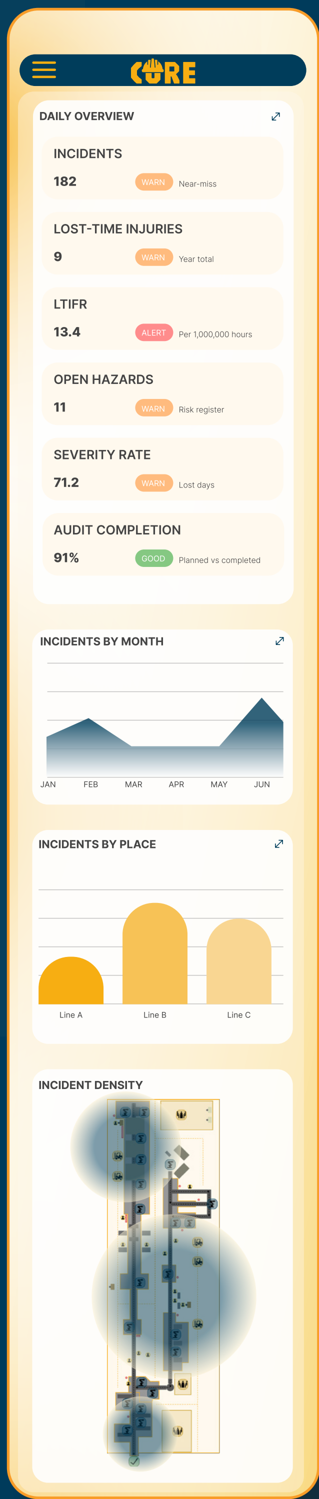

CORE
WORKER
Luca
Assembly line operator
Daily dashboard
My status
Notifications & alerts
Self-awareness
Communication
Profile & privacy
Settings
Help & Support

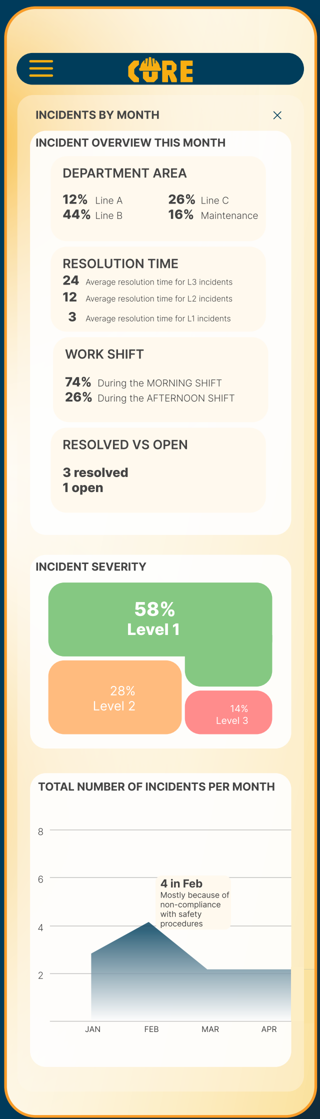

CORE
DAILY OVERVIEW
STATUS
OK
GOOD
No critical alerts
STRESS LEVEL
41/100
GOOD
Private index
PHYSICAL LOAD
58/100
GOOD
Private index
NOISE LEVEL
86/100
ALERT
Shared index
COGNITIVE LOAD
49/100
GOOD
Private index
DAILY BAND USAGE
6h 23m
GOOD
Battery 68%
DAILY TRENDS
100
80
60
40
20
0
07:00
08:00
09:00
10:00
11:00
HEART RATE
72 Bpm
GOOD
Private index
07:00
COMPLETED TASKS
87%
Completed
13%
Missing
WORK BALANCE
68/100
Recovery status:
GOOD
What helped today:
Micro-breaks, reduced physical strain
Fewer notifications, improved focus
Working on one task at a time reduced mental fatigue
Short planning pause before task change improved accuracy
Quieter environment improved concentration

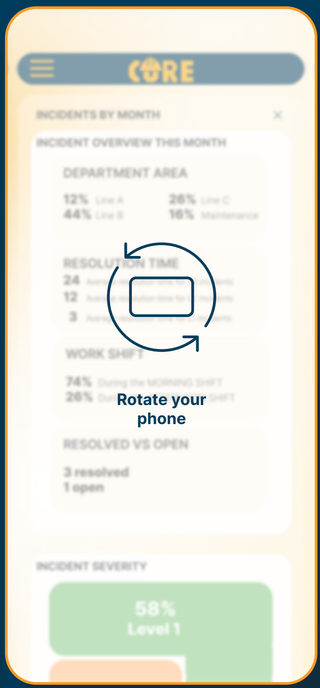

CORE
HEART RATE
Most recent
72 Bpm
GOOD
No critical alerts
Baseline
70 Bpm
GOOD
No critical alerts
Resting rate
60 Bpm
GOOD
No critical alerts
90
60
40
82 Bpm
08:53
Due to ambient temperature
07:00
08:00
09:00
10:00
Hrv
Trend
Normal range min
Hrv Normal range max
Rotate your phone
87 Bpm
11:59
Due to mental focus on the task
70 Bpm
15:36
Due to insufficient breaks
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00

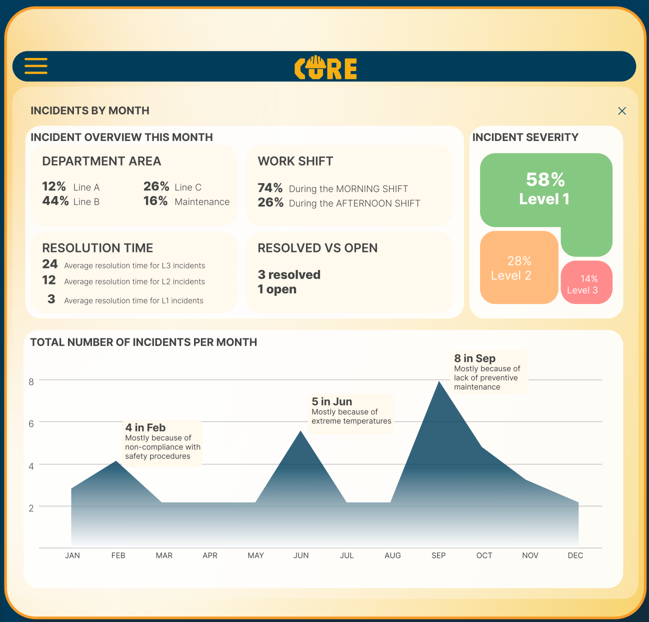

WELCOME
TO CORE SYSTEM
Username
Password
LOG IN


SUPERVISOR
Francesco
Production supervisor
Switch to personal profile
General dashboard
Team status
Alerts & incidents
Analytics & trends
Area & task monitoring
Profile & privacy
Settings
Help & Support


DAILY OVERVIEW
INCIDENTS
182
WARN
Near-miss
LOST-TIME INJURIES
9
WARN
Year total
LTIFR
13.4
ALERT
Per 1,000,000 hours
OPEN HAZARDS
11
WARN
Risk register
SEVERITY RATE
71.2
WARN
Lost days
AUDIT COMPLETION
91%
GOOD
Planned vs completed
INCIDENTS BY MONTH
JAN
FEB
MAR
APR
MAY
JUN
INCIDENTS BY PLACE
Line A
Line B
Line C
INCIDENT DENSITY


CORE
INCIDENTS BY MONTH
INCIDENT OVERVIEW THIS MONTH
DEPARTMENT AREA
12% Line A
44% Line B
26% Line C
16% Maintenance
RESOLUTION TIME
24 Average resolution time for L3 incidents
12 Average resolution time for L2 incidents
3 Average resolution time for L1 incidents
WORK SHIFT
74% During the MORNING SHIFT
26% During the AFTERNOON SHIFT
RESOLVED VS OPEN
3 resolved
1 open
INCIDENT SEVERITY
58% Level 1
28% Level 2
14% Level 3
TOTAL NUMBER OF INCIDENTS PER MONTH
4 in Feb
Mostly because of non-compliance with safety procedures
JAN
FEB
MAR
APR

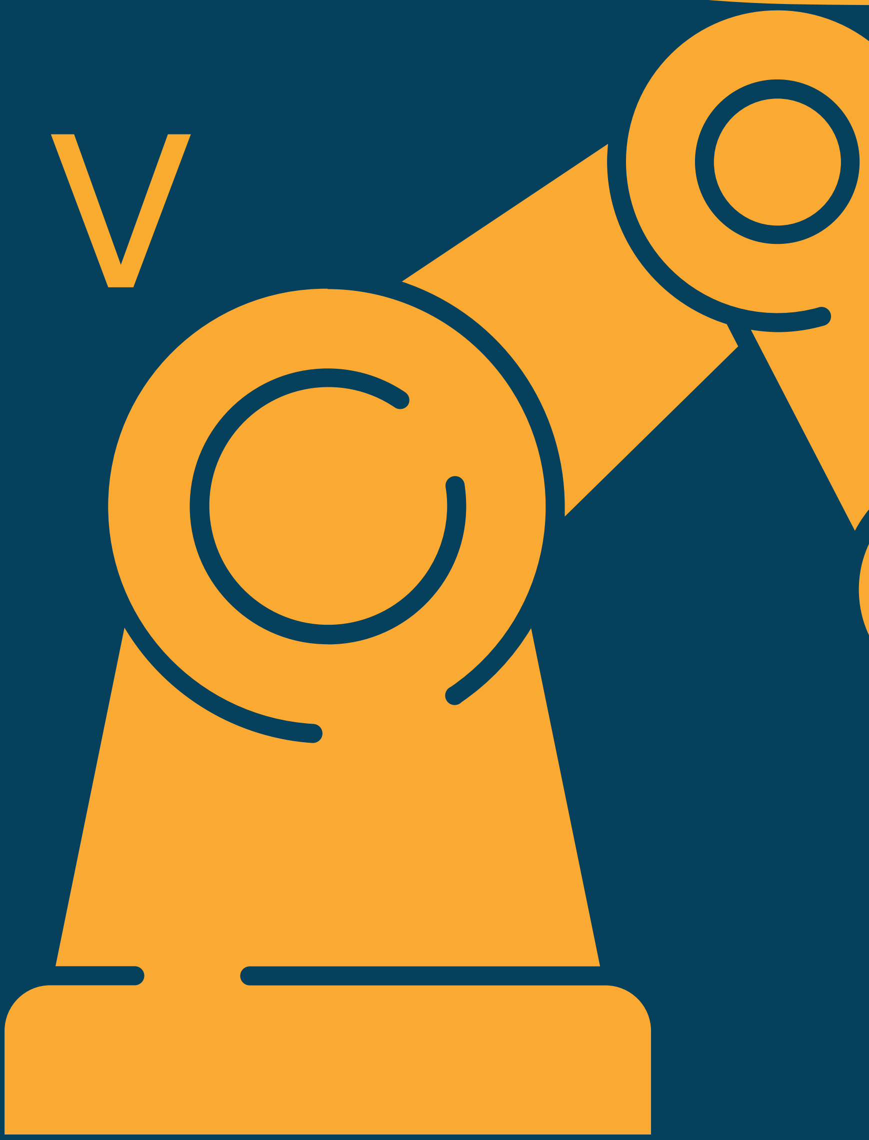

Rotate your phone


CORE
INCIDENTS BY MONTH
INCIDENT OVERVIEW THIS MONTH
DEPARTMENT AREA
12% Line A
44% Line B
26% Line C
16% Maintenance
WORK SHIFT
74% During the MORNING SHIFT
26% During the AFTERNOON SHIFT
RESOLUTION TIME
24 Average resolution time for L3 incidents
12 Average resolution time for L2 incidents
3 Average resolution time for L1 incidents
RESOLVED VS OPEN
3 resolved
1 open
INCIDENT SEVERITY
58% Level 1
28% Level 2
14% Level 3
TOTAL NUMBER OF INCIDENTS PER MONTH
4 in Feb
Mostly because of non-compliance with safety procedures
5 in Jun
Mostly because of extreme temperatures
8 in Sep
Mostly because of lack of preventive maintenance
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC


16:25
General status
OK
No critical alerts
Cognitive load
49
Physical load
53
16:25
L2 ALERT
Posture cue: fatigue
risk detected
Suggestions
Help


CORE
16:25
Back
CORE
16:25
Back
Notifications
13:13
Posture cue
Shoulder elevation
11:45
Focus support
10:06
Micro-break
Sustained repetition
09:20
Posture cue
PPE misuse

PART V



EVALUATION AND CONCLUSIONS

TWELFTH CHAPTER
Conclusions

12.1 How the project addresses the identified needs

The project responds to the identified needs from the research phase by creating an **integrated ecosystem**. This ecosystem includes the Core Band, a wearable device, and the Core System, which is the platform for data analysis and management that can be used both by desktop or smartphone. The research highlighted consistent issues, such as communication delays, the use of separate safety tools, limited understanding of physical and mental health, and a g**eneral lack of systems perceived as supportive rather than controlling.**

Core Band is intended to assist workers in their day-to-day activities. This is achieved through the **constant, non-intrusive communication** of their mental and physical well-being, as well as the detection of dangerous situations that may occur. It is important to note that the design, interaction, and communication are all simple. This is to ensure that the work process is not interrupted, yet awareness is communicated quickly and effectively when the need arises. The device is designed to support **both proactive and reactive safety measures**, depending on the needs of the individual as they go about their workday.

Core System, on the other hand, splits in two to provide a general view of the data collected from core bends and associated artifacts. The main task of the system is to have a focus on patterns, trends and environmental context instead of focusing on the study of the individual. This is very important as it meets the safety management requirements while also respecting the autonomy and independence of workers.

12.2 Potential impacts on safety and cognitive workload

The proposed system enables a paradigm **shift in workplace safety** by making a change from reactive, event-driven management to proactive, condition-based management. By integrating environmental variables with psycho-physical measures, the system discovers repeating patterns of stress and strain not normally identified. This longitudinal approach promotes a **culture of anticipation rather than compliance** by ensuring safety interventions are determined by changing trends and not one-off incidents.

The project is intended to prevent adding more mental demands to already complex work environments from the standpoint of cognitive workload. Core Band reduces the need for visual attention or conscious input during task execution by restricting interaction to necessary feedback and passive data collection. Dashboards are designed to **support comprehension without information overload** by giving temporal trends and aggregated views precedence over raw data. The system supports safety management while accommodating the cognitive limitations of both employees and supervisors by dispersing information among various user roles and levels of detail.

12.3 Alignment with Industry 5.0 principles

The project, therefore, takes **a human-centered approach to technology integration i**n a manufacturing environment, making it an embodiment of Industry 5.0. The project focuses on the well-being, flexibility, and quality of interaction between humans and digital tools, rather than just focusing on efficiency. It does not impose a workflow but rather incorporates Core Band and Core System as **enablers that can be adapted** to different users.

The focus on mental and physical well-being can be linked to Industry 5.0's focus on creating strong, sustainable, and resilient industries. In this scenario, CORE creates an environment that values individual differences and limitations, as well as promoting prevention, awareness, and informed decisions. The ability to **effectively manage data, therefore, adds to ethical issues such as acceptance and trust.**

All things considered, the project shows how design can put Industry 5.0 principles into practice in a practical setting. A balanced approach to innovation in modern manufacturing contexts is provided by the integration of wearable technology and data platforms, which demonstrates how safety, **well-being, and organizational needs can coexist within a single system.**

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