European Agency for Safety and Health at Work

Advanced robotic automation: comparative case study report

Summary

European Agency for Safety and Health at Work

Safety and health at work is everyone's concern. It's good for you. It's good for business.

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Introduction

This document summarises the results of 11 case studies on the implementation of artificial intelligence (AI)-based systems and advanced robotics for the automation of tasks, including cognitive automations. For this purpose, a questionnaire and an interview guide were developed and sent out to companies that are using such systems for the automation of tasks. This allowed gathering insight on the type of technology they use, their implementation process, and the system's impact on occupational safety and health (OSH). Out of 16 cases that were identified, nine companies agreed and were selected for further in-depth interviews, resulting in 11 case studies (ID1-ID11), while for the remaining, 5 short case studies (ID12-1D16) were developed. This report presents the summary and key findings of a comparative report based on the 11 case studies (ID1-ID11). In addition, five policy briefs were developed.

Methodology

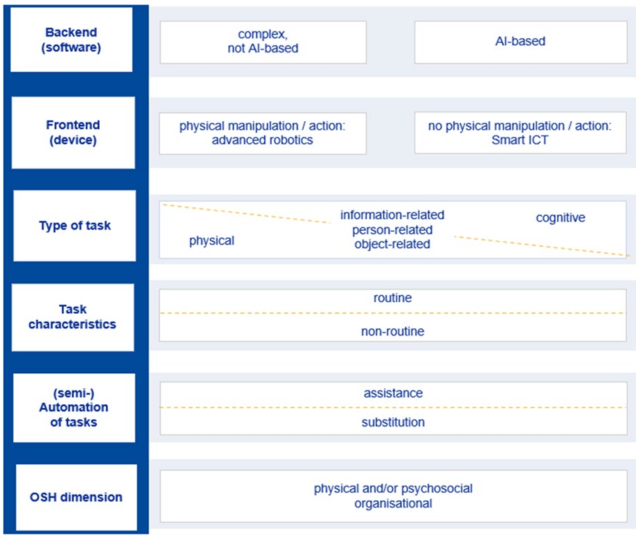
For this work, an initial assessment questionnaire was developed. It contained four multiple choice and 16 open format questions regarding the technology a company uses and what type of task it automates, as well as OSH risks and opportunities. The research team identified potential candidates through desk research and contacted them to inquire about their participation in the project. Companies were then sent a questionnaire to complete on their own time. These answers formed the basis of 16 cases. Out of these, 9 were invited and agreed to participate in the development of 11 detailed case studies (ID1-ID11), while for the remaining cases, 5 short case studies were developed (ID12-ID16). The interviews were targeted at workers in the following positions (or their equivalent in any given company): management, health and safety engineer, data protection officer, worker/workers council member and technical engineer. The interview guideline had three major sections. Section one covered the general information on the company and their implementation process with a total of seven questions, section two addressed the automated task with six questions and the final section addressed the OSH impact of the system. The interview guideline was translated into three languages. Each interview had a duration of 1-1.5 hours and was performed with the written consent of the participants. The answers were completely anonymised. Based on the interview results, detailed case studies were developed. To better contextualise their answers, the taxonomy developed by the European Agency for Safety and Health at Work (EU-OSHA) [1] was used. These 11 case studies (ID-1-ID11) form the basis of a comparative report, which presents the most important collective findings of the case studies. It also formulates recommendations for the successful implementation of advanced robotics or AI-based systems and their impact on OSH. Finally, five topics of interest were identified to be transferred into policy briefs.

[1] EU-OSHA – European Agency for Safety and Health at Work, *Advanced robotics, artificial intelligence and the automation of tasks: definitions, uses, policies and strategies and Occupational Safety and Health*, 2022. Available at: https://osha.europa.eu/en/publications/advanced-robotics-artificial-intelligence-and-automation-tasks-definitions-uses-policies-and-strategies-and-occupational-safety-and-health

Taxonomy for AI-based systems and the automation of tasks

It is not only technologies themselves affecting OSH on potentially different levels. It is also the use of AI-based systems for the automation of tasks that are either physical or cognitive that creates new or changes in existing working systems. In order to provide meaningful advice for prevention, policy and practice regarding AI-based systems and advanced robotics in the workplace, the three dimensions — i.e. physical, psychosocial and organisational safety and health — are included. Non-AI-based robotic systems are also included, as many advanced robotics that can be found already operate without AI. The specific OSH-related challenges and opportunities associated with these systems have been discussed in previous reports published by EU-OSHA.[2,3]

Figure 1: Taxonomy for AI-based systems and advanced robotics for the automation of tasks



Overview of the case studies

A total of nine companies participated in the case study interviews, providing a total of 11case studies. They are primarily located in Europe, however, many participants operate internationally, and one case study refers to a company located in the United States. Two large companies contributed with two case studies each, since those were distinct technologies, automating different tasks.

Based on the above taxonomy developed by EU-OSHA and further analysis, Table 1 presents a short overview on the companies and key descriptive information on them. Below, each case study is described in more detail, however, a complete description is included in each referenced case study's full document.

Overview of case studies

This section contains an overview of 11 case studies that were developed based on the information collected through the interviews with all different stakeholders. Table 1 presents general information on the case study companies, whereas Table 2 provides the categorisation along the presented taxonomy. The companies and systems are presented anonymously. A unique identifier (CS-ID +number) is used to name and distinguish the case studies in a uniform way.

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[2] EU-OSHA – European Agency for Safety and Health at Work, *Cognitive automation: implications for occupational safety and health*, 2022. Available at: https://osha.europa.eu/en/publications/cognitive-automation-implications-occupational-safety-and-health

[3] EU-OSHA – European Agency for Safety and Health at Work, *Advanced robotics and automation: implications for occupational safety and health*, 2022. Available at: https://osha.europa.eu/en/publications/advanced-robotics-and-automation-implications-occupational-safety-and-health

Table 1: Overview of participating companies, technology and tasks automated

UC-ID	Company	Country	Sector*	Size**	Technology	Task
1	Automotive and industrial supplier	Slovenia	Manufacturing	Large	Advanced robotic system	Lifting work pieces for inspection
2	Automation integrator	Sweden	Manufacturing	Medium	AI–robot hybrid sawmill	Quality control and physical handling of lumber
3	Energy and automation company	Germany	Manufacturing	Large	Advanced robotic system + AGVs[4]	Assembly task + material delivery
4	Energy and automation company	Germany	Manufacturing	Large	AI	X-ray-based product inspection
5	Automotive supplier	Portugal	Wholesale and retail trade; repair of motor vehicles and motorcycles	Large	Advanced robotic system	Sewing bags
6	Vehicular automation start-up	USA	Construction	Small	AI	Trenching, via automated excavator
7	Technology developer	Denmark	Electricity, gas, steam and air conditioning supply	Large	AI–robot hybrid	Image analysis and pick and place
8	Government research facility	Germany	Professional, scientific and technical activities	Large	AI	Image analysis of hazardous substances
9	Oncological centre	Germany	Human health and social work activities	Large	AI	Video feature analysis
10	Gas infrastructure operator	Norway	Electricity, gas, steam and air conditioning supply	Large	Advanced robotic system	Gas vessel inspection
11	Agricultural technology developer	Netherlands	Agriculture	Large	Advanced robotic system	Manure cleaning

[4] Autonomous guided vehicles

Table 2: Taxonomy-based categorisation of the case studies

ID	Backend (Software)	Frontend (Device)	Type of task	Task characteristics	(semi-) automation of task	OSH dimensions
1	Complex, not AI-based	Physical manipulation	Physical: Object-related	Routine	Substitution	Physical & Organisational
2	AI-based	Physical manipulation	Physical: Object-related	Routine	Substitution	Physical & Organisational
3	AI-based	No physical manipulation	Cognitive: Object-related	Routine	Assistance	Psychosocial
4	Complex, not AI-based	Physical manipulation	Physical: Object-related	Routine	Assistance	Physical & Psychosocial
5	Complex, not AI-based	Physical manipulation	Physical: Object-related	Routine	Substitution	Physical & Organisational
6	AI-based	Physical manipulation	Physical: Object-related	Routine	Assistance & substitution	Physical
7	AI-based	Physical manipulation	Cognitive: Object-related	Routine	Substitution	Physical & Organisational
8	AI-based	No physical manipulation	Cognitive: Person-related	Routine	Assistance	Psychosocial
9	AI-based	No physical manipulation	Cognitive: Information-related	Routine	Assistance	Psychosocial
10	Complex, not AI-based	Physical manipulation	Physical: Object-related	Routine	Substitution	Physical & Organisational
11	Complex, not AI-based	Physical manipulation	Physical: Object-related	Routine	Substitution	Physical & Psychosocial

Overview of the policy brief contents

The following policy briefs were developed based on the findings from the use examples and cases.

Implementing advanced robotics and AI-based systems for task automation: Drivers, barriers and recommendations

Based on the experiences of companies that have already successfully introduced advanced robotics or AI-based systems for the automation of tasks (including cobots and cognitive automations) into their workplace, taking early initial steps can facilitate success in the long run. Accumulating barriers and drivers from different countries as well as different sectors can also allow one to identify underlying, transferable driver and/or drivers from which a wide range of other companies can benefit.

Significant drivers for the implementation of advanced robotics and AI-based systems are:

- motivated workforce;
- exchange of expertise between companies, universities and other stakeholders;
- first-hand experience; and
- early worker involvement.

Identified barriers for the implementation of advanced robotics and AI-based systems are:

- worker resistance;
- lack of European focus; and
- mismatch between technology and regulations.

Facilitating acceptance of AI-based systems in the workplace and minimising organisational impact

Organisational adjustments can help facilitate this process and possibly increase the rate of success. This is of interest for OSH for a number of reasons. There are numerous approaches to and theories on change management. Different companies follow different approaches for internal and external reasons. Hence, addressing each approach on a granular level would reduce applicability of the insight gained from interviewing several companies on their experiences with the implementation process of advanced robotics and AI-based systems.

Organisational steps taken to support their workers during the implementation of AI-based systems or advanced robotics for the automation of tasks differ from company to company. However, two elements are seen to have significant impact on the success of an implementation. The first has to do with the measures taken to provide guidance to the workers during the implementation period to address any rising concerns. Addressing this through additional, targeted support and guidance for workers has been prioritised by many interviewed companies. These measures include additional training, to upskill or reskill workers, seminars on how the system works to illustrate that the robot is not intended to cause any job loss, but rather move workers into better workspaces, and in some cases, the provided guidance includes one-on-one conversations to address specific fears.

The second is using the introduction of an AI-based system or advanced robotic system to restructure the workplace for OSH benefits. This can target production cycles, workers' shift cycles or even night shifts. Another important factor to consider is the social impact the technology can have within a company. While the impact that the technology can have on workers and their surroundings is often primarily assessed with regard to the task to be automated, it can also impact the social structure of a company. Frequently, concerns of social isolation are brought up. However, based on the case studies' experiences, this concern could not be confirmed. The second phenomenon is related to the inclusion of advanced robotic systems or AI-based systems into the social structure of a workplace. There are incidences, where the acceptance towards the systems has become so high, that workers have assigned the individual systems names and address them as such. This is seen as an indicator of high acceptance and trust and low negative attitude or fear towards the technology.

Another organisational factor to be considered is the monitoring for arising OSH risks. It is possible that not all OSH risks are noticeable before or during the implementation. Therefore, companies must continue to monitor for new OSH risks and regularly update the associated risk assessment. One approach followed is conducting workplace inspections that are carried out by work safety specialists and possibly a technology specialist on a regular basis to identify possible new threats, based on time-dependent factors like wear. Several companies create specialised worker feedback systems through which employees are able to alert any changes or concerns based on their first-hand experience with the system. While all companies agreed that some form of OSH risk monitoring with autonomous systems is important, they also highlighted that these monitoring measures need to be in line with the right for privacy of their workers.

Advanced robotics and AI-based systems in the workplace: OSH challenges and opportunities originating from actual implementations

New technologies in the workplace create both challenges and opportunities for OSH. Advanced robotics and AI-based systems for the automation of tasks are no exception, allowing adding nuance to these insights. The versatility in advanced robotics and AI-based systems is one of their most well-known characteristics. They can be used in a wide range of workplaces, supporting and automating numerous tasks, either physical or cognitive. Each individual case study can come with challenges and opportunities specific to their scenario, and those need to be addressed on an individual basis. However, there are several repeatedly occurring OSH challenges and opportunities when it comes these technologies. Opportunities include the reduction of physical workload, improvement of physical health and workplace safety, a reduction of cognitive load, improved wellbeing, increased task variety, reduction of monotony, the chance for upskilling, more job and time control, a more inclusive workplace, less time behind a screen and more social interaction at the workplace. Risks and challenges arise from the fear of job loss, increased cognitive workload, task consolidation, the residual physical risks, fear towards the technology, demographic changes in the workforce and deskilling.

Automating cognitive tasks in the workplace using AI-based systems: Cases and recommendations

When integrating AI-based systems several factors can contribute to the success or failure of the implementation. Many AI-based solutions are often custom-fit, to the specific task and environment in which they perform. Companies looking to automate a task via an AI-based system should first assess the suitability of said task to be automated and the system they intend to use. The provided examples have in common that the companies trained their systems themselves, or provided the data on which the integrator trained the system. One potential challenge related to training any AI-based system can be found in the over-representation or under-representation of specific cases within the training data that creates biased conclusions. By creating and training on their own indexed data, companies have more control and can assess the data for bias. This however does not necessarily fully protect them from unconscious bias. The potential consequences of biased training data can be severe, especially if an AI is involved in processes affecting a person’s wellbeing (e.g. medical decision support systems) or personal development (e.g. human resources).

Automating physical tasks using ai-based systems in the workplace: Cases and recommendations

The implementation process can be just as diverse, with different strategies being the most efficient for different companies. Which parties are involved and to what extent not only depends on the company size but also on the level of experience with advanced technological systems. While some companies develop in-house solutions, others use third-party suppliers and customise those robots to their needs. It is therefore challenging to try and create a standard list of implementation steps to follow for every company, rather that providing some general recomendations, while a case by case approach would be more appropriate.

Key findings of the comparative report

Motivators and goals

A key finding of the project presents itself in relation to the case studies’ motivators and goals and OSH. The vast majority of case studies implemented the AI or the robotic system with the explicit intention to improve OSH at their workplace. Other goals were financially motivated or because the system allowed workers to restructure aspects of the company.

Task automation

While the literature indicates that the majority of AI and robotic applications are researched in the human healthcare and social work sector, the case studies did not reflect these findings. The companies that participated in the development of the case studies and case studies consist of a diverse set operating in different sectors. It must be noted that due to the small sample size this could not be considered as representative of the actual distribution in Europe. However, when looking at the type of task that gets automated by the systems we see predominantly physical object-related tasks, followed by cognitive information-related tasks and cognitive object-related tasks. Furthermore, one cognitive person-related task was also automated. All the systems considered in the case studies were employed in routine work.

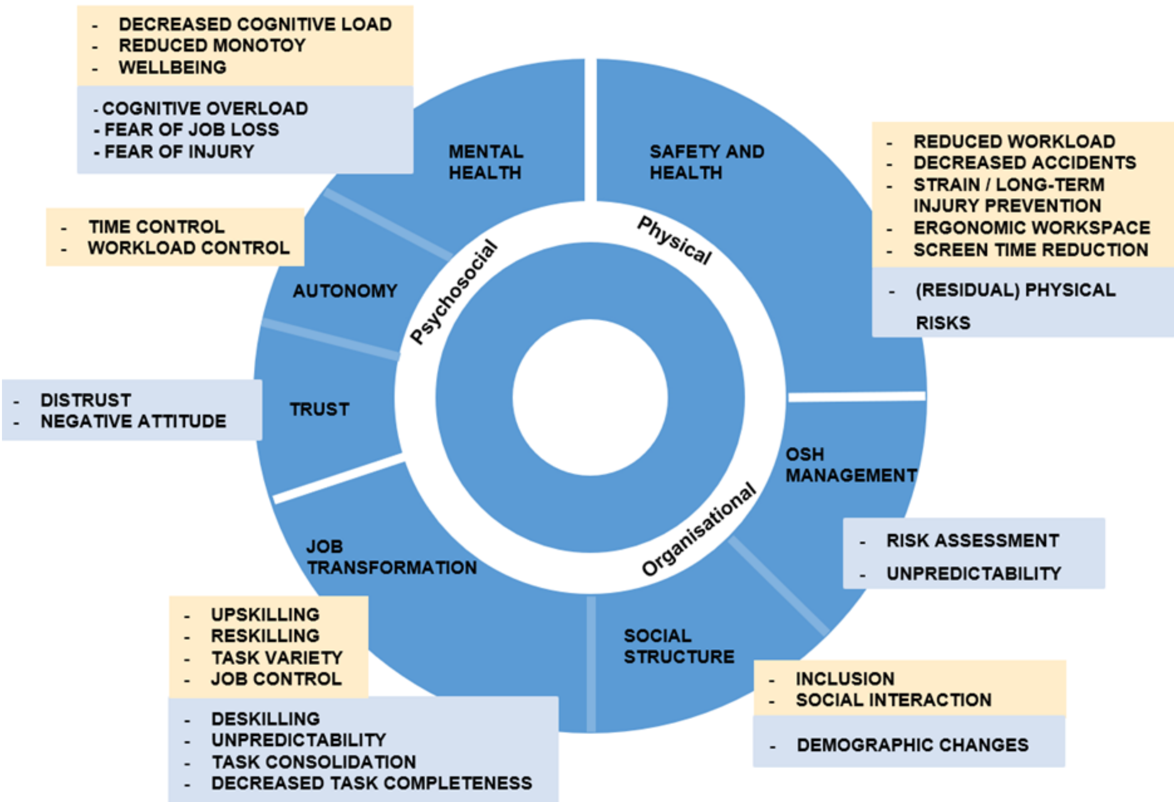
Difficulties and challenges

Companies encounter difficulties and challenges during the implementation in three main areas. Technology-related difficulties include the lack of available systems and problems of integrating new technology in an old production line. Human-related difficulties arise from worker resistance. Organisational-related difficulties are encountered on the financial site of the implementation, time constraints, lack of experience and matching the technology to current safety standards.

OSH challenges and opportunities

The companies list a number of OSH challenges and opportunities in relation to the implementation of an AI-based system or an advanced robotic system. Figure 2 illustrates these factors.

Figure 2: Overview of OSH challenges and opportunities



Comparison of AI-based systems and advanced robotics

The analysis of the case studies highlights that the commonly seen barrier of AI being used to automate only cognitive tasks without a physical component and robotic systems to perform only physical tasks is becoming increasingly blurry. Many advanced robotic systems incorporate AI into their working mechanisms and create hybrid systems with a wider range of capabilities. This also results in increasingly fewer challenges and opportunities being unique to only one type of technology.

Regarding AI-based systems for cognitive automation, there are generally fewer OSH concerns reported. One reason for this could be that many AI-based systems operate almost invisibly or indistinguishably from hard-coded software for the worker. In addition, many of the AI-based systems described in the case studies were developed internally by the companies themselves, hence, they had significant control over the system. Regarding such AI-based systems it is also important to note that the concern that a machine might change its behaviour during active work could not be confirmed by the case study. The AI-based systems identified were trained in advance, and typically do not continue learning during active operation. There are instances where the system is retrained, however the update would also not happen during active operation, and the worker would be informed of major updates.

Regarding advanced robotic systems for the automation of tasks, as soon as there is automation of physical tasks, physical OSH concerns are brought up. However, all case studies that use such technologies agree that the benefits a worker will have from using the system outweigh residual risks.

A concern brought up in the context of both the automation of physical and cognitive tasks is deskilling. The case studies confirmed that singular instances of deskilling can occur, however these are conscious choices by the company to no longer train a certain skill, as the technology has rendered it redundant, and it is assessed to be irrelevant for the workers' future. On the other hand, there are case studies that are acutely aware that the manually performed version of a task can hold unique qualities compared to the automated, hence they insist that the original skill is upheld. Regardless of the type of automation, all systems come with some form of reskilling or upskilling for workers.

Recommendations for the implementation of AI-based or advanced robotic systems

Throughout the interview process a number of recommendations for the successful implementation of AI-based systems or advanced robotics could be extracted.

Early worker involvement can be facilitated by a number of methods from a company. Some companies do so by providing access to test devices, information, and training on processes related to digitalisation, AI-based systems and advanced robotics to workers regardless of their job position. This type of early worker engagement has led to an increase in acceptance for new systems, and an overall positive attitude towards the subject of task automation. It was also associated with reduced overall inhibitions towards modern technology.

Early worker involvement goes hand in hand with a functional communication strategy. Empirical research supports the companies' experience that having a formal communication avenue while introducing a change initiative reduced uncertainty and enhanced commitment.[5,6] Communicating future changes to employees can reduce feelings of uncertainty towards the rationale behind the change. Furthermore, clear and direct communication has been found to promote supportive behaviour to

[5] Bordia, P., Hobman, E., Jones, E., Gallois, C., & Callan, V. J. (2004). Uncertainty during organizational change: Types, consequences, and management strategies. *Journal of Business and Psychology, 18*, 507-532. https://doi.org/10.1023/B:JOBU.0000028449.99127.f7

[6] Hobman, E. V., Bordia, P., & Gallois, C. (2004). Perceived dissimilarity and work group involvement: The moderating effects of group openness to diversity. *Group & Organization Management, 29*(5), 560-587. https://doi.org/10.1177/1059601103254269

change from workers.[7] All these findings in literature were reconfirmed by the information collected for the development of the case studies through the interviews. Having both personal (e.g. team lead) and anonymous (e.g. feedback box, or via workers council representative) communication systems have been described as helpful to receive worker feedback and create conversation around relevant topics.

The relative novelty of advanced robotic systems in the workplace is accompanied by a workforce inexperienced in how to interact with them. To reduce unfamiliarity in the interaction, system designers should orient themselves with established interaction design principles, one of them being the EN ISO 9241-110. The standard contains seven interaction principles for human–technology interaction called suitability for the user's tasks, self-descriptiveness, conformity with user expectations, learnability, controllability, use error robustness and user engagement. They can be used to design and evaluate human–robot interaction[8] and human–computer interaction as well.

Similarly to worker involvement, consideration of OSH implications and involvement of the person responsible for OSH at the workplace level should start as early as possible during the implementation. Including consideration as early as the design process of a system (if possible) can help maximise the positive OSH impact the system has in the long run. In addition, this approach reduces the amount of adjustments that are needed later in the process. One way to involve OSH early in the process is by including OSH experts, however some case studies have also identified a positive effect when they consulted their workers for any OSH-related concerns they might have about a system, before the system is implemented. This allowed companies not only to address concerns that were unfounded, it also enabled them to take active measures to make the system match the operators' expectation of OSH.

[7] Kozak, M., Kozak, S., Kozakova, A., & Martinak, D. (2020). Is fear of robots stealing jobs haunting European workers? A multilevel study of automation insecurity in the EU. *IFAC-PapersOnLine, 53*(2), 17493-17498. https://doi.org/10.1016/j.ifacol.2020.12.2160

[8] Sommer, S., Rosen, P. H., & Wischniewski, S. (2019). Interaktionsmodalitäten für die Mensch-Roboter-Interaktion – ein systematisches Review. In Proceedings of *65. Kongress der Gesellschaft für Arbeitswissenschaft.* GfA-Press. https://gfa2019.gesellschaft-fuer-arbeitswissenschaft.de/inhalt/B.9.4.pdf

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