COLLABORATIVE ROBOT THAT AUTOMATES SEWING OF BAGS IN AUTOMOTIVE SUPPLIER INDUSTRY (ID5)

1 Introduction

Automating tasks through technological advancements has been an ongoing process in many industries. This development can also significantly impact occupational safety and health (OSH) in a work environment. It enables the removal of workers from hazardous situations and can improve the quality of work. This can be accomplished by automating cognitively strenuous tasks using an artificial intelligence (AI)-based system or by 'delegating' repetitive tasks to accurate and tireless machines like intelligent robotic systems. Some tasks might not be fully automated, but workers can still receive support through, for example, collaborative robots (cobots) operating in a shared space with workers. An increasing number of companies employ AI or advanced robotics. Although still in their infancy in terms of deployment, AI-based systems for the automation of both cognitive and physical tasks, as well as intelligent cobots, show promise in a variety of sectors. However, more information is needed on how they are implemented and managed in the workplace to help ensure workers' safety and health in present as well as in future applications.

EU-OSHA has developed a number of case studies with the aim of investigating the practical implementation of AI-based systems for the automation of physical and cognitive tasks and of intelligent cobots in the workplace, their impact on workers, how OSH is managed in relation to such systems, and to gain a better understanding of the drivers, barriers and success factors for the safe and effective implementation of these systems.

To develop these case studies, several key informants at the EU and international levels, such as workers' representatives and industry associations representing the targeted sectors, were consulted. Initially, 16 cases were identified and preliminary information was collected through a questionnaire. Hereafter, 11 of them were further developed into cases studies, including higher levels of information collected at the workplace level.

2 Methodology

The primary data source for the case studies was interviews held with different stakeholders within companies. For each case study, up to five interviews were conducted with workers of the company from different work areas. The participants included operators, data protection officers, health and safety engineers, managers work-councillors and technology officers.

The interviews had a duration of 1-1.5 hours each and were performed in the participants' native language, if possible, or alternatively in English. The interviews were conducted using an interview guide, while the results of the interviews were anonymised.

3 General company description

The company is an **automotive supplier** operating on a global scale and specialises in the field of drive and chassis technology. They provide customised, integrated solutions for automobile manufacturers, mobility providers and other companies with a focus on transportation and mobility. They were founded in the early 1900s in Germany and currently have more than 188 locations in over 31 countries. The location of this case study is one of their factories in **Portugal**. The company currently employs over 150,000 workers worldwide. Per definition, this company qualifies as a **large enterprise**.

The company operates under five core values, which are all presented in the backdrop of teamwork as a driving force for innovation and success. These values are passion, anticipation, diversity, empowerment and accountability. Connecting all five core values is a common undertone of continuous improvement of their approach to work, be it physical or cognitive work, through innovative technology and human-centred development. This includes the call for workers to submit projects and suggestions to improve working conditions and create workspaces that are more inclusive.

The company has introduced robotic systems in a number of locations, automating a variety of different tasks. This spans from stationary **industrial robots and cobots to automated guided vehicles (AGVs)** moving across the shop floor. The company also expresses the intention to increase automation of repetitive, monotonous tasks through robotic systems in the future, so workers can focus on tasks that require higher qualifications. Prior to introducing any new system, the company heavily focuses on risk assessment. In prior projects, they identified **risk assessment to be more complex for advanced robotics** due to new aspects of interaction between people and technology.

The interviewed experts from the company work in management and also include a health and safety officer, a technical engineer specialising in robotics and a worker working with the system.

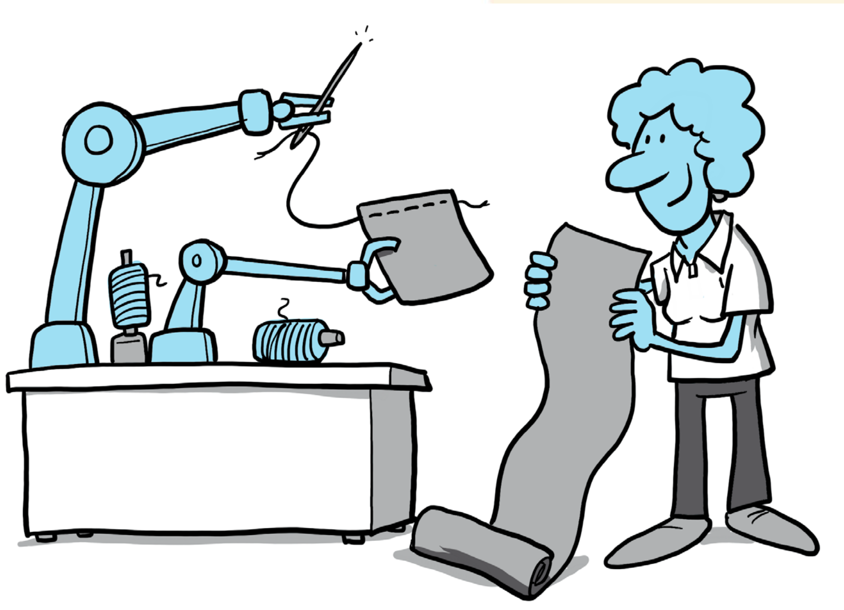
3.1 Description of the system

The companies' different locations hold a variety of applications for advanced robotic systems. The most prominent technology in this case study is a **cobot** that automates the **sewing of bags**, which was previously done manually. However, the company has highlighted that they try to automate their production as much as possible. This includes the implementation of a variety of advanced robotic systems, which will also be briefly touched upon in this case study. The use of several advanced robotic systems results in a wide spectrum of either fully or semi-automated tasks. Larger industrial robots automate tasks related to lifting heavy workpieces or fully automating repetitive tasks. AGVs perform component delivery for assembly or machining. **These systems drive autonomously through a worksite using several input sensors to navigate to their target location.** The more localised tasks of retrieving components for a machine or assembly process as well as assistance during parts assembly itself are performed by collaborative robots. In this case study, the workers interact with the system in two ways. **They can use the AGVs to regulate their supply of inventory** and then use the cobot to perform the actual assembly task. AGVs reduce walking distances for workers, allowing them to perform the assembly task with greater focus, as the cobot supports them.

The cobot, which is the primary focus, is part of a sewing task. It is a **one-armed multi-axis** robot from **a third-party supplier** that was customised to fit the specific task at hand. In the beginning, manual sewing was necessary, due to the comparatively complicated pattern of sewing that needed to be performed. In the past, there were no robots or other machinery capable of performing this task effectively. However, more recent developments in the capabilities of collaborative robotic systems changed this. The majority of sewing projects are still too complex and have to be done manually. However, for specific bags, the cobot can sew all the seams. The worker supplies the cobot with the necessary material to perform the sewing task. Once the sewing is completed, the cobot also performs an initial quality control, to assess if all seams are of sufficient quality. **The worker can then start a new sewing cycle for the cobot while they perform further assembly steps on the bag.** Overall, the cobot is able to perform the sewing task faster and with higher efficiency than a worker.

A cartoon-style representation of the system, performed tasks and interaction with workers, including some of the challenges and opportunities for OSH is presented in Figure 1.

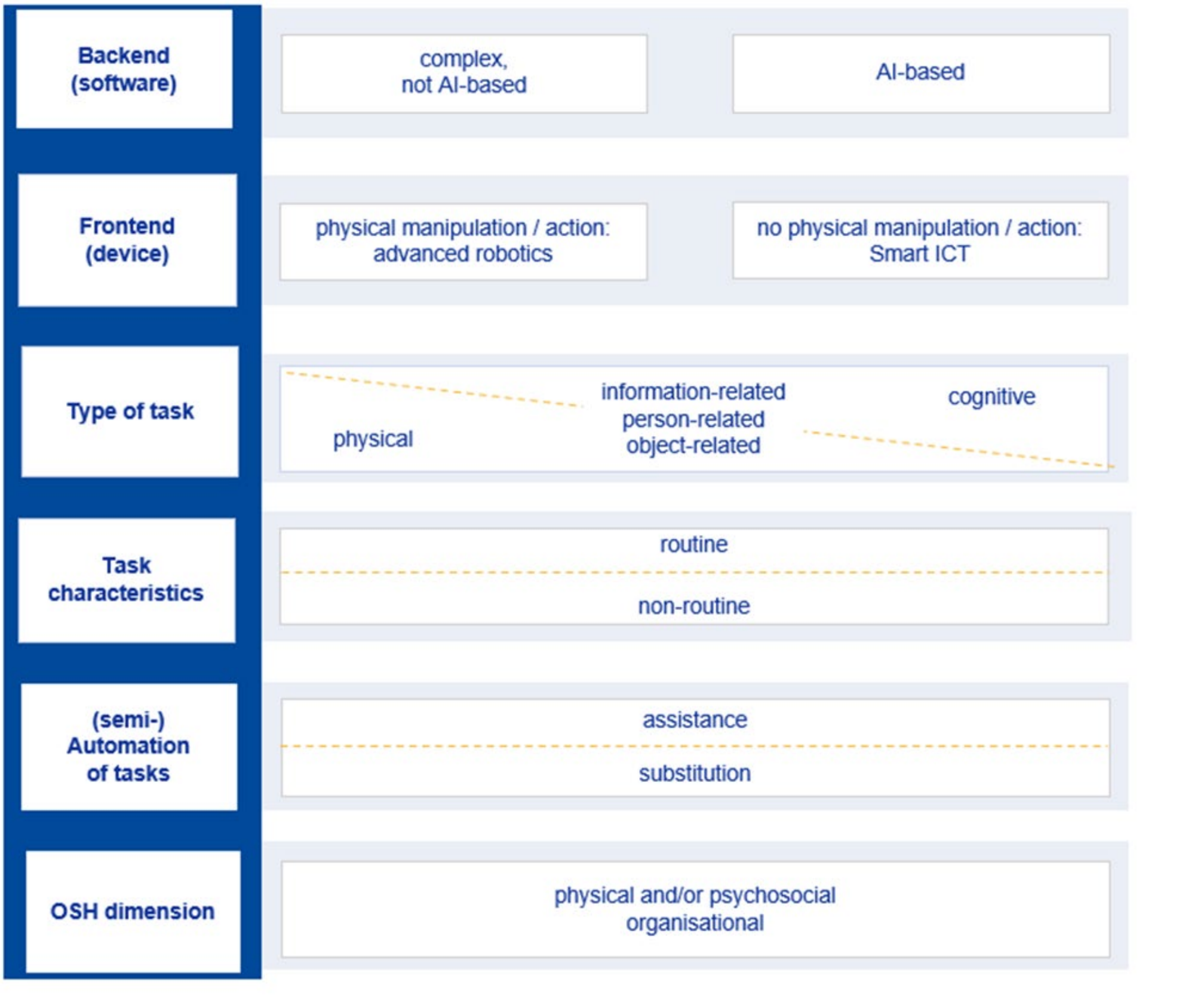
Figure 1. Collaborative robot that automates sewing of bags in automotive industry



3.2 Taxonomy-based categorisation

To categorise different types of technology, a taxonomy specific for different important criteria of AI-based systems and advanced robotics was developed by EU-OSHA.[1] This taxonomy includes, among others, the type of backend and frontend being used and the type of task performed, as well as which category it falls under (information-related, person-related, or object-related). It distinguishes between routine and non-routine task characteristics as well as the degree of automation in the forms of assistance or substitution. Finally, the taxonomy takes into account different OSH dimensions (physical, psychosocial and/or organisational) that are impacted by the technology.

Figure 2. Taxonomy for AI-based systems and advanced robotics for the automation of tasks



According to the taxonomy developed for this study, all three types of technology in this case study perform **manual tasks** with a **non-AI backend software**. They all perform an **object-related** task with a noticeable degree of **repetitiveness** and with **physical manipulation** of the workpieces.

Regarding the AGVs, their main task, 'transportation of parts', can be considered **fully automated**, however, the loading and unloading is still performed manually in some cases. So, more specifically, the transporting and carrying of workpieces is **substituted**. A similar categorisation can also apply to the advanced industrial robotic systems, which fully automate **lifting tasks** to move workpieces between stations. This is again a substitution of manual labour. Lastly, the cobots **substitute** most of the manual sewing task for the bags, with only possible exceptions for some seams. All these tasks are routine tasks for workers in that factory.

[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

The latter-described OSH dimensions, which are positively impacted by the robotic systems as well as AGVs, are primarily **physical**, however the company also describes some **organisational** benefits.

As the interviewees highlighted, the company is taking active steps to increase the automation of their production line. This has resulted in a wide variety of jobs impacted as well as changes in worker activities. As the cobot is part of this process, pinpointing its sole contribution to these changes was difficult. However, the larger changes that can be observed are still relevant to include when referring to the impact the cobot has had. In this case, a wide variety of **jobs** are impacted regarding their **work activities, job content** and **routines**.

All the jobs in the factory's production line are impacted by the introduction of the cobot and automation of production. It has led to a restructuring of work in general, as there is a rotation system in place now. Previously, workers remained in one workplace for the entirety of their eight-hour shift, as differing task completion time made it inefficient to rotate. Now they rotate between several workstations throughout their shift. Rotation takes place every two hours. The posts they rotate among do not all have the same level of demand, so this rotation is seen as positive in balancing day-to-day life in the workplace.

Work activities have also changed. The biggest change has to do with the production line configuration — before it was mandatory to have **sewing training**. This is **no longer a requirement**. Instead, all workers now receive **robot training**. This is needed for them to operate the cobot correctly when stationed at the sewing post. This post was where the workers would dedicate the most time. Now, workers primarily operate the cobot, assemble the sewn products and ensure the cobot has the material needed to perform the sewing task. Furthermore, **maintenance** personnel received **training** from the **robot supplier**, who did a workshop with them when the robot was implemented on the production line in order to prepare them for their new task.

Once the manual option of sewing without the support of the cobot has been removed from the specific sewing post, the use of the technology becomes **mandatory**.

4 Implementation process

A key factor for the successful integration of technology into a new work environment is the implementation process. Several factors, such as the identification of objectives and goals prior to implementing the technology, design decisions and participation, worker involvement and training, as well as the inclusion of guidelines or legislation, can influence it. In addition, some of the most important steps are the assessment of whether the intended goals have been reached, documentation of what challenges were faced, and finally consideration of how these lessons influence future company plans regarding the implementation of either new systems or more of those already implemented.

4.1 Motivators and goals

Setting **goals** prior to implementing a technology can help quantify the success of the implementation and also inform what kind of technology is needed to reach them. The interviewees expressed a number of objectives and goals for the introduction of the cobot. They can be categorised into two major groups: **economic** and **workforce-oriented**.

Regarding the automation of production, especially the robotics aspect, this has been motivated by economic considerations. Production increase, and guaranteeing quality and maintenance of the process, while also making it more economically competitive, was a target. Furthermore, staying up to date in terms of technology has been pointed out as a motivator. The inclusion of robotic systems aims to ensure the quality of the products throughout this process. However, from an economic standpoint, the cobot is not a direct facilitator of increased productivity but rather a proportional gain in process quality. **There is no automatic economic return from the implementation of the cobot alone.**

Besides production-focused reasons, the company introduced the cobot with several facets of their workers' **wellbeing** in mind. The ergonomic design and impact of the system on the workplace was taken into consideration. The cobot helps to reduce **repetitive motion** as well as enable a more diverse workday. One of the initial goals was precisely to facilitate more **ergonomic work**. According to the interviewees, the cobot indeed makes their work easier, as using it does not require as much effort as before, resulting in less muscle pain. As the cobot performs the previously time-consuming task of sewing, **workers can rotate among workstations now instead of remaining at the same station for eight hours**. This new, more flexible work schedule also frees up staff to perform other operations or help each other.

According to the interviewees, **the goal of implementing robots, cobots and AGVs is not to eliminate jobs but to expedite tasks or facilitate** them, so that the more time-consuming tasks can be performed by machines and thus allow workers to focus on other tasks.

As apparent in the previous paragraphs, some of the goals have already received a primary assessment and the implementation of the system has been **considered a success**. Regarding the economic impact of the system, more time is needed to fully assess the impact of all measures taken. The worker-related goals, however, can already be assessed to an extent. The implemented system lightens the workload and effort for workers. The control of the machine is smoother and less effort is required than carrying out the task manually.

4.2 Implementation

Before a new technology can be introduced into a workplace, there are a variety of factors to consider and often several stakeholders to involve. The implementation process can differ from company to company.

4.2.1 Implementation steps

The decision process was perceived as complicated and time consuming. It involved a variety of stakeholders and multifactorial considerations regarding the previously formulated goals. The first step towards implementing the cobot was a presentation of the project, where the company actively **assessed their production line** and looked for **opportunities to automate processes**. The decision of which measures to take was made primarily by the factory's process engineering group. However, before finalisation of these plans, health and safety management, the production department, the finance department, maintenance workers and general management were involved in the planning process. **Worker involvement came later in the process**, after the decision about which tasks to automate with which technology had been made. The parties involved in these decisions were the system developers and people in the company who were researching these types of technology. This group contained mostly members of the engineering team.

The introduction of the cobot was then carried out in two phases. Prior to using the cobot, workers received specialised training. The company first put the cobot on the production line and had a manual machine present as well. At this point, the workers were given the option of choosing how to carry out their task. After a week, the manual machine was removed. Then workers started using the cobot full time and, according to the interviewees, adapted easily. The interviewed worker mentioned that she has contact with this technology since it was implemented about a year ago and uses it daily (when working). Their feedback was positive, saying it is a helpful and useful tool.

4.2.2 Standards and regulations

The cobot was implemented in the production site in Portugal. Hence, the technology and the way it was implemented adheres to the required national and European standards and regulations. There has always been the **involvement of the company's OSH department** throughout the implementation process. The company performed an internal risk assessment that resulted in the system being regarded as safe for workers. The risk assessment itself is described as very similar to the assessment made for machinery other than cobots, while being overall more complex as the factor of interaction had to be taken into consideration.

4.2.3 Difficulties and challenges during the implementation

While the overall chain of decisions needed to implement the cobot was described as complicated and time consuming by the interviewees, this is also partially due to the novelty of the technology.

Once the cobot was in place, there was **initial resistance** from the workers' side to use it. When presented with both the cobot and the manual option to perform their task, workers overwhelmingly chose the manual machine. However, this resistance is not attributed to the cobot itself or a negative attitude towards robotic systems but rather the common resistance towards changing a familiar routine. Furthermore, some initial scepticism about the safety of the cobot by the workers contributed to the resistance. This, however, was resolved once the workers started to experience themselves that the system was indeed safe. As the manual option was removed after a week, workers started using the cobot and they **adapted easily**. The feedback has been positive.

From a technological standpoint, the most complex issue in terms of robotics seems to be that the existing collaborative robots have a **maximum load of 15 kg** and certain types of applications require more strength. This makes the implementation of cobots not a viable option for certain workplaces, even if outside the weight limitation a cobot would be well suited.

Besides these, there were no specific difficulties reported to have occurred during the implementation process.

4.3 Worker involvement

Worker involvement during the implementation process can contribute to the success of a technology's implementation. Depending on the circumstances, this involvement can start at the design stage, or once training to use the technology starts. While there are external factors that can limit the extent to which workers can be involved, companies seeking to introduce AI-based systems should consider at what stage worker input can be included.

As mentioned above, there was no active participation during the decision and system design process by workers. This is primarily because the used cobot was bought from a third-party supplier and needed custom specifications to perform the sewing task. Workers were involved at the point where they needed to undergo specialised training to operate the robot.

4.3.1 Training and worker qualifications

Worker training and education is a major element for the success of technology implementation.[2,3] Every worker must have specific training on every machine in the factory. The cobot is no exception to that. Training is provided by the company itself. Learning how to use the cobot was described as quite simple and user friendly. The interviewees said that they can easily train new workers to operate it. The necessary skills build on the ones first acquired during introductory training in the factory itself. The training on the cobot specifically covers all the necessary aspects concerning its operation, including how to handle **unexpected and emergency situations**. When there are any questions from a worker on operating the robot, there are team leaders or managers who can address the questions.

Maintenance personnel received training from the robot supplier through a workshop when the robot was implemented on the production line. Their task differs from the cobot operator's, hence the specialised training.

One of the concerns, when it comes to the automation of tasks through AI-based and robotic systems, is the process of deskilling. Automation like this is generally seen as a starting point for one of three skill developments: ***deskilling, reskilling or upskilling****.* Prior to the cobot performing the sewing of seams in this task, workers were trained in operating industrial sewing machines. This training no longer takes place, as the skill is no longer required. Instead, the workers learn how to operate the cobot. **Reskilling** is taking place to also **keep workers' skill sets relevant** in the current developments and for future demands of the industry.

4.3.2 Feedback system and report handling

Being aware and open towards worker feedback can be beneficial for a company introducing new technologies to their workplace. Regarding the cobot, the received feedback has been very positive. The cobot has been described as very user friendly. It has also been reported that the technology (the cobot and other advanced systems) facilitates the workers' tasks and therefore their jobs have been made easier. The ease with which workers adapted has been interpreted as a sign that the robot has brought a great advantage to the workers. The robot is only in one post of the factory but currently there is no feedback that workers do not wish to be assigned to this post. The interviewed worker pointed out specifically that that particular post within the production line is the **most desirable** among their colleagues.

Should any negative feedback arise, or if the workers have any concerns, they have dedicated team leaders and managers to whom they can speak.

4.3.3 Level of trust and control

An adequate level of human trust towards the interacting system promotes appropriate system use,[4,5] while extreme forms of trust can lead to adverse effects. Excessive trust can lead to automation complacency,[6] whereas insufficient trust may lead to neglect of the technology.[3]

In addition to trusting the system, a worker's level of control can have significant influence on a number of factors, like acceptance and attention given to the maintenance of a technology. According to the interviewees, a high level of trust is currently placed in the system. Confidence levels that the cobot can perform its task effectively and reliably are high. The interviewed worker pointed out that they have been using the technology since it was implemented about **a year ago** and use it daily. The feedback was positive, saying it is a helpful and useful tool. They said that they feel a **high level of control** when using the cobot.

---

[2] Waldeck, N. E. (2000). *Advanced manufacturing technologies and workforce development*. Garland Press.

[3] Fraser, K., Harris, K., & Luong, L. (2007). Improving the implementation effectiveness of cellular manufacturing: A comprehensive framework for practitioners. *International Journal of Production Research, 45*(24), 5835-5856. https://doi.org/10.1080/00207540601159516

[4] Parasuraman, R., & Riley, V. (1997). Humans and automation: Use, misuse, disuse, abuse. *Human Factors, 39*(2), 230-253. https://doi.org/10.1518/001872097778543886

[5] Hancock, P. A., Kessler, T. T., Kaplan, A. D., Brill, J. C., & Szalma, J. L. (2020). Evolving Trust in Robots: Specification Through Sequential and Comparative Meta-Analyses. *Human Factors, 63*(7), 1196-1229. https://doi.org/10.1177/0018720820922080

4.3.4 Company culture and structure

The introduction of the cobot was part of a larger movement to automate production in the factory. Hence, there were structural changes to the workers' routines and workstations. These changes cannot be solely attributed to the cobot, however the cobot did have an effect. 'The work environment has changed significantly with the integration of the cobot into the **workday structure**. Moving from an eight-hour stationary workstation to a **two-hour routine-based system** is a drastic change. Common concerns that come with increasing automation, like **social isolation, could not be confirmed** by this case study. But increasing automation does not increase social isolation as the cobot itself is not isolated. It is in the same position that the manual machine had previously been in. **Socialisation might have even increased**, according to the interviewees since workers rotate posts more frequently and end up interacting more with other colleagues. Larger company structures have not changed during the current phase of automation.

Within the scientific literature, concerns of social isolation and job loss are among the most named negative impacts of automation. Companies might opt to provide additional support for workers who interact with the system or experience other kinds of concerns. Workers know their assigned team lead and manager and are encouraged to report concerns to them when they arise. Currently, the interviewees are not aware of any concerns relating to the cobot.

4.4 Future developments

The company has confirmed plans to continue automating their production and include innovative technology to both benefit their workers and keep them competitive in the market. The implementation of more **industrial robotic systems** is going to start in the near future — as will implementation of **an AI-based system** for part failure detection. The company also has some ideas for replacing more manual operations with robots and **component inspection tasks with an AI-based system**. Currently, these are projects in the research phase, as they are contacting suppliers to assess feasibility.

5 OSH impact

The introduction of advanced robotics or AI-based systems can have a wide impact on OSH. It can pose a number of challenges as well as opportunities unique to each case study. Therefore, it is important to identify possible barriers and drivers to consider them in future projects. These new forms of task automation can even lead to changes in the overall OSH management of a company. Through the interviews, a number of these factors for this specific case study have been identified and discussed.

5.1 Challenges

As advanced robotics and AI-based systems allow highly individualised solutions for a company, they can also face challenges specific to their case study. In addition, more universal challenges can emerge, which the company then has to address. The interviews contained a number of OSH challenges the company had to face, both during the implementation phase as well as in ongoing production.

After extensive risk assessment, the factory concluded that the **cobot added no new OSH risks** to the workplace, beyond the risks that already existed. The risk of entrapment already existed with the industrial-grade sewing machines, as did being pricked by a needle as a result of misuse or inattentiveness. The risk has decreased because the **sewing area** of the cobot is **protected with an acrylic screen**, and if a worker wants to access the area, the screen must first be removed.

Challenges regarding OSH were considered temporary and primarily organisational, in the form of risk assessments and an initial resistance of workers to changing their routine.

5.1.1 Adequate risk assessments

The company has assessed that there is a residual risk of physical injuries for workers who share a workspace with AGVs and cobots. However, having performed risk assessments for each new technology as well as installing proper guarding and safety devices where needed, there have been no injuries related to these technologies. However, the process of adequate risk assessment for collaborative robotic systems and AGVs has been found to be overall more **complex** as there are new aspects of **human–machine interaction** that need to be considered. This also helped identify a need for increased focus on proper set-up of safety devices and maintenance routines, such as cleaning, to ensure physical safety. Hence, expertise for these tasks was needed and special assignments for critical tasks such as maintenance needed to be done.

5.1.2 Negative attitude

While there have not been official reports on a negative attitude towards the cobot, or an explicit fear of it, interviewees mentioned that in the initial days of the cobot being in the workplace some workers were not fully confident about the physical safety of the system. This was perceived as one contributing factor to the **initial resistance** towards using the cobot. However, this fear was no longer prevalent once the workers actively used the cobot.

5.1.3 Deskilling

While the training provided by the company to use the robotic system is a form of reskilling their workers, they also acknowledge that the previous training in industrial sewing is no longer performed. This is a form of deskilling. This skill is in less demand in the current development of workplaces in Europe and has been replaced with a more future-oriented skill.

5.1.4 Physical risks

The factory performed a risk assessment of the new workplace and added safety measures where needed. However, they concluded that the cobot does not add any additional dangers to the workplace. **Residual risks**, based on human error, however, cannot be eliminated by the cobot.

5.2 Opportunities

The introduction of the technology to the production site also held numerous OSH benefits and opportunities.

5.2.1 Worker qualifications

Comprehensive and specialised training for workers is provided to everyone who needs to work with the cobot. Trainings are based both on the new and altered tasks that are to be performed by a worker as well as the level of expertise needed to perform them (for example, robotic maintenance), which has increased organisational needs for **specialised training**. The training the company and the cobot supplier provides for all workers who participate in the rotation or are charged with technology maintenance, and thereby interact with the cobot, is a form of reskilling and upskilling. It provides new, **future-oriented skills** to their workers that they can potentially use for a long time.

5.2.2 Physical workload and health

The robotic systems as well as the AGVs have had an impact on OSH within the factory. The introduction of the cobot has **reduced physical workload**. Repetitive movements can be a health hazard, and the cobot automates the most precision-based repetitions of bag assembly. In general, the interviewees reported overall **improved ergonomics** at workstations and less trapping hazards for workers than with the previous machines. This change was specifically attributed to the introduction of the cobot, which is important to highlight given the general move towards automation in the factory.

5.2.3 Task variety and job demand

The introduction of the cobot is also credited with a noticeable change in job routines for the workers. Before the implementation of the cobot, a worker would stay at the same post for eight hours, performing the same type of task for their entire shift. The cobot has automated the most time-consuming part of the bag assembly process, allowing the factory to introduce a rotation system where workers change stations every two hours. Workstations differ in their **level of cognitive and physical demand**, so the rotation has been seen as a way to balance the overall demand on workers.

5.2.4 Social interaction

The cobot has not directly changed the social interaction at the post where it has been installed. Workers worked alone there, both before and after the cobot's introduction. However, the resulting rotation system has been attributed to more interaction between workers. This is an interesting example of how a specific system can possibly incite positive changes that were not the explicit goal of its implementation.

5.2.5 High-risk groups

Regarding high-risk groups, the interviewees pointed out that there are **no specific groups exposed to greater risks when working with the cobot**. As the interviewee who works with the cobot reported, the work has become physically less demanding. This could imply that people with a lower general fitness, or of an older age, could now work at these posts with less physical strain. But the actual long-term effect of the cobot on physical wellbeing or increased accessibility needs to be assessed over time.

5.3 Barriers and drivers

When going through the process of integrating a new system into a workplace, companies may encounter a variety of barriers and drivers. Identifying these can help this company as well as others avoid barriers and promote drivers for their process automation in the future.

5.3.1 Barriers

This case study company had a high familiarity with introducing innovative technologies into their factory setting. Nonetheless, they encountered barriers when it came to the cobot's implementation. The decision process was described as especially complicated and time consuming. Deciding on the right system to automate this specific task came with a lot of additional research into product options and technical limitations. In their wider research for automating more tasks through either cobots or other advanced robotic systems, they found the weight **lifting maximum** of 15 kg as limiting.

The second barrier they encountered was post implementation, where workers exhibited initial **hesitation** and feelings of rejection towards the cobot. This was attributed to distrust in the system's safety despite the extensive training the workers were given. However, this resistance decreased over time, when workers gained positive experience with the cobot, experiencing first-hand that it was indeed safe for them to work with.

5.3.2 Drivers

One driver for the long-term success of the cobot in its post was **the workers' ability to adjust** to the technology quickly and easily. Additionally, this factory and the company overall exhibit a high interest in using innovative technology to optimise their processes and support their workers. This allowed them to facilitate larger changes in the workers' environment through targeted automation. The previously mentioned rotation system is one example for innovative technology driving changes beyond their primary task.

5.4 OSH management

New technologies can lead to a change in work procedure. This includes expectations for the technology and subsequent OSH management.

5.4.1 Expectations for OSH

The primary expectation towards OSH was already an integral part of the motivators to use advanced robotics in general. This type of automation was expected to be beneficial to the **life quality** of workers, specifically relating to their **physical wellbeing** and **long-term health**. Repetitive movements can be straining for joints and possibly result in long-term injuries, especially for factory workers. The implementation aimed at reducing these hazards. In this case study, the expectations are considered met as the cobot quantifiably reduces the need for repetitive movements.

5.4.2 Emerging OSH risks and monitoring

The factory currently does not foresee any specific OSH risks emerging from the use of the cobot. OSH risks are assessed as part of the risk assessment prior to implementing a new technology. Regarding continuous monitoring for new and emerging risks, the factory encourages their workers to relate any problems with the machine to their team lead or manager as well as trained maintenance staff who ensure the upkeep of the cobot and could identify changes to the system that would need to be considered. Furthermore, there are **self-tests** that the cobot performs when turned on to certify it is working properly. So far, no defects have been detected.

5.4.3 Communication strategies

Should new OSH risks emerge or be identified, the workers would be informed about them. If, from the workers' side, problems arise, they are aware of whom to approach with their concerns so that appropriate action can be taken. However, no specific or new communication strategy was introduced regarding the cobot.

5.4.4 Organisational and social impact

As mentioned above, the cobot has affected the work structure of production workers in this factory. Management saw an opportunity to improve workers' daily routine, facilitated through the cobot's abilities, and decided to adjust accordingly. However, there have been no other fundamental organisational or social changes made.

5.4.5 Integration of OSH management

As this company is continuously interested in using innovative technologies in their factories, they already had experience with the processes and steps from an OSH management point of view. Their OSH department was continuously involved during the introduction of the cobot, however, this was not a change to their OSH management, but rather their standard procedure.

5.4.6 Need for action

Regarding both external and internal stakeholders, no urgent need for action was identified. The most complex issue in terms of robotics that was mentioned is that currently existing cobots have a **maximum load of 15 kg** and certain types of applications require more strength. This is a technological limitation that currently **limits the potential use of cobots** in a different setting.

5.4.7 Cybersecurity

With technology becoming increasingly interconnected and data itself being a resource needed by some advanced robotics or AI-based systems to improve their functionality, the topic of cybersecurity becomes prevalent in companies employing these technologies. The way that cybersecurity is handled at a company level is a key factor in securing the data when it comes to AI-based systems. Some systems require additional safety measures, depending on their use. Another factor that increases the relevance of specified cybersecurity is the active collection of data through a system. In these cases, data privacy of the users becomes very important. In this case study, **no additional steps for cybersecurity** had to be taken. The cobot does not collect any personal data of the user, nor does it, for example, film its surroundings.

A cartoon-style representation of the system, including some of the challenges and opportunities for OSH is presented in Figure 3.

Figure 3. Collaborative robot that automates sewing of bags, posing challenges and opportunities for OSH

6 Key takeaways

There are a number of key takeaways from this factory's use of advanced robotics in their production site. The use and functionality of advanced robotics can differ greatly from case study to case study. However, gathering information on similar case studies and sharing applicable insights about opportunities, risks and challenges, or other lessons learned, can help companies navigate the implementation process more efficiently and successfully, especially concerning OSH.

With robotic automation, the physical benefits are often the first ones one is aware of. As the majority of advanced robotics and cobots are currently being used to automate physical tasks, it strengthens the image that their effects on OSH are also primarily physical. This case study does confirm the **physical benefits** the system has had for its workers. Less repetitive motions and an overall more ergonomic workplace can reduce the development of strain injuries, which are especially prevalent in factory workers.

However, this case study highlights the importance of not only taking the primary OSH effects into consideration but also the **ripple effects** it can have on workers, workplaces and organisational processes. The physical automation of a repetitive task might also decrease monotony or boredom, while a cognitive automation might have physical implications, like increased sitting time. The newly established rotational system is an example of one such process that changed surrounding the cobot, while not being dependent on the cobot's task itself. The **increase in task variety** has been reported as beneficial in creating more balanced job demands throughout the workday. More balanced job demands can potentially lead to a variety of positive physical and psychological effects in the long run. Similarly, the cobot was implemented to perform physical tasks but also **reduce monotony** for workers. Monotony is a known negative influence on mental wellbeing. This further highlights the importance of monitoring the impact of a system in a holistic way, and over time. Initial assessments of the worksite after a new technology has been introduced is common practice in many industries, however, repeated assessments over a longer period of time can reveal more detailed and more comprehensive insights on the worker and workplace. This long-term holistic impact assessment of OSH could enable a company to enhance positive secondary benefits and prevent negative ones in the future.

A key component in OSH is risk assessment; it is not only good practice but mandatory. Advanced robotics, like cobots or AGVs, enable new forms of interaction between a worker and technology. This type of interaction might not necessarily be covered or be reflected in sufficient detail in existing risk assessment guidelines. This case study experienced little to no major barriers when introducing a cobot to their production line as they had experience working with innovative technology and processes like **risk assessment of advanced machines**. One point they did find more complex was an adequate risk assessment that addresses the cobot and human–robot interaction sufficiently. While there are some standards and tools available for risk assessment of advanced machinery, when it comes to cobots the available tools and guidelines often first need to be understood, if it is a company's first time implementing a cobot, or interpreted or adjusted specifically to the case study. Here, having experience with these systems can be advantageous to navigate this process more effectively.

As the capabilities of robotic systems increase, the demand for certain skills to perform certain tasks manually is likely to change. There will be skills that drop in demand, while others will increase in the future. These are considerations companies must make when analysing which tasks to automate and how to educate and reskill their workforce. This case study decided to focus on providing their workforce with new skills that they considered relevant in the future of work. A skill set that was related to the task the cobot automates, however, is no longer needed to work at that post. This assessment of **which skills are considered important for the future of work**, and which are considered to be declining in relevance, should be made with as much foresight as possible.

The final key takeaway of this case study relates back to the first one: perceiving a robot as **not isolated** but instead as part of the larger workplace environment. The cobot automating a time-consuming task created an opportunity to restructure the daily routine of workers. While it would have been possible to maintain the 'eight hours at one post' shift structure, having workers perform the same production steps all day, the company saw an opportunity to leverage bigger changes. With the new rotation system, workers experience more task variety, less monotony and possibly more social interaction during their shift. The rotation allows them to perform tasks of different cognitive and physical demand throughout the day for a more balanced work experience. While this effect does not directly result from interacting with the cobot, it does originate from its introduction in the workplace. This is a good example of organisational change incited by an advanced robot, to benefit workers beyond the system itself.

Authors: Eva Heinold, Federal Institute for Occupational Safety and Health (BAuA), Patricia Helen Rosen, Federal Institute for Occupational Safety and Health (BAuA), Dr Sascha Wischniewski, Federal Institute for Occupational Safety and Health (BAuA).

Project management: Ioannis Anyfantis, Annick Starren (EU-OSHA).

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