COGNITIVE AND PHYSICAL AUTOMATION IN A SAWMILL PRODUCTION LINE (ID2)

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 examined for this case study is a supplier for a variety of automated solutions and one of the largest automation integrators in Sweden. It offers its customers automated guided vehicles, machine, service, consultancy and training. The industries that the company works with include food, automotive, manufacturing, pharmaceuticals, logistics and timber. They employ 150 workers and have been active since the 1960s in Sweden.

By supplying customers with individualised, intelligent solutions, the company aims to increase efficiency and quality in the customers' production and logistics. Fitting the solution to the customers' needs is one of the company's key points of operation. This includes close collaboration with the customer starting at conception with feasibility studies and extends beyond final implementation into continued training and customer support. This case example is based on their solution for a **sawmill production line in which they employ a combination of robotic automation and an AI-based visual system**.

3.1 Description of the system

The company provided an case study of a technology that performs both cognitive and physical tasks. The overall application is on the conveyor belt in a sawmill production line. The industrial robot is used for sorting and handling defective boards in a continuous flow. Three different systems work together for this. First, a visual system detects the boards that are defective. A second system guides the industrial robot to pick the defective boards and, finally, the multifunction gripper removes them from the conveyor belt.

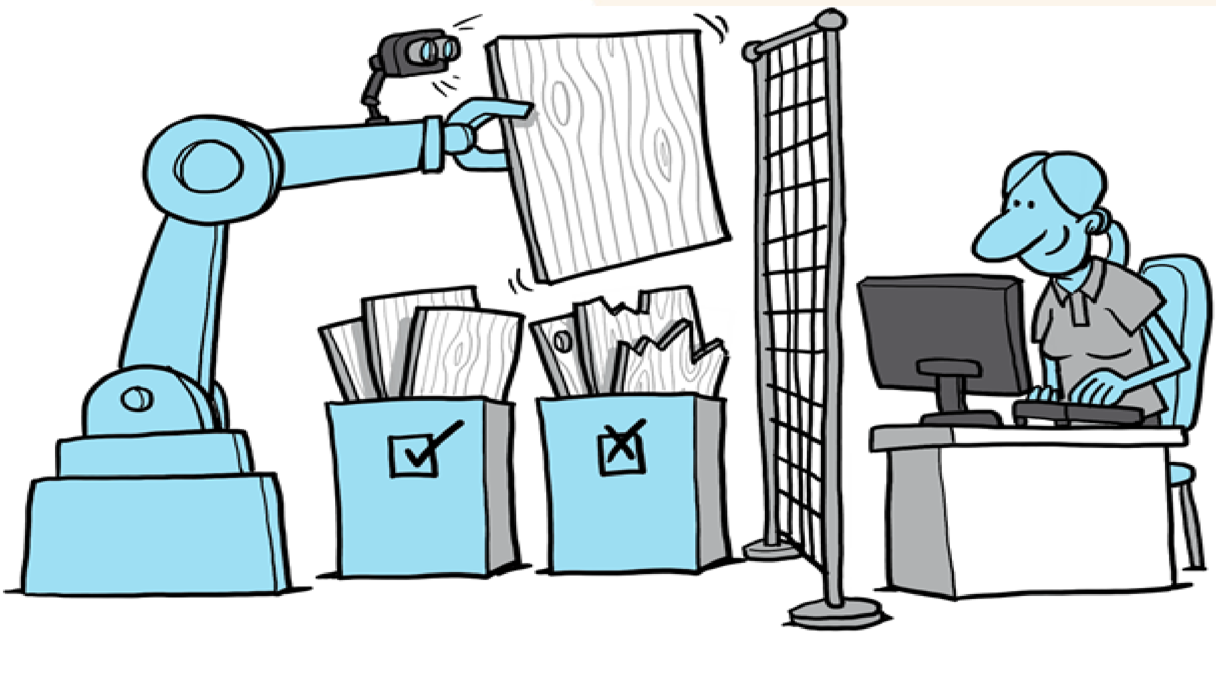
The system uses two distinct visual applications to identify the defective boards and guide the robot's movement. Both applications are connected to a personal computer with an AI-based software developed by the company. The software performs analysis, identification and evaluation of the boards to detect defects. The first visual application uses a 3D time-of-flight camera.[1] 3D Cameras produce a point-cloud[2] and the second visual system evaluates the point-cloud against a number of parameters, which leads to an 'OK' or 'Not OK' decision.

If the option 'OK' is selected, the system will let the board pass along the belt without taking action. If a defect is detected, the board is stopped at the robot station — the second vision system sends the coordinates to the industrial robot that picks it up and puts it on a shelf for discarded scrap material.

The visual inspection component is supervised by workers in a control room. While this task was previously performed next to a conveyer belt, one goal of this automation was to relocate workers into a more ergonomic environment and away from potential hazards. Control rooms achieve this while also giving workers better conditions to perform their tasks.

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. Cognitive and physical automation in a sawmill production line.



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.[3] This taxonomy includes, among others, the

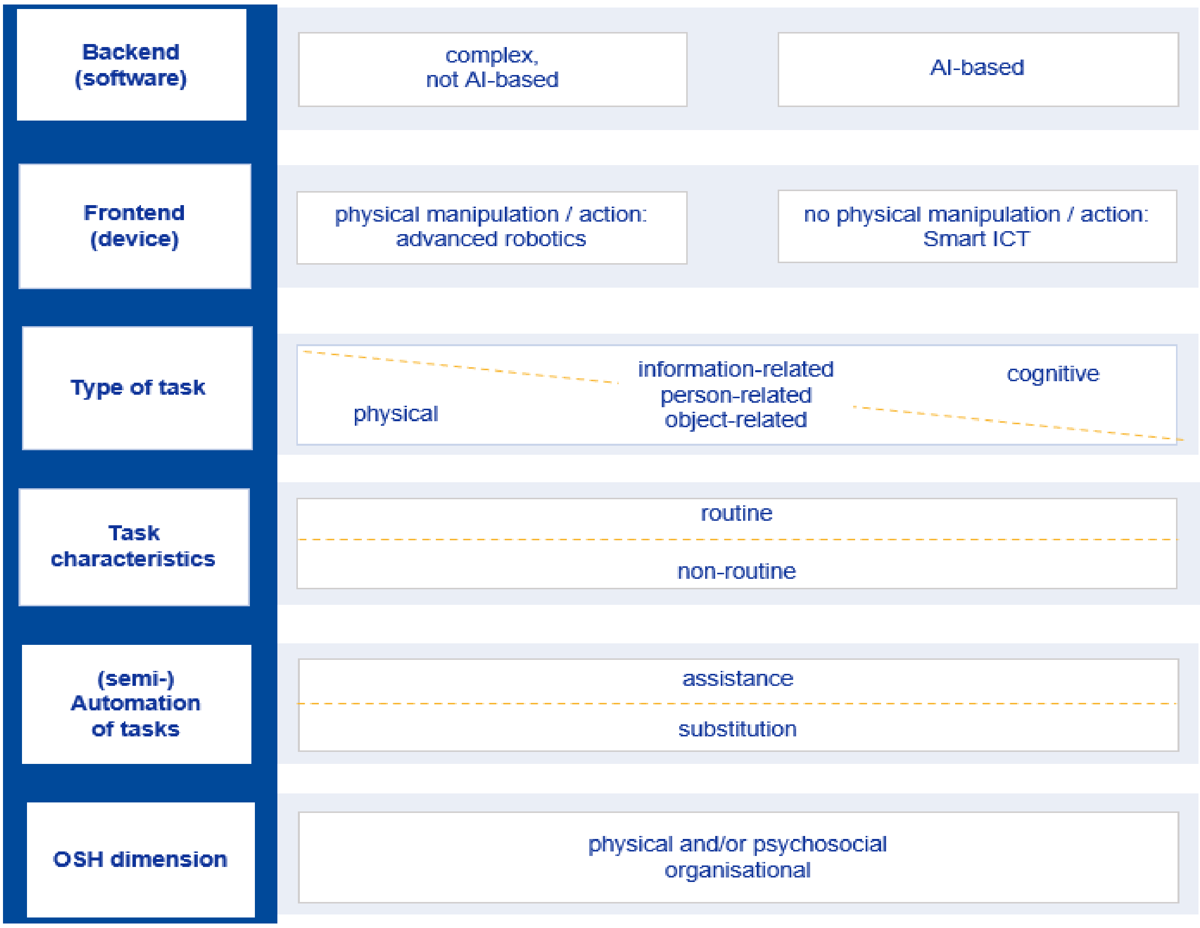
[1] Hansard, M., Lee, S., Choi, O., & Horaud, R. (2012). *Time-of-flight cameras: Principles, methods and applications*. Springer. https://www.doi.org/10.1007/978-1-4471-4658-2

[2] Representation of an object using 3D coordinates (X, Y, Z).

[3] 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:

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 form 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



In sawmills that do not use this kind of technology, an operator stands next to a conveyor belt where wooden planks pass by at 1-1.2 metres per second. They perform visual inspection of the lumber, hour after hour, and have to make instantaneous decisions on whether each one is too crooked for continuous production or broken. If a piece is found to be unsuitable, workers can remove the piece of wood at speed, or stop the whole belt. Lumber pieces can weigh up to 100 kg, although the average weight is closer to 20-30 kg.

The system is a mix of **cognitive and physical tasks**, based on an **AI-backend software**. It replaces several tasks of a process operator at a sawmill production line (a **manual, object-related** task with **high physical strain** and other **physical hazards** — no example provided by the company) with automation, removing the worker from danger. This is performed in combination with a visual system in place that analyses the product for suitability. Here, **AI-based software** is used. It would, in theory, substitute a **cognitive task**, however, the company has integrated the system from the start, hence workers never filled this role. The main impacts the system has on OSH are physical, however, some **psychosocial effects can be found when considering it automates a cognitive task** that requires extended periods of concentration. These benefits would be experienced from workers who previously performed this task; however, in this case, workers never had to.

As such, AI-based systems replace low-skilled work. However, **supervising** and **maintenance staff** need additional training for the robot application and therefore must undergo special training.

https://osha.europa.eu/en/publications/advanced-robotics-artificial-intelligence-and-automation-tasks-definitions-uses-policies-and-strategies-and-occupational-safety-and-health

With regard to the change of **job content**, one can say that operators in this company's control rooms have another aspect to surveil: the feedback of the AI-based visual system. Those in the operator room also have to do some manual approvals in individual cases — the program stops the production line if it is uncertain.

For technicians and maintenance crew, there are more new work aspects. The used visual system is novel to the industry, hence operators have to learn how to use it. In addition, the type of robots used on this conveyer belt are not normally found in the sector. Hence, the biggest change in job content is the educational period to learn to use and interact with the new advanced robotic system. Operators who would previously have worked on the conveyer belt do not have to perform visual inspections and no longer have to lift heavy lumber.

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 technology.

The described technology is novel in Europe. The work of handling wood on the line of a sawmill is generally performed manually, but this technology enables companies to fully automate the production and only have operators working in control rooms. This way, production is more efficient. The technology builds on 3D cameras that scan the material and make decisions based on what they have learned — in this case, whether a log or piece of lumber is of sufficient quality to proceed to processing, or whether it should be diverted and discarded. The sawmill industry has low margins in terms of profits, so they must focus on **efficiency** measures. The technology has a positive effect on overall **production costs** and enables companies to keep production in Sweden rather than outsource it.

Another motivator in this case study is the intention to automate a form of work where there are significant **OSH risks**. Working in a sawmill has **physical risks** connected to the machinery and also as a result of handling large and heavy workpieces. There were also OSH concerns in the form of high and repetitive **noise**, **heavy lifting, dust** and **general fatigue** from looking at the conveyor belt for too long.

Additionally, as the AI increasingly learns, production becomes more **flexible**, and more parts of work can be automated.

One of the interviewees explained that an overarching goal was the conceptualisation of the most modern sawmill possible. The technology they use to achieve this goal is new, and while it has been part of the sawmill's production from the beginning, it is not entirely possible to judge if all intended goals have been reached yet. However, the interviewees reported that the current outlook is good.

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. With AI-based systems and advanced robotics being so customisable in their application, the general implementation differs for each case study. Nonetheless, there can be common implementation steps taken, with regard to who is involved in the process. The standards considered to implement a technology are equally important, both with regard to which are widely used and which are relevant to a specific case study. Furthermore, the individual difficulties and challenges are as vital to understanding the success of a case study as the ones more broadly shared among several case studies.

4.2.1 7Implementation steps

When starting the conception phase of this project, the initial idea was to build the world's most modern and automated sawmill. A signifier of this is that there would be no operators directly working on the production line anymore, but instead have **control rooms** to oversee and manage production. To achieve this, new automated solutions were needed. In continuous and close cooperation between the sawmill and the integrator from the early stages of conceptualisation until final integration, the needed technological solutions were developed. This includes the advanced robotic system presented in this case study. The continuous communication between integrator and client allowed both parties to address all relevant concerns at any stage of the process. After finalising the concept, the system had to be built and integrated into the worksite. This included the creation of new AI-based software, which had to be trained to successfully fill its role later in the production. The system was then tested in the developers' workshop. After both the software and hardware were finalised, it was then moved and integrated into the production site. Before introducing the system into full production, operators received the needed training to assess the system's output, and additional technical personnel were trained to address the mechanical needs of the system.

4.2.2 Standards and regulations

The technology complies with the Machinery Directive 2006/42/EC. Additionally, the Swedish Work Environment Authority had increased its regulatory focus on the lumber and sawmill industry to both raise awareness and decrease injuries in the sector. Their regulations as well as recommendations are consulted to ensure safety.

4.2.3 Difficulties and challenges during the implementation

The main challenges of this project were seen in the development of the software and how to design it to fulfil its purpose effectively and efficiently. There is no similar technology in place in any sawmill in the world, hence they had to **develop it from scratch**. This was a work-intensive process, especially considering the high-risk environment the system was intended to automate. Additionally, should the AI not work sufficiently, it could have not only impacted production negatively but would also have been significantly less effective in reducing physical workload for floor workers, as well as not reducing their exposure to dangerous working zones.

Transferring both the hardware and software from the developing facilities to the sawmill also proved to be a challenge in terms of fine adjustment based on the conditions in the new facility. There is a **limited level of detail that could be tested in the developers' workshop**, hence there were additional factors that the integrator was not aware of by the time of installation. This led to minor adjustments needing to be made on site.

4.2.4 Future developments

The development of this specific case study is considered largely complete. However, there are still steps needed to have the full production running. The longer the production runs, the **larger the database the AI can learn from becomes**. There are considerations that this **might** lead to previously unknown, **additional error cases** that the developers have to address when, and if, they arise. But overall, this project is considered complete. As the sawmill is newly built, the existing high technological standards put little to no pressure on them to modernise soon. However, as using the most current technology is vital to the idea behind this production, it is likely that the sawmill will continue to keep up with technological advancements. With regard to future developments, the interviewees noted that this kind of technology is getting more and more advanced, and it is increasingly possible to replace dangerous or straining human labour. And as the technology is **more flexible** than before, the interviewees predict that more case studies will appear in the future. They highlighted that future developments, especially in deep learning, hold a lot of potential for AI-based systems but are hard to predict with regard to their timeline.

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.

The sawmill for which the advanced robotic system in this case study was developed and installed was new, and specifically integrated AI technology as well as the robotic components had to be developed from the start. The decisions were initially made on a **management level** and there was **no worker involvement in the design or planning phase**. The **sawmill's management** worked in close and constant collaboration with **the integrator** to create a system that fit their specific needs. Project planners gave the developers input on what to prioritise, for example, what counts as an error case (that is, specific problems with the lumber that the system should flag). The company provided descriptions on which interventions are handled by operators and the developers then tried to solve them with the present technology. The workers were involved in the sense that prior to using the system they received the **necessary training**, relating to both the system's functioning and safety. Furthermore, the sawmill operates with the capability that should the system not be able to perform (for example, be out for extended maintenance), production can go on. So, workers also need to know how the production process functions without the AI system.

4.3.1 Training and worker qualifications

Worker training and education is a major element for the success of technology implementation.[4,5] The operators received **training** in how to use the new AI-based system, how to interact with the user interface and how to interpret the system's output. However, they do not learn the mechanisms of the underlying technology, or how to program it themselves. The focus lies on teaching workers what they are able to do and what the different indicators mean, including what to do if they light up and what the necessary conditions for the system are. This is achieved with a clear and **easily understandable user interface**. The training also includes special attention to all **alarm indications** and how to handle these exceptions. In an emergency situation, there is the recommendation to initiate an **emergency stop**, as described in available documentation. This triggers the robotic cell and conveyer belt to stop working. Additionally, the training includes how to correctly file documentation. Prior to installing the system, the integrator also requires that anyone using the technology has the needed **certification**.

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**. However, there is a backup included in the system so that, should there be an error with the robot, production can continue manually. Hence, it is vital for the company to **prevent deskilling** of their workers, as they need to be able to handle production manually as well.

4.3.2 Level of trust and control

An adequate level of human trust towards the interacting system promotes appropriate system use,[6,7] **while extreme forms of trust can lead to adverse effects. Excessive trust can lead to automation complacency,**[8] **whereas insufficient trust may lead to neglect of the technology.**

In addition to trusting the system, an adequate level of worker control over the technology can significantly influence a number of factors. Trust is especially dependent on time used and experience with a technology. While writing this report, the sawmill and its production line are comparatively new. There have been no reports of mistrust towards the system, however, it still cannot be assessed how strongly the operators trust in the system. The developers reported that they consider the system to be overall safe and ready for use, with the exception of possibly new, yet unknown, error cases that may occur in the future.

Using the technology is **compulsory** for the workers. However, with regard to workers' **control of the system**, they can adjust tolerances, that is, what lumber should be scrapped and what should be kept. They have a start and stop button, as well as the option to choose an operation mode. There are different **drift modes**. For example, one can choose to use the robot even without the AI-based vision system for semi-automatic operation. However, workers have no access to the underlying source code to adjust parameters like production speed.

4.3.3 Company culture and structure

As the sawmill was built with this technology from the start, there have been no changes in the company culture and structure. While this leads to no changes in company culture or structure from a previous operation mode, one can see changes compared to the traditional set-up of a sawmill. In comparison to other sawmills, this case study relocates manual workers away from the conveyer belt and moves them into more supervisory positions.

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.

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

5 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

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

7 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

8 Parasuraman, R., & Manzey, D. H. (2010). Complacency and bias in human use of automation: An attentional integration. *Human Factors, 52*(3), 381-410. https://doi.org/10.1177/0018720810376055

5.1 Challenges

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

5.1.1 Physical safety

Improving physical safety was a fundamental objective during the construction of this advanced robotic system. This goal is considered achieved through the system, however, the presence of heavy machinery always has a residual safety risk. One risk is that in the production line, there is now a **multi-axial robot**. This can theoretically pose a physical risk should a worker get too close to it. There are safety measures in place, including that workers cannot enter the robot's workspace while it is active, however, should these fail or be deliberately ignored, the system could collide with a worker. Other risks include malfunctions in the two software systems mentioned above (guiding and vision) that also affect the industrial robot workspace. These hazards are countered with **additional safety arrangements** in the robot workspace. This includes perimeter guarding surrounding the robot workspace so that the operator does not have access to the moving robot. There are also **safety functions** integrated into the robot controller, limiting the movement of the robot, if needed. There is a high level of awareness regarding physical dangers in the lumber industry, however, the interviewees reported a partial reliance on this awareness, rather than implementing additional security measures. The interviewees also stressed that when working with heavy machinery, there are always physical risks in case of an accident or malfunction.

5.1.2 Residual environmental risks

Identified risks within this sawmill were considered rather general, mainly stemming from the use of an industrial robot, in the form of **mechanical risks**. While the whole system was designed to limit exposure to environmental factors of a sawmill like **noise** and **dust**, the advanced robotic system could not eliminate them entirely.

5.2 Opportunities

The introduction of the advanced robotic system to the production site also held numerous OSH benefits and opportunities.

5.2.1 Physical workload and health

The primary OSH opportunity of this system is the **reduction in physical workload** and increased physical health as a result. As previously mentioned, workers in sawmills typically remove unsuitable pieces of wood at operating speed, or stop the whole belt should that not be possible. In this line of work, lumber pieces can be very heavy. Workers no longer having to lift this weight possibly several times a day can have **long-term health benefits**. Additionally, handling this weight manually always contains the risk of a serious accident, which is now no longer the case.

5.2.2 Wellbeing

Possible psychosocial OSH benefits can be achieved through the worker being **removed from a dangerous environment** and improving safety for those times when coexisting in a space with the robot is necessary. Sawmills are known to be dangerous workplaces, therefore, making it safer in any way can increase the feeling of safety for workers and thereby be beneficial for the workers' overall wellbeing.

5.2.3 High-risk groups

The interviewees noted that, especially with regard to the AI-based vision system, the range of workers theoretically being able to work for the sawmill has **expanded**. The AI can replace the capacity of the human eye to an increasing degree. Previously, **sight impairments** could have hindered job performance and safety, but now, as the system has automated this task, this is no longer the case.

Hence, the interviewees did **not identify a specific high-risk group** to work with either the AI or the robotic part of the conveyer belt. Only those who would be physically unfit to perform the task manually in case of a partial system shutdown could be considered at risk, however, this is unrelated to the new technology.

5.2.4 Monotony reduction

The visual inspection of moving lumber on a conveyer belt can be repetitive and monotonous, and requires long periods of concentration. The monotony can result in workers feeling fatigue, while continuous concentration can be **mentally exhausting**. The AI-based vision system automates this task completely. Workers now perform other tasks, like supervising the system output, and can experience **larger task variety**.

5.3 Barriers and drivers

Many companies go through the process of integrating advanced robotics or AI-based systems in their workspace for the first time. The present case study encountered a variety of barriers and drivers throughout this process. Identifying these can help this company as well as others avoid barriers and promote drivers for their process automation.

5.3.1 Barriers

There is a high level of awareness regarding physical dangers in the lumber industry, however, the interviewees reported a partial **reliance on this awareness as a safety measure**. However, it is not enough to only educate workers on possible dangers of a machine. Rather, companies should implement additional security measures beyond the minimum requirement. **Working against an industry culture** can be a barrier in increasing OSH at any workplace, should workers not comply with the safety rules added, but rather rely on assumed correct behaviour.

5.3.2 Drivers

One success factor in the implementation of the system is **active collaboration between the sawmill and the technology integrator**. There has been a continuously running dialogue throughout the entire process.

In this case, the company uses advanced technology and reduces OSH risks associated with heavy lifting, noise and other environmental hazards typical for lumber production. However, the final scope of the technology and possible future automation is hard to predict, even for the system developers themselves. The capabilities of deep learning are especially difficult to foresee. The interviewees reported many discussions on this topic, in terms of both collaborative machines and AI-based systems.

Another driver mentioned by the interviewees is both the **ability and willingness of all participants to approach an industry standard, including its problems, and think outside the box to solve them**. As current practice shows, sawmills can function without the use of AI-based systems and robotics. However, seeking solutions for the problems this set-up has, beyond what is already being used in the industry, led to the creation of this combination of AI and robotic technology. The mindset to innovate and improve is therefore a foundation and driver of OSH improvements through AI-based systems or advanced robotics in this particular case.

To a certain degree, the **sawmill's managers' willingness to deviate from industry standards** is also credited as a success factor in this project. They approached the integrator with an idea previously non-existent in the industry. This also meant they have foregone the possibility of testing different models before deciding on one for their company, as others can do when selecting a cobot. However, as they communicated their goals and needs for the technology clearly, the integrator was able to deliver a system novel to the industry.

On the development side, **the clear set of rules regarding machine safety** through the CE labelling and process of handing it over to the customer was also identified as a driver in the success of the project. The **Machinery Directive** especially provides a **clear and structured guideline**. The **CE certification** ensures that the integrator provides a correct and safe product, and that if operators follow the given instructions and make reasonable adjustments only, the system stays safe.

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 expectations towards the new systems regarding OSH were both **physical** and **psychosocial**. The robotic system was expected to reduce physical workload and exposure to loud and repetitive noise, heavy lifting and dust. Simultaneously, the AI-based vision system was expected to **reduce fatigue from looking at the conveyor belt for too long**. As mentioned above, the sawmill was built with the technology from the start, hence these expectations were more general, and not related to any ongoing practice. So far, the expectations have been met by the system.

5.4.2 Emerging OSH risks and monitoring

During the development of the system, there has been an ongoing dialogue between the sawmill and the developers concerning any emerging problems, including OSH risks. The interviewees did not name any newly discovered OSH risks with regard to this technology. Known risks, like the remainder of physical tasks to be completed by workers, were addressed with adequate safety measures. The **system itself does not have a way to monitor for OSH risks**, however, as lines of communication should a problem be encountered have been established, any new OSH risks will likely be addressed in the same way.

5.4.3 Communication strategies

Communication strategies, specifically regarding OSH, in the system include the training that workers receive, as well as readily available instructions. Furthermore, **warning signs** have been put in place, both on the shop floor and the **user interface** of the AI. Should any OSH risks emerge, workers will be informed directly. In addition, the integrator of the system will be informed as well.

5.4.4 Organisational and social impact

As the sawmill was established with this technology from the start, it has not undergone any organisational or social changes. Only in comparison to other sawmills, which do not use this type of technology, can one see differences. Workers are moved from solitary positions on the conveyer belt into a supervisory space. The interviewees indicated that these are not solitary offices, hence social interaction for workers is potentially increased due to the introduction of this system.

5.4.5 Integration of OSH management

To manage any remaining OSH risks, the system developers highlighted the importance of CE certification for the technology. Additionally, they provide the standards used to build the machine to the sawmill and the system complies with the **Machinery Directive** 2006/42/EC.

Training is highlighted as a primary and important tool to manage any remaining OSH risks. This includes providing special training for workers to ensure that the person with the **right qualifications** is in the right place at the right time, to address a situation.

And lastly, technological safety measures, like a gate around the system that can only be opened once the robot is turned off, help manage OSH risks as well.

Compared to other sawmills, this company needed to train and upskill their workers to use the new technology safely and effectively, before starting the production process. Even experienced operators from a traditional sawmill set-up needed to be trained to work in this environment, on top of their previous training.

5.4.6 Need for action

When asked if there was any identifiable need for action from any stakeholder (operators, data security officers, health and safety engineers, managers work-councillors and technology officers), the interviewees solely stressed the importance of enabling operators to receive the necessary training to safely use the machines. This, however, was highlighted as of general importance for any company that considers using this type of technology, not in relation to this specific case study.

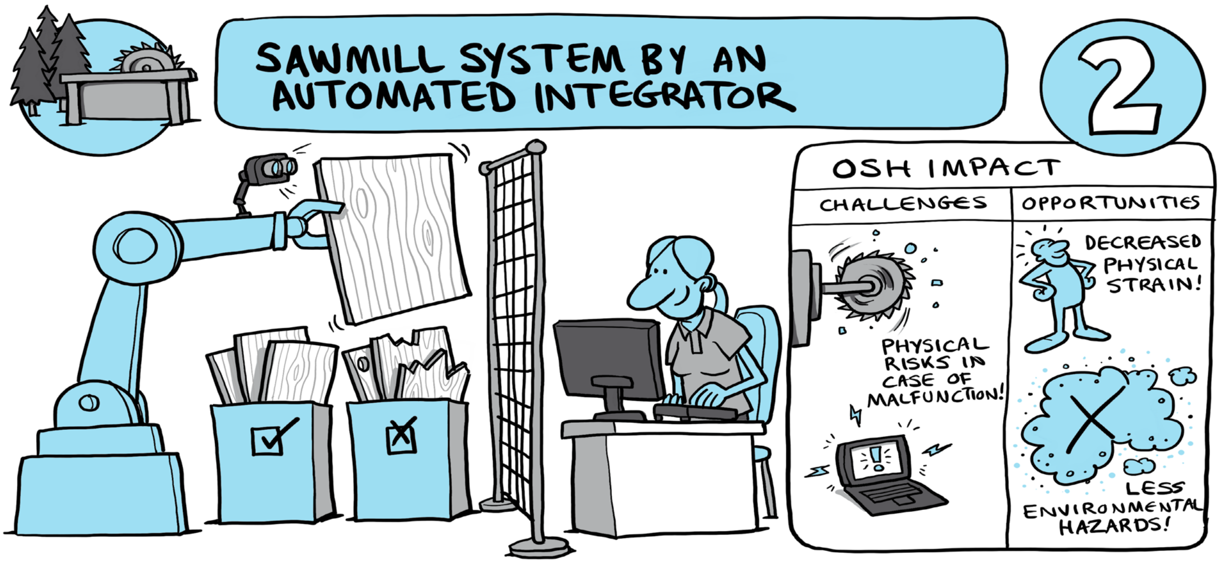
5.4.7 Cybersecurity

With technology becoming increasingly interconnected and data itself being a resource needed by some 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 measurements, depending on their use.

The implementation of a new technology can, in some cases, lead to changes being made to a company's existing cybersecurity. In this case study, **no additional steps towards cybersecurity** were taken. It is entirely protected by the general cybersecurity measures the company has in place. The AI-based system **does not handle any person-related data**. Additionally, the advanced robotic parts of the system itself are only connected locally, not to any other server. This way it is an unlikely target for a cyberattack, as it is not a feasible point of entry into the system.

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

Figure 3. Cognitive and physical posing challenges and opportunities for OSH



6 Key takeaways

There are a number of key takeaways gained by the experiences in this case study from introducing an AI-based vision system in combination with a robotic system into their workplace.

One of them is the role of **risk taking and innovation** in OSH. New technology, like AI-based systems, advanced robotics or machines that utilise both, like in this case study, currently presents new ground for most companies. But even within this new technology, it is possible to innovate and create solutions uniquely suited for a specific application that has greater OSH benefits compared to any previously existing solution. Hence, it is vital to create and nourish an economy-wide culture of innovation, and to support companies that strive for new solutions to existing OSH problems.

This coincides with a larger issue regarding **industry conventions** and mindsets. If a procedure is widely considered to be an industry standard, plans to change it and subsequently related routines and practices can lead to headwinds during the development and implementation of said technology. In this case, clear communication between all included parties is especially relevant. The positive effect of a company's mindset to specifically break with industry standards and set a goal to be highly innovative can be seen in this case study.

Lastly, in this case study, interviewees continuously highlighted how beneficial it can be when the **legislation and technological requirements fit the technology in question**. This case study specifically highlights the Machinery Directive as providing detailed guidelines on several factors. This makes the development process easier, as well as the instruction and communication with the operators on how to use the system, and how to use it safely. If all relevant factors are sufficiently addressed in the official directives, they can prove to be supportive for all stakeholders involved in the implementation process.

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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.