A ROBOT AUTOMATING MANURE CLEANING TO MAINTAIN HYGIENE IN LIVESTOCK (ID11)

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 **Dutch technology developer focuses on agricultural machines related specifically to the tenure of milk cattle**. The company was founded in the 1950s in the Netherlands, and currently employs more than 2,000 workers at two production sites. Among their customer target group are agricultural institutes and farmers who are using their products in over 45 countries both inside and outside of the EU.

A core value of the company is innovation. They present it as a fundamental prerequisite to face future challenges of food production and a growing population. Next to becoming more efficient, food production must also become more sustainable. By developing advanced robotic and AI-based systems, they see a path to create a work environment that is not only more profitable but also more sustainable both for the farmers and their cattle. They approach this through a holistic view, where they provide interconnected innovative technology for the whole production site. Their product range covers advanced robotics for cleaning and providing food to the cows, to AI-supported operational management.

Working in agriculture has historically been demanding physical labour.[1] Innovative technology offers a way to make working in this sector not only safer and more efficient for the animals involved but, most importantly, also for the farmers.

As the company is the developer of several advanced robotics and AI-based systems, and not the end user, the company has a unique perspective on the implementation process as well as the OSH impact of the technology. During the implementation process, **they work closely with their clients** to gather valuable insight for their operations and future technological developments.

3.1 Description of the system

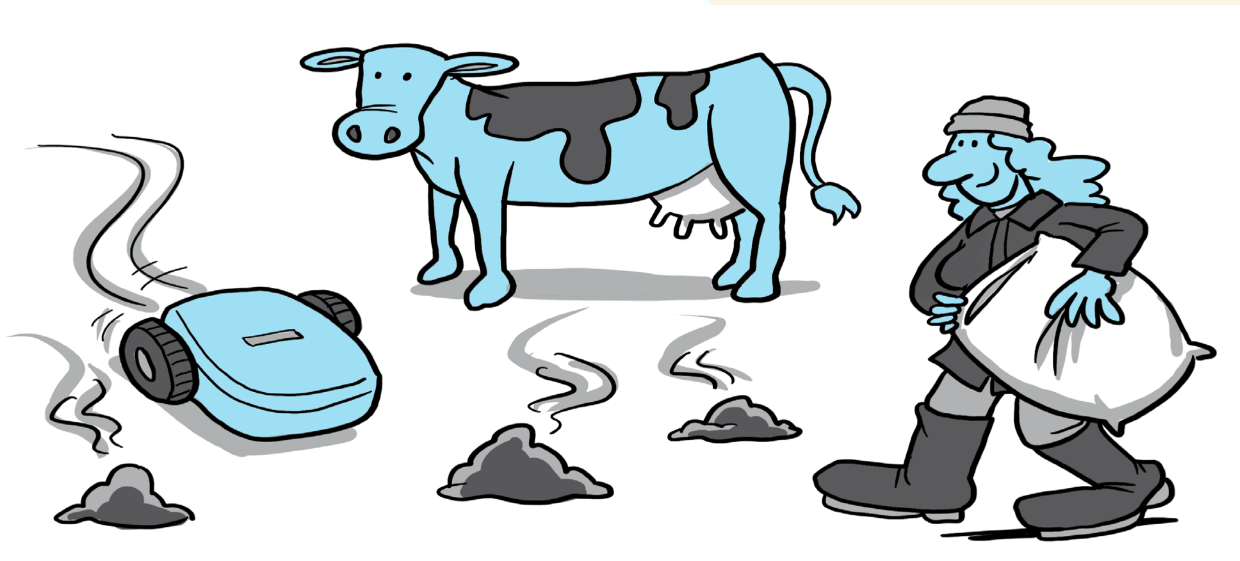
As indicated above, the company produces a wide variety of advanced robotics and AI-based systems for the agricultural sector, including milking robots, feeding robots and cleaning robots. They can be used to automate a wide spectrum of tasks. **This case study focuses on a cleaning robot that is used to maintain hygiene inside the cow enclosures.** It is important to maintain hygiene in a milk cow's living space because it reduces the risk of the cows falling sick.

The specific robotic system presented in this case study is an **autonomous driving robot that specialises in manure clean-up**. The robot autonomously drives through the stables and collects manure in its tank. Once it is full, it drives to a deposit station and empties its tank there. The robot can navigate around the stables and cows. Ideally, after setting up the robot for the first time, it performs its daily routine autonomously. Individualised routes through the stable can be programmed with a daily schedule, typically averaging 8-12 cycles daily. If needed, the robot can also drive to a docking station to recharge. All their advanced robotics function on batteries, as part of their goal to reduce direct emissions as much as possible.

The robot itself has several means to navigate the farm's surroundings, which are mandatory for it to be usable in an environment where both humans and cows walk around in unpredictable ways. They have sensitivity bumpers that are triggered if an obstacle of 15 kg or more is encountered, which triggers the auto-stop function in the robot. The robot also has LED lamps for visual indication as an additional safety measure. Audio signals are also emitted by the robot to communicate to the cows that they stand in the path of the robot (the cows are capable of learning what the sound signal means).

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. A robot automating manure cleaning to maintain hygiene in livestock

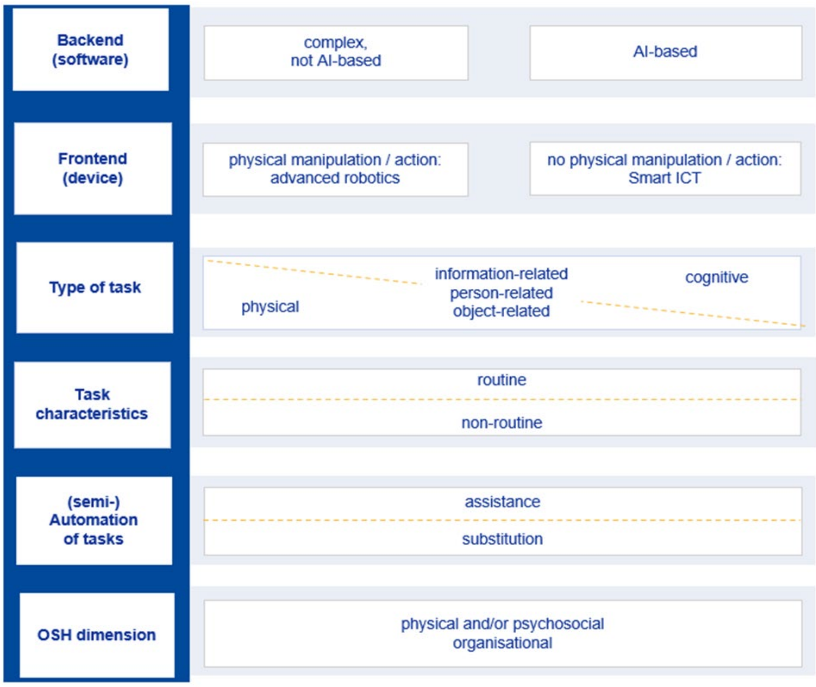


[1] Jakob, M. C., Santa, D., Holte, K. A., Sikkeland, I. J., Hilt, B., & Lundqvist, P. (2021). Occupational health and safety in agriculture – A brief report on organization, legislation and support in selected European countries. *Annals of Agricultural and Environmental Medicine, 28*(3), 452-457. https://doi.org/10.26444/aaem/140197

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.[2] 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 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



According to the taxonomy developed for this study, the advanced robotics system performs a **physical task** without an **AI-backend software**. The task itself is **object-related**, as well as **a routine**. Its task is to move manure, **which can be classified as physical manipulation of its surroundings**. The advanced robotics system navigates its surroundings autonomously by using several types of sensors and cameras in order to **substitute the farmer's work**. The farmer generally no longer performs this task manually. This reduces physical workload for the farmer. The OSH dimensions, which are affected by the advanced robotics, are primarily physical and organisational.

The interviewees outlined that there are a number of advanced robotics that they offer to farmers, which can be used simultaneously on a farm. The manure-cleaning robot specifically impacts farmers and their maintenance staff the most directly. However, most farms today have a non-robotic solution for manure cleaning in place; but the advanced robot performs the task more effectively. Hence, the **general work activities of the farm staff** do not change due to the robot's presence.

So, while the farmers' **job content** has undergone change, this change is not solely attributed to the implementation of a singular manure robot but more to the automation of agricultural work through robotic systems in general. Every single robot contributes to it. Manure removal was previously done by a non-robotic system in most stables so, for the vast majority of farms, the job content of removing manure was no longer performed by humans regardless. However, the introduction of the robotic system resulted in an **expansion in job content** for the farmer. They now have to monitor and maintain the robot, as needed. This requires new skills, which they can gain through special training.

[2] 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

Regarding their **routine**, farmers have gained a certain amount of flexibility from using robotic systems. A farm and cattle need to be taken care of 24 hours a day. Robotic systems can perform their tasks independently from normal working hours and do so without tiring. This allows farmers to schedule the automated tasks as needed, and they are free to allocate their remaining time to other activities.

The robotic system presents an interesting case study, as it performs its task largely autonomously even though it still shares its workplace with the farmers. The farmer not only has to be aware of the robot in terms of scheduling and maintenance tasks but also of it as a physical presence in their workspace. The robot has the means to avoid obstacles (a requirement needed to work around living animals effectively). Nevertheless, it is a new, moving presence in the workplace.

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 advanced robotics in the agricultural business. These goals align with some of the farmers' goals.

The company produces advanced robotics **to improve the working conditions on dairy farms as well as the living conditions for dairy cattle**. They advocate for good animal treatment and see their technology as a means to contribute to that.

A goal during the implementation process is to **make the farmer independent from the company** in their use of the system. Once the robots are installed, farmers should be able to perform basic maintenance or change the routes as needed. This way, they are empowered to create a workplace suited to their needs.

Farmers who typically buy these advanced robotic systems, including the aforementioned manure robot, also typically **seek to improve the hygiene of their livestock**. Furthermore, they want to **gain more autonomy over their time and workspace**. Having a robotic system that can be programmed to fit one's individual needs, and be remote controlled if needed, offers them increased flexibility in their work and social life.

From the company's point of view, the advanced robotics and AI-based solutions have contributed to reaching their goals, however, they see that there is continuous room for innovation and improvement. The farmers also report the positive effects of the system, successfully reaching their goal as well.

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 Implementation steps

The technology developer has a creative department for idea development. They try to come up with new, innovative technology, or otherwise improvements to existing systems. After an idea has been approved for development, it is sent over to a continuous development department for verification. The verification process includes test runs in workshops, which are clean farms, meaning they have no fodder or manure, and 30-40 actual test farmers, to test the system under real-life conditions.

The rough development process starts at conception, then continues with verification through test farmers and progresses to validation through commercial users. **The implementation process of the robotic system at a farm can vary.** It is highly dependent on how much technology is already present and being used as well as what type of advanced robotic system is being installed. The technology however is highly adaptable, so it can be adapted to virtually any farm set-up.

After the **robot is installed by a service mechanic**, one or two base routes are programmed with a daily schedule set by the farmer. This typically averages 8-12 cycles being driven daily, but this frequency is adaptable to the farmer's needs. After this set-up, the robot can perform its task autonomously, with no need for human intervention. In the case of alarms, incidents or disruptions of any kind, the farmer is informed through a digital platform, which can be accessed by phone, tablet or computer.

After a farmer has purchased a robot, they also have access to Farm Management Support. This department helps farmers gain insights on automation opportunities for their farms and provides advice. The robot needs maintenance every 3-6 months, for which a specialist from the company comes to the farm.

4.2.2 Standards and regulations

For the robot to be usable in an environment with living cattle and humans walking around it, it must meet several safety standards. Firstly, it has specialised bumpers that detect obstacles of 15 kg or more, which triggers a stop in the system. The trigger weight had to be carefully set, as the main task of the robot is to move objects (manure). Hence, a too-low threshold would have decreased the robot's efficiency, and too high a threshold would have made it unsafe. LED lights are also mandatory for autonomously moving robotic systems in the Netherlands to help farmers see the robot.

4.2.3 Difficulties and challenges during the implementation

The robot was developed to be easy to install and function in virtually any cow stable. **Difficulties encountered during the implementation typically stem from the farmer's side.** To use the technology, one needs a basic level of technological understanding. However, there are cases in which farmers do not own a smartphone or tablet. This significantly limits the usefulness of the robot, as alarms cannot be accessed, it cannot be remote controlled from anywhere but the stationary computer, and the communication with tech support is limited without a smartphone (sending pictures of any possible incidents or physical defects is significantly more complicated).

Interestingly, some farmers also encounter physical challenges. The joystick, which can be used to remote control the manure robot, also contains commands (for example, on-off) to improve usability. However, for some farmers, the joystick is physically too small for their thumbs to use it precisely. This typically requires some familiarising with the joystick to use it as intended, but the option for different-sized controllers could be considered in the future.

Another problem they face during implementation is a lack of standardisation between different technologies. The robots ideally are to connect with the Internet and Wi-Fi in the same way as a smartphone and laptop, but that is not the case at the moment. This is a challenge that is currently being worked on.

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 initial development of the technology is done by experts in the field of robotic development and agriculture. However, this is done, as described above, by a team inside the developer's company. However, involvement of the end user, in this case a farmer, is a priority 5he the company. They have **dedicated test farms that get involved in the development process, as early as prototypes are available, to provide feedback for the robots' further development**.

As for worker involvement at the farms, this differs from case to case, heavily dependent on the farm size. Many dairy farms are still family-owned, hence there is not necessarily a traditional separation of departments. Typically, buying a robotic system is decided by the owner of the farm, and the rest of the farm staff are informed about the change accordingly.

4.3.1 Training and worker qualifications

Worker training and education is a major element for the success of technology implementation.[3,4]

To set up the system, the company provides a skilled worker. They perform the physical set-up of the robot as well as its charging station and, together with the farmer, they then plan the routes and routines for the robot. During this set-up, the farmer learns how to interact with the digital platform used to set routines for the robot, so they can be changed if needed. Other than that, the robot does not require any specialised training. Any alarms set by it are comprehensible to a first-time user, and for any specialised technological problems, maintenance staff are informed.

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**. Given that the primary task of the robotic system is to move manure, developers and farmers do not see a risk of deskilling. Should a farmer not have any experience with advanced robotic systems, introducing the robot can expand their technological knowledge to a certain degree if they wish to learn about how the robot functions. The Dutch company also offers additional training for farmers to gain more knowledge on robotic systems and their maintenance, to help farmers be more independent from them.

The initial set-up also includes information on safety functions, like an emergency stop. All of this company's robots have sensors that can trigger **emergency stops, as well as remote shut down options for the farmer should an unexpected situation arise**.

4.3.2 Feedback system and report handling

The company highly values the feedback they get, not only from their test farms but from all end users. The feedback has been consistently positive. In singular cases, farms face issues with the installation of the technology. There are specific farms that require more attention due to a more complex set-up, or environment, which can be perceived to have lowered usability.

If something goes wrong with the cleaning robot, the farmer does not need to immediately inspect the system themselves manually, instead they can use a Bluetooth-connected remote control. Should a robot get stuck, the farmer can navigate it manually using a joystick towards its charging station for repair. **Minor incidents like this occur frequently and can be resolved by the farmer**, however, in the rare case that there are issues with the motor or tyres, farmers can call the company's mechanics to come replace the broken parts. In this process, speed is a focus of the company. Many of their robotic systems help the farmers in their daily tasks. Having a non-functioning robot for several days can create difficulties, as cows need to be milked daily.

Regarding OSH-related reports, so far, there have been no major incidents reported with the cleaning robot.

4.3.3 Level of trust and control

An adequate level of human trust towards the interacting system promotes appropriate system use,[5,6] while extreme forms of trust can lead to adverse effects. Excessive trust can lead to automation complacency,[7] whereas insufficient trust may lead to neglect of the technology.

The interviewees reported a very positive attitude from farmers towards the robotics systems once they were installed. They are perceived as a significant assistance to the farmers and have had a positive effect on the cows as well. There were no reports of incidents that indicate an insufficient or excessive amount of trust in the technology.

In addition to trusting the system, a worker's **level of control** can have significant influence on a number of factors. The farmer has full control over the robot and can control it remotely and manually at any time. The farmer chooses which primary routes the robot takes and at which frequency, and they can change it as needed. While the robot is following instructions, it moves autonomously and can, in theory, be an obstacle for anyone who does not have access to the remote control options. In the case of dairy farms, this can be, for

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

4 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

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

6 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

7 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

example, veterinarians or farm workers occupied with other tasks. However, even if the remote control cannot be accessed by a person who encounters the robot, it has safety measures in place to avoid dangerous collisions.

The question regarding whether the robot use is mandatory or choice-based depends on the situation. In theory, those on a farm who have access to the robotic control can decide to not let the robot do its routines and perform these tasks themselves. This is generally very ineffective, results in hard labour and is typically not done. The robot developers also try to decrease any downtime from defects with the robot by providing immediate support. So, theoretically, farmers have the choice not to use the robot, but no incentive not to do so once it is set up.

4.3.4 Company culture and structure

The changes that automation through advanced robotic systems can bring to a workplace can impact both company culture and social structures. The extent of this differs from system to system and company to company, but it is an effect that should not be overlooked. Regarding the cleaning robot alone in this case study, no changes to the company culture or social structures were named, with regard to the feedback they have from their test farmers. However, looking at the bigger picture of automation, they are aware that the automation of tasks through advanced robotic systems leads to a significant role and responsibility shift on a dairy farm. **By introducing robots to their farms, the farmers shift away from the traditionally perceived roll of manual labourer, towards becoming a manager.**

Interestingly, there are observations on the social behaviour of the cows, which now share a living space with the robotic system. This robot apparently is sometimes treated as part of the herd by the cows. Cows are known to be intelligent and social animals that react to their surroundings. The robot often drives among the cows, which learn to interpret its noises and react accordingly. A cow seems to need 1-2 weeks to accept the robot.

4.4 Future developments

As the company is the primary developer of innovative agricultural technology, they firmly intend to continue innovating and developing new systems in the future. In addition, they are also interested in constantly improving on their existing products.

Taking an outside perspective, they see an increase in advanced robotics being used in an agricultural context. To them, this development started in the early 1990s and is unlikely to stop anytime soon. The variety of technology that can be developed nowadays allows farmers to work more efficiently and flexibly. This, plus rising costs, provides incentive for farmers to work with advanced robotics.

They have a roadmap for their operations until 2025 — which will be followed by one until 2050 — that heavily focuses on improving communication between their advanced robotics, their data and the cloud. They also develop robotic systems that communicate their needs with one another (for example, a feeding machine informs a transport robot that it is low on fodder. The transport robot then autonomously collects new grass and brings it to the feeder). These types of technologies can significantly impact the role farmers will have on a farm in the future. The company expects that innovation will be guided by the data they collect from their test farms to develop advanced robotics tailored to real-life needs, with improved quality, effectiveness and user-friendliness. Another focus of their future developments is the reduction of emissions.

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. In addition, 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 might also present 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.

5.1.1 Physical safety

The company stresses that their robotic systems are developed with safety as a priority. However, as it is an autonomously moving robot that shares the same workspace with farmers, they also acknowledge that there is an **existing physical risk**. Currently, the robot's force stop functions when it comes into contact with objects of 15 kg or more, which is compliant with the law and the company's own safety testing. In individual circumstances, a collision could still result in a person tripping or falling. This, however, is described as unlikely.

5.1.2 Negative attitude towards robots

There are individual cases of farmers having a negative attitude towards technology or robotics. This makes it less likely for them to buy the system. However, these attitudes can also be present in their workforce. It is possible that this attitude is connected to the fear of job loss as a result of the rapid changes that the agricultural industry has undergone in the last two decades.

5.1.3 High-risk groups

While not a specific high-risk group for a person-related characterisation, test farmers can be considered at higher risk than commercial end users. In theory, they test the system prior to its final updates, while it is in its prototype stage. Here, malfunctions cannot be ruled out entirely. However, to reach the prototype stage, the system already needs to comply with the general safety standards of the company and the law.

5.2 Opportunities

The introduction of the advanced robot to farms also holds numerous OSH benefits and opportunities.

5.2.1 Mental workload

The reliability of the manure robot, and robotic automation of farms in general, is described as decreasing the mental workload of farmers. As the robotic system does not fall sick or tire, farmers generally rely on it to perform its tasks to the expected standard. There is no need for supervision with the robot. Knowing that a task will be performed to high standards, without having to schedule it to be done by someone manually, can be a relief on mental workload.

5.2.2 Physical workload

While the general task of manure cleaning was automated on most farms to a degree, it was far less flexible and covered less surface area than this robot. Hence, farmers still had to manually remove manure from the enclosures. This is a physically straining task, often performed in a forward-bending posture. With the robotic system, not only can it cover more ground than a fixed system, it also performs the task better, decreasing the need for a farmer to manually intervene. Furthermore, the robot can be remote controlled to leave its programmed path. Therefore, it can also be used to spot clean. Overall, this reduces the physical workload of the farm staff.

5.2.3 Flexibility

Schedules on a dairy farm used to be tied to the natural daily cycle of the cows. They need to be milked twice a day. During these times, the stables are less full, which results in tasks that need to be done inside the stable (like removing manure) having to be performed during these times, and so forth. With the robotic system in place, tasks can be assigned to it during these times, freeing the farm worker to do other tasks. Furthermore, the robot does not tire, hence it can be used continuously. By scheduling the robot to do its tasks outside of normal working hours, or in tandem with other tasks that need to be performed on the farm, the work staff has greater control over how they spend their time, and also when they can take time off.

5.2.4 Social interaction

Speaking in the larger context of automating tasks on a dairy farm through advanced robotics, not only the manure robot, some farmers report an increased social life. As more and more tasks become automated and need less and less human intervention, farmers are free to allocate their time to other things. This can include other work tasks, and some time will need to be allocated to manage the technology on the farm, however, this also includes spending more time socialising outside the workplace. This includes a social life and more quality time with family or other social contacts. In select cases on family farms, it is now possible for some family members to pursue a second career, and only attend to the farm part 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 to avoid barriers and promote drivers for their process automation in the future.

5.3.1 Barriers

A barrier encountered by the company is a **lack of skilled workers, specifically service mechanics**. There is a shortage of these types of workers in the current market. This can slow down roll-out of advanced robotics. The Dutch company is already trying to address this shortage by actively training people themselves.

Another barrier is a **lack of compatibility between farms and the robotic technology**. Most farms were not created with robotic systems in mind, hence the technology has to be fitted to the environment. This can be a challenge when corridors are not accessible to the robot, hindering it from fully performing its tasks. Today, farms are being built with these types of technology in mind, but setting up the robotic system on an older farm can make the process significantly slower.

5.3.2 Drivers

A factor that has accelerated the implementation rate of advanced robotics like the manure cleaning robot was the COVID-19 pandemic. It increased the need for autonomous technology, which allowed people to keep working without risking their health. **The increased demand was challenging at times, however, overall, it was a driver for the company.**

Another positive influence on the development and implementation of advanced robotics in the agricultural sector is the accumulated experience. With around 10 years of experience with these types of robots alone, and more with automation in general, it has become easier to develop new systems tailored to farmers' needs.

Lastly, the **cooperation with the farmers running their test farms is a significant contributor to their success**. The insight gained from testing a system in its future work environment is invaluable to drive innovation and create technology that is functional and robust.

5.4 OSH management

New technologies can lead to a change in work procedure. This includes expectations for the technology and subsequent OSH management. The interviewees highlighted that OSH is a major motivator for change in their workplaces, to the point that they have implemented systems to primarily increase ergonomics, not economics.

5.4.1 Expectations for OSH

The manure robot is intended to make the work life of farmers easier and more flexible. Simultaneously, the technology was expected to increase hygiene for the cows. It has to be said that while the system can increase hygiene, it does not mean that the farmers' workplace is now free of the natural amount of dirt that comes from working with livestock. The central expectation for OSH regarding the manure robot, and robotic automation on farms in general, is to create a **workplace for farmers that is not only less physically demanding but also allows for more flexibility**. This expectation so far has been met.

5.4.2 Emerging OSH risks and monitoring

The company is continuously testing their robotic systems for any defects or developments. This includes developments concerning OSH. Once the robot is installed on a farm, the degree of monitoring is decided by the farmer. Depending on the contract, the robot can collect data on its status and monitor itself for critical developments (like material wear). This, however, is an additional service.

They mainly use their test farms to monitor for any OSH-related developments and rely on their feedback in combination with the robot's own data.

5.4.3 Communication strategies

Should there be any major OSH developments, farmers will be informed by the company. Regarding general developments, farmers are informed about updates by the control software. Farmers can also choose to improve their technical skill set through training. This training goes beyond the instruction received to use the robot and is voluntary. For any concerns, including OSH concerns, farmers can contact the service department of the company.

5.4.4 Organisational and social impact

For farmers, the organisational impact highly depends on the prior level of automation at their farm. Should this be the first robotic system, it can trigger significant changes, and even more so if no manual manure cleaning system was in place before. It allows farmers to spend more time managing their farms and attending to their cows. As mentioned before, **the reliability and autonomy of the system might also impact their social life positively**.

5.4.5 Integration of OSH management

When the company started to develop autonomously moving robotic systems, they knew they needed to develop new OSH features. This can be seen in the added sensors and safety measures like in the interface. To adjust these new features, they not only adhered to the law-based force maximums, which such a machine is allowed to exert, but also did extensive testing themselves. For robots that move, they created test dummies to model and test collision scenarios with people, cows and structures. Based on their own research, they adapted the level of force needed to stop the robot. Push forces were lowered significantly, not just for safety reasons but also so that tires and motors last longer.

5.4.6 Need for action

The interviewees see a general need for an awareness campaign regarding the risks, but mostly refer to the benefits of robotic systems. They perceive there to be too many misconceptions and prejudices against advanced robotics. This limits their ability to be used for improving OSH on farms. They perceive robots as a tool to allow farmers to do their work more safely and effectively but are aware that some hold negative attitudes towards them. They would like this to change in the future as they see that automation is the logical next step in agriculture.

5.4.7 Cybersecurity

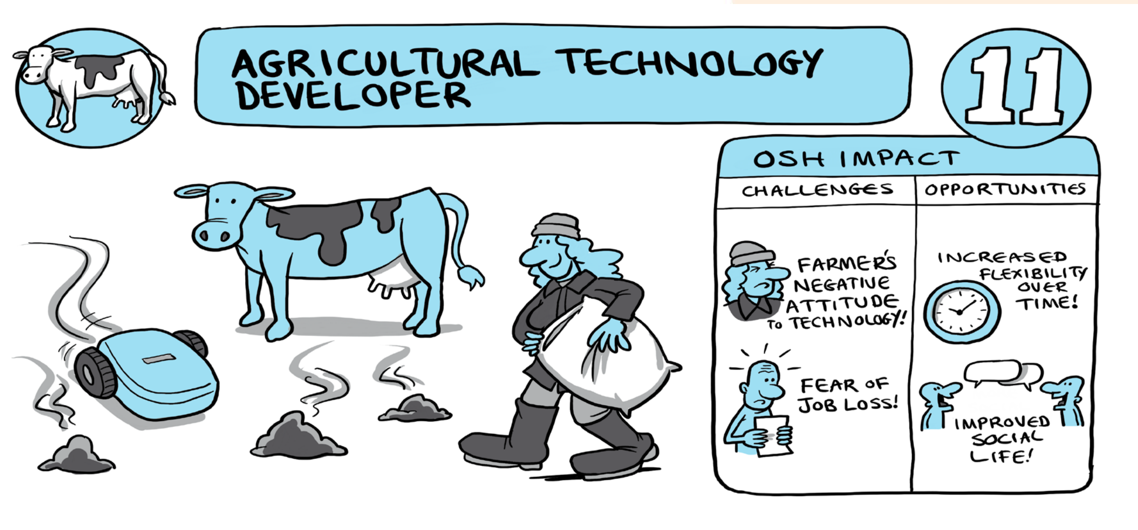
With technology becoming increasingly interconnected and data itself being a resource needed by some advanced robotics and AI-based systems to improve their functionality, the topic of cybersecurity becomes prevalent in companies using these technologies. Some systems might require additional safety measures, depending on their use.

Firstly, the manure robot does not collect any person-related data. It does not have the ability to do so. Sending the data it can collect (for example, runtime) to the company is an optional feature for the farmer. If the robot is used in combination with the Dutch company's farm management system, the farmer can access 10hese data. **This management system has the option to assist the farmer in strategic planning using an AI-based software.** This, however, is also optional.

The company's technology is programmed so that certified users can access their own accounts. All data are protected under security measures. However, the **robot itself is an unlikely target for a cyberattack**.

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

Figure 3. Manure cleaning robot, posing challenges and opportunities for OSH



6 Key takeaways

This case study presents a robotic system that automates a task that was largely automated by non-robotic technology previously. The advanced robotics offer farmers a way to improve upon the manual solution by being faster, more flexible and performing the task to a higher standard. This directly affects their final product: dairy. By improving the hygiene standards for milk cattle, the cows are less likely to fall sick, saving the farmer money and avoiding the loss of livestock.

This case study is a good example of how robotic automation incites a shift in the work content of farmers. **A previously highly physical job is now shifting towards taking a supervisory role over a number of robotic systems automating several tasks on the farm.** The farmer still makes the executive decisions about what is done and when it is done, however, more and more tasks are performed by robots. This shift needs a certain openness towards technology to succeed. In the experience of the company, farmers who have an initial reservation towards the technology quickly realise the benefits they gain from them once they have experienced them first-hand. This leads interviewees to expect the introduction of more and more advanced robotics on dairy farms.

As seen in other case studies, advanced robotics and AI-based systems are not always and exclusively employed at workplaces that formally had no automation. More and more frequently, they replace technology rather than human labour directly, as a task was already automated in some way. This way, they are a means to increase production quality, rather than improve OSH. This does not mean that they do not impact OSH; they do so in a different way, using technology to automate a previously fully manual task. **These types of advanced robotics allow for organisational changes, based on their higher quality of work.** For farmers using this specific robotic system, this can also mean mental benefits, as they know that their cattle are healthier due to the robot. They also have greater control over the advanced robotics than the manual one (remote control), and gain information from the robot that the manual system could not provide. So, while the robot automates a physical task, it puts the farmer in a position to make more informed decisions, with fewer spatial constraints, as the system can be accessed online.

This case study shows that just because a task is already automated, partially or fully, **there are still benefits to continuously considering options for further automation through a more advanced technology**.

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