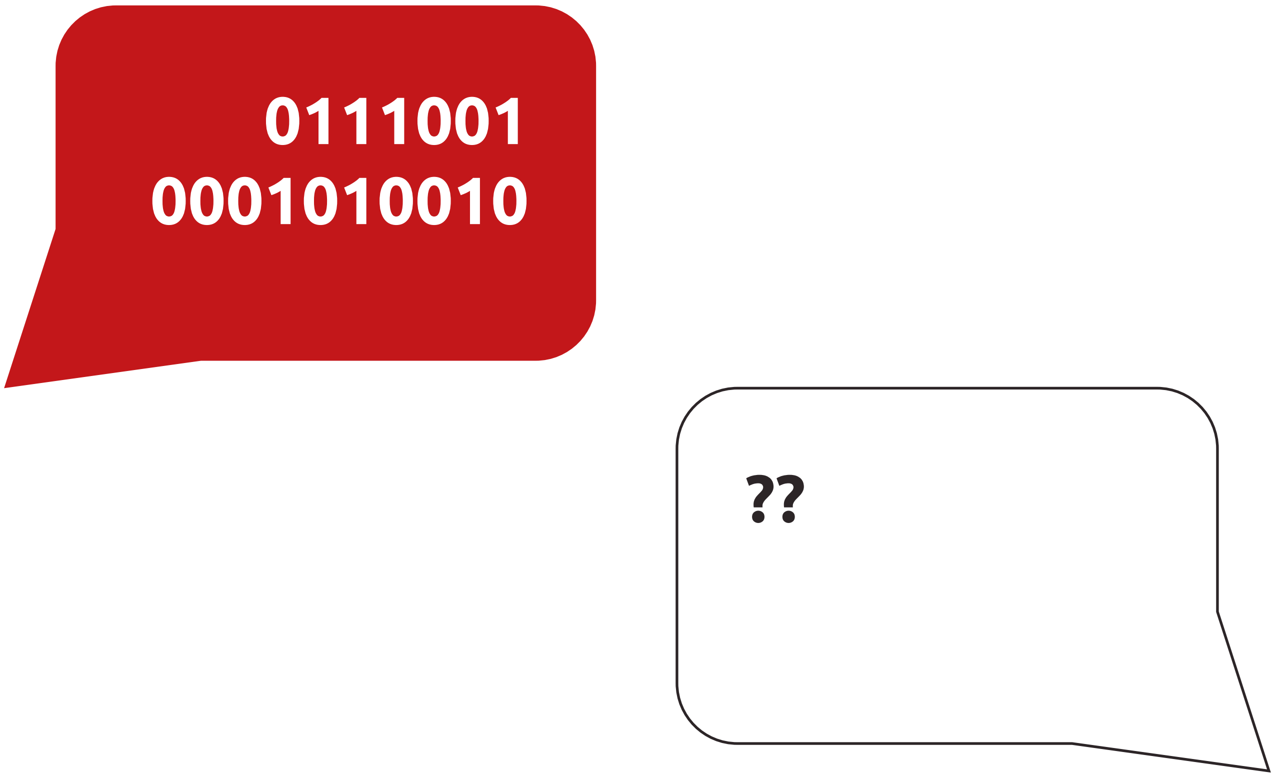

ROBOT CODE OF CONDUCT

Pleasurable, Cohesive and Appropriate Behaviours for Automated Dairy Farming

Master Thesis - A Robot Code of Conduct
Developing guidelines to steer the design of behaviours of smart agents on automated dairy farming.

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Thesis Report
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In collaboration with
Lely Industries N.V.

"So often we subconsciously compare robots to humans and AI to human intelligence. The comparison limits our imagination. Focused on trying to recreate ourselves, we're not thinking creatively about how to use robots to help humans flourish."

Kate Darling

ACKNOWLEDGMENT

First of all, thank you so much to everyone that made this project come to life because words fail to describe how much I enjoyed carrying out this thesis. Thanks to everyone at Lely for the opportunity to explore this thought-provoking topic and for always making me feel part of that vibrant family. I want to thank all the experts that I talked to during these months, you made this project possible by contributing with your time, interest, and knowledge. But I am especially grateful to the best supervisory team I could have wished for, who guided me like a lighthouse while supporting and encouraging my exploration. Thank you for being so involved and sharing excitement about this project, it was honestly a pleasure working with you.

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SUMMARY

Robot systems are essentially a new species spreading around us, one that we willingly designed and introduced. Neither a natural species nor a mere human artefact. We have limited information about these smart agents. What do they want, what do you need from us, and how can we find a common ground of understanding to enhance each other through collaboration. Lely took a step into exploring these questions.

As a dutch-based company with a diverse portfolio of robot solutions, Lely thrives to bring dairy farming to the future. They cover many tasks assisting farmers and cows in barns worldwide. These increasingly capable entities are no longer tools but partners so we must take the next step into carefully designing our coexistence and collaboration with these robotic systems.

After extensive literature on Human-Robot Interaction (HRI) and research activities with a variety of stakeholders, I developed a Robot Code of Conduct. This code guides developers into designing robotic systems delivering pleasurable, fitting and cohesive interactions. It provides intermediate-level knowledge on robot behavioural design by carrying the reader through three sets of guidelines differing in abstraction and actionability.

This project contributes to the field of HRI while spreading awareness of its relevance in practice. The document contains many influential factors that are applied and tailored to designing automated solutions in dairy farming. This document sets a direction and gives concrete guidelines to steer the development of the portfolio towards a vision where all Lely systems work and communicate desirably. Where they communicate as one. I obtained positive results from assessing the content and direction of this document with developers and farmers, however, further tests would be necessary for a more precise validation of this Robot Code of Conduct. Future research would be essential to transition from bringing awareness to relevant factors, to defining more recommendations and appropriate solutions.

CONTENT

1

INTRODUCTION

1.1 Context of the project

Automation is designed to enhance human life. Products like the ones below (Figure 1) are solutions to provide farmers with a more profitable, enjoyable and sustainable future for their dairy farming practice.

They are part of the growing portfolio of Lely, a company based in the Netherlands that develops automated solutions to assist dairy farms worldwide. However, if you look at those machines, what are these entities exactly? What do they do? Can they be considered ¨smart¨? What makes us attribute them a certain degree of agency or even personality? **Robots are designed for concrete purposes. They adapt and evolved through time, and their intentions or the reasons behind their actions are often unclear.** Exclusively focused on dairy farming, there is a variety of solutions aiming to fulfil the same purpose but in different ways. Altogether it is intricate to understand, and therefore collaborate with robots. Currently, regulations are scarce. Standards like the ISO/TS 15066:2016 (International Organization for Standardization, 2016) cover intrinsic safety aspects and Asimov´s laws, but they do not move far beyond that. As a consequence, there is an obvious disparity in communication among automated solutions. Many recent initiatives state the need for robot regulations to cover unknown aspects of human-robot interaction, particularly addressing the roboticists responsibilities. **As for Lely products, unlike their behaviour and communication, their aesthetic design is cohesive and clear.**

Figure 1. Showcase robots Lely campus

All Lely robotic solutions, even those developed by third parties, look like one. The Red rules set a common direction in this matter so developers know how they should design the robots and why. Behaviours are more complex to define and steer than visual design due to the many factors involved and their subjectivity to change. Nonetheless, they have a vast impact on the user experience and even the success of the task. The robots are the ultimate ambassadors of the brand so they should act accordingly. **This project explores the potential of a code of conduct to guide the design of the robot and artificial intelligence.** This document aims to guide developers at Lely into designing cohesive, pleasant and fitting behaviours for their automated systems.

1.2 Assignment

The goal is to bring awareness to HRI at Lely, and assist its developers in designing robots to improve the experience delivered by these systems. This intervention must accommodate all current robotic solutions at Lely which operate in a variety of contexts. Additionally, to fit the high-pace innovative nature of Lely the final design needs to be flexible to future developments.

Figure 2 illustrates a summary of the process followed from the exploration and problem framing to the final design of a Robot Code of Conduct. I carried out design activities parallel to primary and secondary research. All the information acquired through literature and research with experts fed the final design.

I applied methodologies on participatory research, semi-structured interviews, observation, enactment, etcetera. However, I adapted them depending on the goal of the activity or questions to solve. **My process was therefore very organic and defined by the continued contact with stakeholders.** The coming chapters describe this process in detail. Ultimately I was designing two solutions in one which was challenging yet compelling.

- My target group were the company developers. The goal was to design an intervention fitting their needs and process.
- Nonetheless, the solution was meant to improve interactions between robots and farmers, technicians, cows and other users.

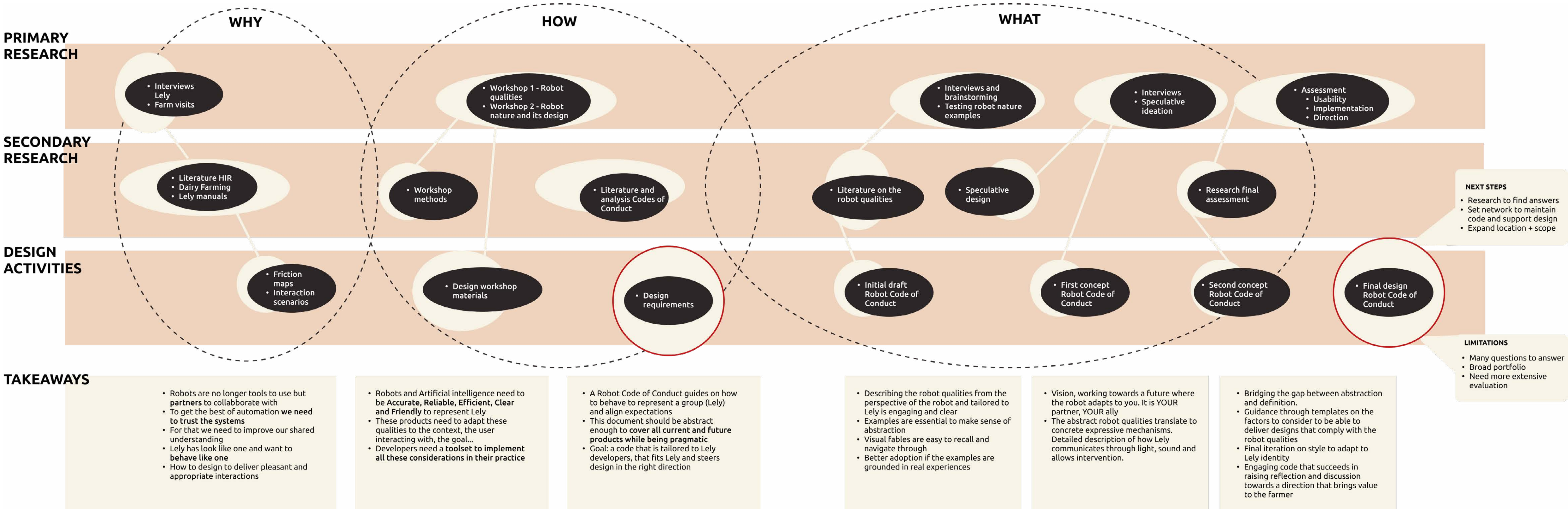


Figure 2. Overview process

2

EXPLORING THE CONTEXT

2.1 Methodology

I started with an exploration cycle with a two-fold focus. On the one hand, I wanted to get acquainted with the context of dairy farming and the stakeholders involved. On the other hand, it was essential to learn about the state of the art of Human-Robot Interaction (HRI) and the intersection of these two (Figure 3).

Lely is a company based in the Netherlands that provides automated solutions for dairy farming worldwide. This project originates from their interest in **improving the interactions of their robotic product with their users.** The goal is to create guidelines for developing desirable robot behaviour, similar to how codes of conduct orientate employees into acting according to the company values. Having Asimov robotic laws as a starting point, I will broaden the scope to explore all the nuances of working and living together with these automated agents. Through research I aim to frame the problem,and identify the relevant factors playing a role. I also aim to study whether a Code of Conduct would be a fitting solution, and deliver a grounded design.

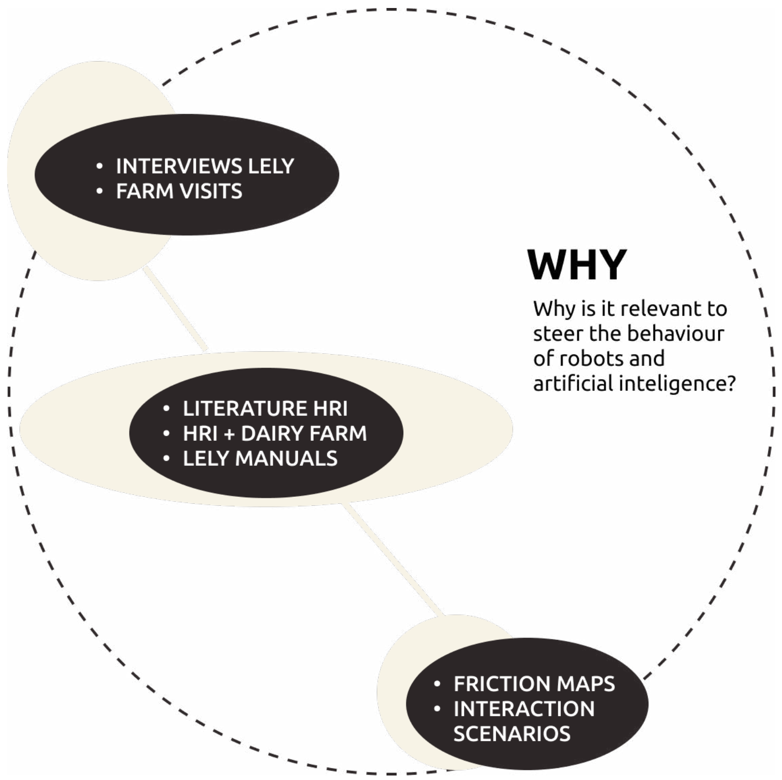


Figure 3. Exploration part

The exploration started with a mind-map (Appendix C) where I reflected on my initial conception of the topic (acknowledging my bias and limitations). All humans create and hold mental models of people, objects and situations, often unconsciously, that bias our actions and decisions. We must scrutinize this bias in the design of technology and robotic solutions due to their increasing power and influence in our life (Howard & Borenstein, 2018). Mind-maps can be used as a form of a cognitive map to represent the conception of a topic and its relationships ("Implementing Mental models", 2019) to be aware of the initial ideas and preconceptions on a topic. It is also an interesting reflective tool, as it is easy to pinpoint your learnings at the end of the project (Chapter 6 Discussion). I describe the insights obtained in the illustration below (Figure 4). I realized that I needed to open my mind to fill the knowledge gaps, and challenge what I thought I knew. After this initial reflection I started carrying out the main activities of this cycle:

Literature review

Fundamental to this project was to perform extensive secondary research. The topic I explored is relatively new, and so is the field of HRI, which ease the gathering of a recent and relevant collection of literature.

Exper talks

Discussing with different stakeholders bridged the gap between the literature and the context of use. I carried out semi-structured interviews with 16 experts during this cycle over a variety of topics (starting with the one listed in Appendix B). These were one-to-one meetings either online (using Microsoft Teams) or on-site (at the company or a farm). I refer to experts as stakeholders that are experts in their subject. For this cycle, the experts were:

- **4** P. developers/owners
- **3** Lely testers
- **2** Software Architects
- **2** Lely technical support
- **2** Experts farm management support
- **2** Lely farmers
- **1** Expert third parties

My knowledge of dairy farming was scarce. I had limited contact with the sector throughout my life.

My conception of robots was highly influenced by science fiction. I had a vision of their potential but was **not aware of what robots could be capable of doing**, and I could not recall consciously interacting with any robot before.

I had more information about Codes of Conduct than I thought. I could discern some **information from my personal experiences** as a human belonging to groups and entities.

Figure 4. Insights mind-map

Lely products

The company has a rich and growing portfolio. I aim to deliver a solution accommodating all current and future products, so I studied the product capabilities through the manuals that were available online. I also had the opportunity to test some products myself and observe them working in the workshop and at the farm.

Lely farms

Lely has contract with some farms to test their products, I visited four of these test farms. There, I had the opportunity to discuss with stakeholders more often present in the barn, such as farmers and technicians. I also could place all the information in the context and observe the live interactions. For example on a visit with other interns I could live the reality of co-existing with automated entities currently (Figure 5). Great workers questionable partners.

When visiting the farms and talking with experts I applied techniques on Observation and Interviewing (Jamshed, 2014). Nonetheless, the process remained flexible and highly dynamic. I adapted the planning along the way, researching subjects discussed with experts and questioning experts on topics I discovered through the literature. A variety of disciplines, scenarios, and topics progressively filled the puzzle.

The Juno did not realize that **a group of interns where in a narrow alley visiting the farm.**

The Juno did not realize that **the group already left the alley 45 minutes ago.**

Figure 5. Juno against the interns

2.2 HRI - Towards a common understanding

Moving around our homes cleaning the floor, assisting in the manufacture of our goods, or even intervening in our surgeries; robots are more and more present.

The term robot can be defined as an "autonomous machine capable of sensing its environment, carrying out computations to make decisions, and performing actions in the real world" (Guizzo, 2018). Robots also have a vast potential to help humans physically, emotionally, and cognitively (Philips et al., 2016). As a result, many companies are developing them for diverse applications from defence to companionship. Unlike tools and machines created by humans for an exclusive purpose, robots can be re-programmed to carry out different tasks.
Their versatility and increased agency make our relationship with these objects move from the simple notion of "use" (Lupetti et al., 2021) to "**collaboration-oriented relations**, where smart objects can influence, take control, or even overrule the actions of their users, as governed by their intent" (Rozendaal et al., 2018).
The field of Human-Robot Interaction was born to understand and guide these complex relationships combining knowledge from many disciplines such as engineering, sociology, robotics, design, and psychology (Bartneck et al., 2019). Robots are becoming more capable, increasing their presence in our lives and the control they get over activities, procedures, and even decisions.

"Farmers are becoming "dependent" on the robots. Robots are becoming our eyes and ears"

Lely test farmer

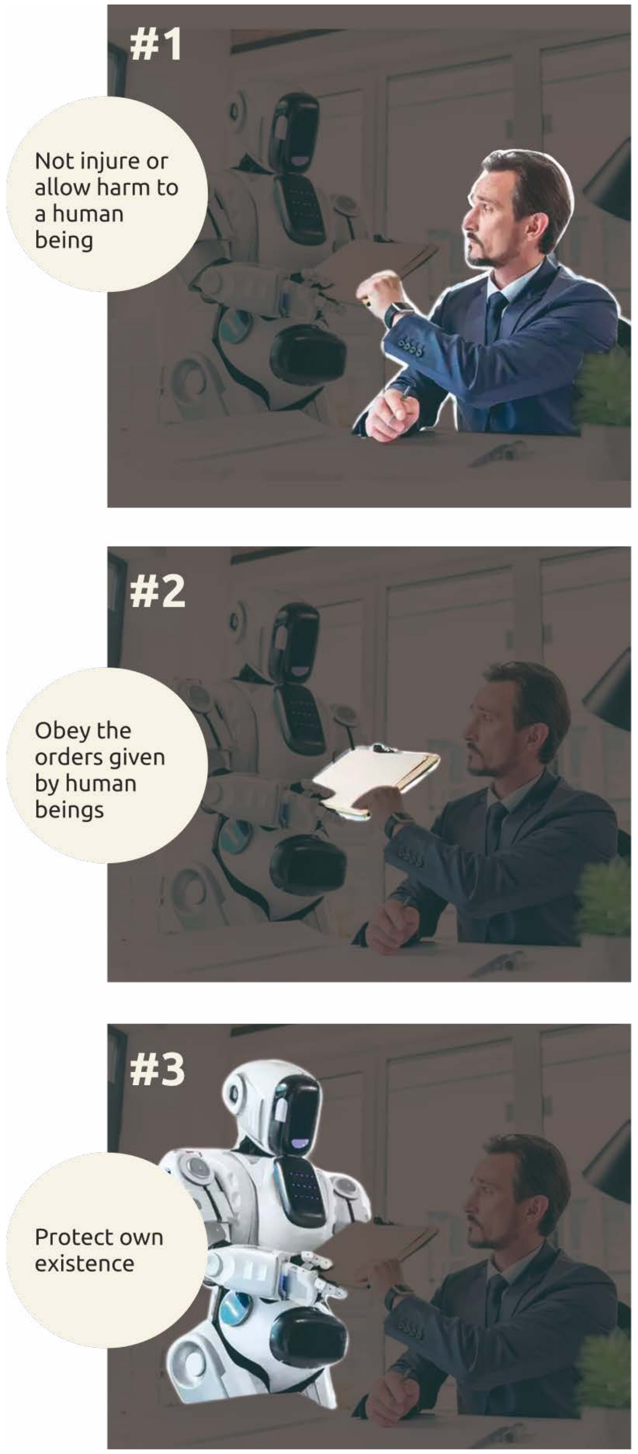


Figure 6. Three Laws of Robotics by Isaac Asimov

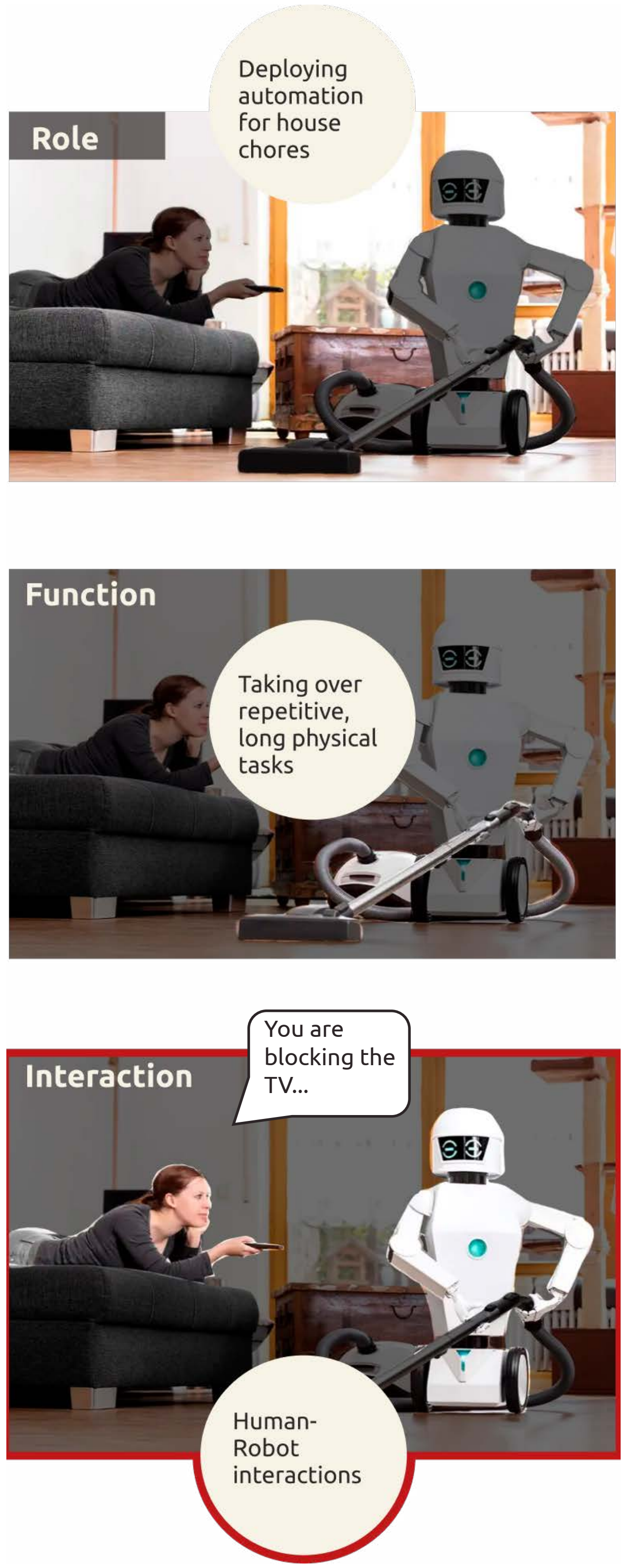


Figure 7. Responsible design

Automation is meant to improve our lives. However, its increased power puts humans in a vulnerable position rising personal and societal concerns. Most people have moved past the science-fiction implanted fear of robots turning against us exterminating the human race. Asimov laws covered our backs (Figure 6), three simple and yet respected commandments. Even the fear of being replaced by these new machines, which has been among us since the industrial revolution, is leaving room for more important questions."I am not concerned about a sex robot replacing your partner, but I am of companies designing these robots to take profit of consumers with in-app purchases in the heat of the moment" (Darling, 2021). **Safety regulations and Asimov laws are no longer enough.** There is an obvious need for frameworks and rules to steer the design of smart agents responsibly.

By responsible design at a high level, I mean responsible deployment. Creating robots for roles that will exploit their potential to attend to our basic needs (Maslow's pyramid (Maslow, 1943)) so we, humans, can focus on the top needs like self-enhancement.

At a medium level, I translate responsible design to responsible function. For a specific application, **how to tailor robot functionalities to enhance humans' work** experience. Meaning by that, robots should be prepared to accommodate tasks and aspects of the job that are negatively perceived (work interruptions or physical danger) and to boost the positive ones (task variety or problem-solving) (Welfare et al., 2019).

At the most concrete level, the responsible design stands for responsible interactions, facilitating a pleasant collaboration, and preventing frustrations and discomfort. Appropriate guidelines to achieve responsible design should be flexible to adapt to the robot context of use, to identify the needs that the robot could fulfil and the fitting manner to do so. This project zooms in and explores this last level (Figure 7).

This project explores the context of dairy farming and its adoption of automation where many people aim to achieve a state of "flow" with their animals and machinery. Thus, harvesting a connection with the animals, checking their individual condition, while enjoying the robotic efficiency of the process (Driessen & Heutinck, 2015). Robots like AMS (Automated Milking Sytems) take over the negative aspects providing time flexibility and better physical health to the farmers. However, it is a continuous learning process. Robots bring along new challenges, one of them being the mental stress caused by handling alarms of the robot system (Lundström & Lindblom, 2021). One of the biggest challenges of HRI is to reach a common understanding between humans and machines, reduce discomfort, and work together according to the principle of least collaborative effort (Thellman & Ziemke, 2021). In other words, a shared comprehension between robots and humans will improve our collaboration and communication. Yet the lack of it, not knowing what a machine will do, and how you should act towards it, is highly unpleasant.

When interacting with a robot, a human can try to distil its behaviour by the physical properties of the machine. Affordances set some expectations on the behaviour or potential use of the object. However, that is hardly enough. Appearances can be deceiving, and many mechanisms could be hidden. Thellman & Ziemke recommend acknowledging the robot as an intentional agent and trying to understand how it conceives a situation to predict its actions based on the goals and desires of the agent. The problem is that "the mechanisms by which humans and robots perceive and understand the world differ considerably [...] the perceptual belief problem makes it difficult for people to predict how robots will behave in response to events that transpire in the environment [...] also negatively impact[ing] people's trust in robotic systems" (Thellman & Ziemke, 2021).

This makes farmers doubtful about the performance of robotic systems. Some farmers end up doing tasks themselves when not trusting the results or capacity of the robots, and get frustrated. Building trust in the systems is therefore essential. Trust can be defined as "the willingness to be vulnerable to a referent with the expectation of a positive outcome" (Mayer et al., 1995).

"We can see robots as humans from different cultures doing their best to communicate and understand each other"

Lely product owner

Trust in automation is similar to interpersonal trust. Perceptions of human ability, benevolence, and integrity can be linked to perceptions of robot performance, purpose and process (Alarcon et al., 2021). Factors affecting trust can be categorized as human-related, environmental and robot-related. For this project, I will focus on the factors related to the robots, although I will account for the characteristics of the context and the stakeholders involved. Among the robot-related factors, Alarcon differentiates also performance-related and attribute-related factors. Lely has already a strong portfolio. It is interesting to analyse how the current product attributes influence trust, but for the scope of this thesis, I will exclusively target factors related to the performance, how the robot behaves and uses its features. According to the literature and most developers and stakeholders I have interviewed, I found "Predictability" and "Explainability" to be the key factors influencing trust in the systems. From interviews with 16 experts, 11 mentioned how predictability and explainability affected their work in different ways (Figure 8).

Predictability

Unpredictability can make users experience a sense of control loss and hinder collaboration. For a robot to be predictable it should present certain structural regularities in its actions and the cause of these actions should be easy to discern, visible and identifiable (Schadenberg et al., 2021).

"Many times it is impossible to know where the robot will go. That is particularly annoying if I am passing with the tractor, or if there is someone in the barn who is not that familiar with the robot".

Lely test farmer

This is a big challenge for many reasons, among them that

1. Part of automation is to adapt to changes in the environment which defies the need for structural regularities
2. The aforementioned "perceptual belief problem". The causes of actions in complex systems are often subtle or unperceivable for humans (e.g. a robot selecting a certain route based on a calculation with more than 100 parameters).

Explainability

Explainability is another crucial topic, and not only for robots, but it is also a key factor in building trust in Artificial Intelligence (AI). The goal is to convey the right amount of information so humans can have agency and feel in control without getting overwhelmed with too much information. Robots that fail in displaying transparency on their capabilities and intentions are found unsettling, and less competent (De Graaf et al., 2021).

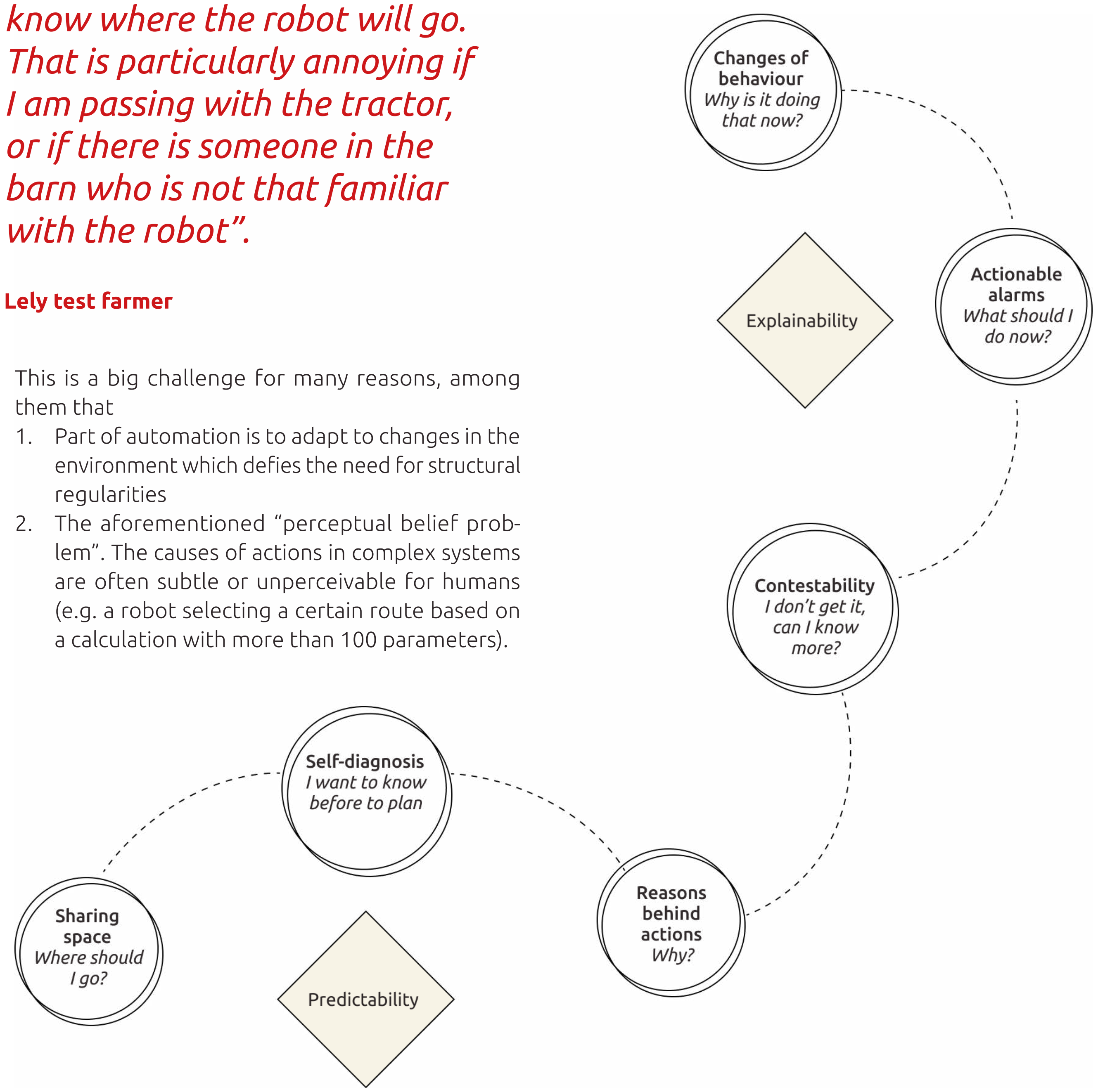


Figure 8. Expert references to Predictability and Explainability

Expectations

Expectations on robot performance is also a relevant factor, tightly linked to the previous ones. People hold mental models of the robots and high beliefs about their capabilities, often unrealistic (Philips et al., 2016). Setting the right expectations contributes to improving the system predictability and explainability, and vice-versa. Several strategies are emerging to address these challenges. I will introduce some of them that come back in Chapter 4 as they contribute directly to the design solution. The robot can communicate at many levels. Even the most subtle nuances in its expression can have a substantial impact on the experience of the user interacting with it (Figure 9).

- Robots could express **hesitation**, for example, with a long pause and a subtle movement. This behaviour may inform the user about the internal state of the robot, which can help set the right expectations on its capabilities and limitations (Moon et al., 2021).

- Politeness strategies can accomplish a similar effect. **Apologizing or clarifying the difficulty of the task** can mitigate the effect of robot errors. They can even help the user to understand how he/she can intervene to prevent or fix this mistake (Lee et al., 2010).

- The tone of voice. It does not only affect user satisfaction, but it also gives a certain character to the robot. **The tone of voice and attitude can express urgency, state or nudge behaviours (e.g. whispering encourage the listener to approach)**.

- Unintended behaviours. We, humans, are **often unaware of some of the actions we make and how others perceive them**. The same applies to robots. Accounting for this and preventing robots actions to appear chaotic or arbitrary will potentially reduce the perceived relational risks of interacting with it (Stuck et al., 2021).

- **Robot-robot communication**. The same way their unintended behaviours can teach us (positively or negatively) about the robot capabilities and intentions, we can also design the inter robot communication to hint us into how to interact with the machine.

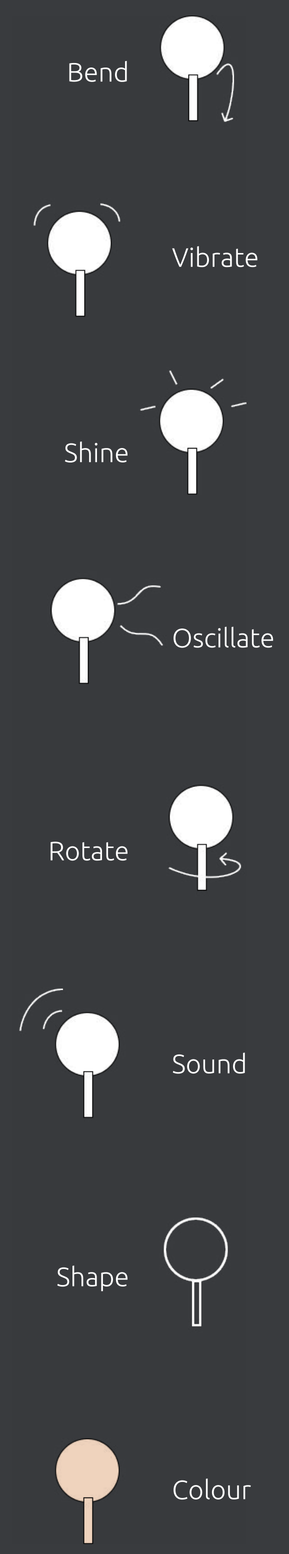


Figure 9. Expressions

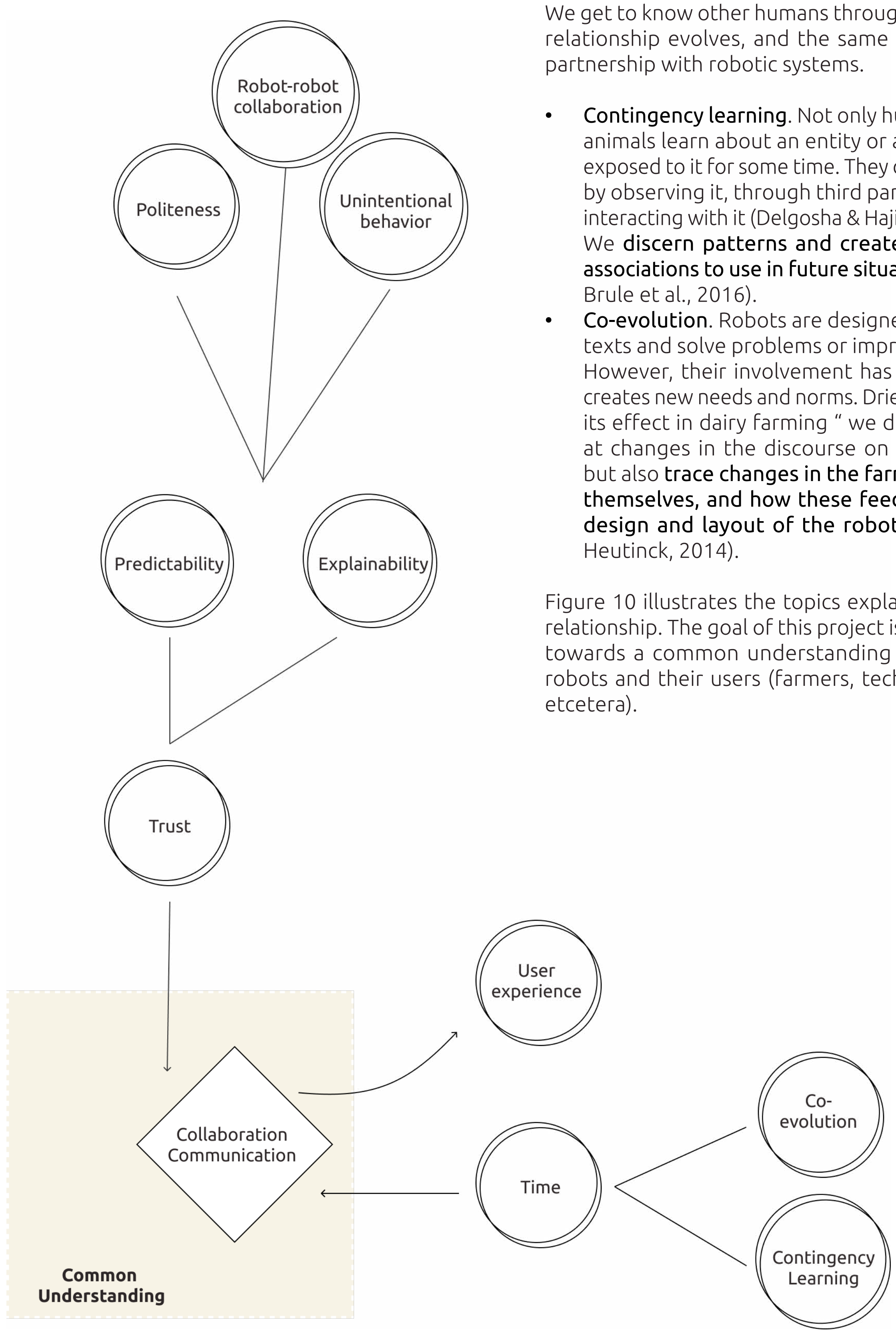


Figure10. Summary of factors

Time

Finally, an element that cannot be overlooked is time. We get to know other humans through time and our relationship evolves, and the same applies to our partnership with robotic systems.

- **Contingency learning**. Not only humans but also animals learn about an entity or agent by being exposed to it for some time. They can learn either by observing it, through third parties or actively interacting with it (Delgosha & Hajiheydari, 2020). We **discern patterns and create cause-effect associations to use in future situations** (Van den Brule et al., 2016).
- **Co-evolution**. Robots are designed to fit in contexts and solve problems or improve situations. However, their involvement has an effect that creates new needs and norms. Driessen described its effect in dairy farming " we do not just look at changes in the discourse on dairy farming, but also **trace changes in the farmers and cows themselves, and how these feedback into the design and layout of the robot.**" (Driessen & Heutinck, 2014).

Figure 10 illustrates the topics explained and their relationship. The goal of this project is to take a step towards a common understanding between Lely robots and their users (farmers, technicians, cows, etcetera).

2.3 Lely - Automated farming solutions

Then, which strategies should robots use to improve human-robot understanding? What is already being used?

The truth is that there is no one-size-fits-all formula. The success of an implementation depends heavily on the context of use, the characteristics of the stakeholders involved, the goal of the interaction, etcetera. Therefore, we must **tailor solutions to the application**.

Lely is a company based and originated in the Netherlands that provides a variety of automated solutions for dairy farming internationally. Farming is an undeniably complex task as it requires "knowledge and consideration of a wide range of biological, technological, practical, political, legal, economic, ethical and social factors and circumstances" (Ludström & Lindblom, 2021). For all these reasons and motivations, there is considerable research going on about the feasibility and benefits of incorporating robots and autonomous systems in agriculture and farming (Pedersen et al., 2006).
The company vision (Figure 11) targets the main three motivations among farmers to choose automation.

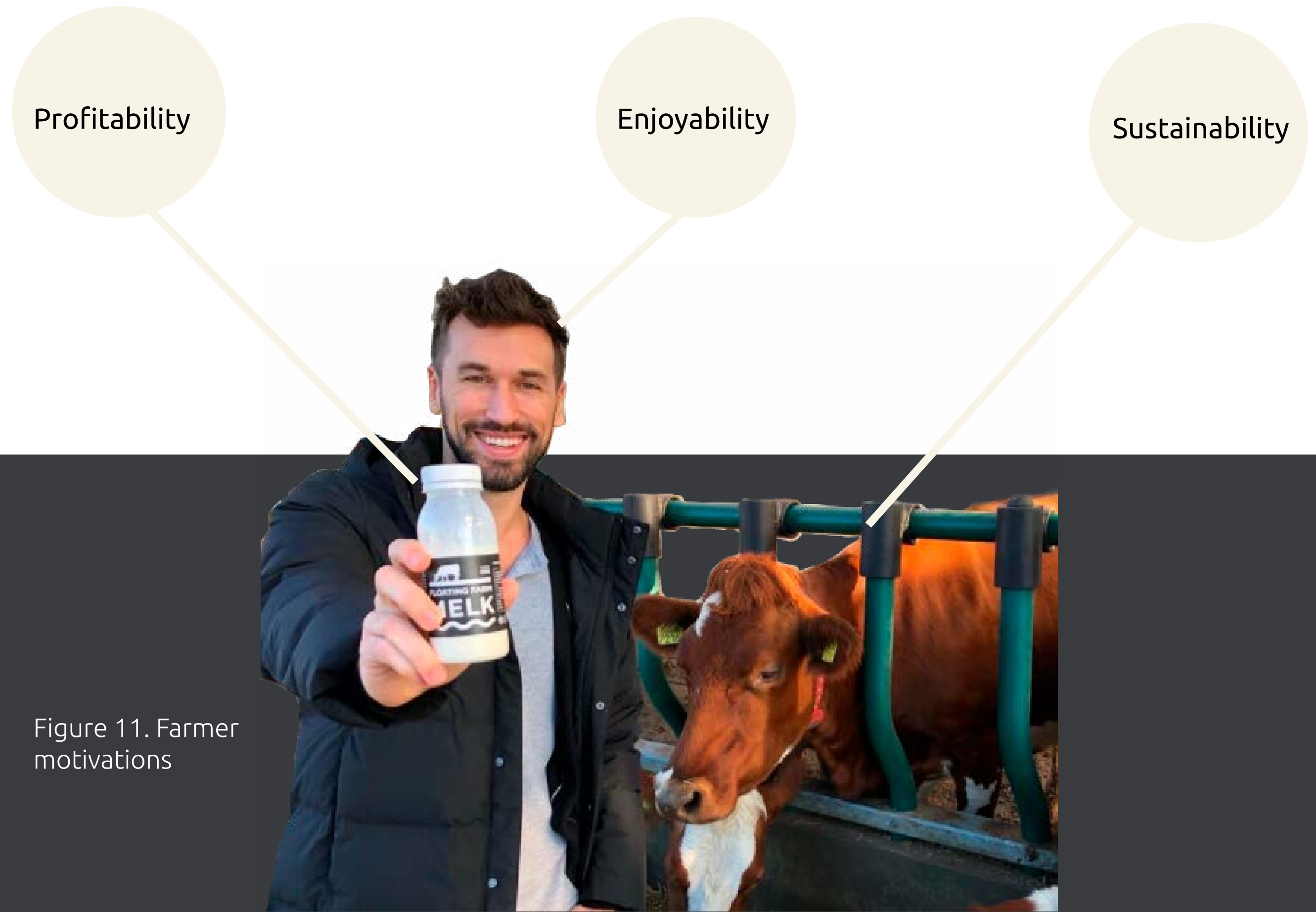


Figure 11. Farmer motivations

Sustainability

Farmers that want to ensure the continuity of their practice reach out for solutions that help them step into the future of farming. One of the main threats is the pressure of laws and regulations to reduce livestock gas emissions (mainly nitrogen, ammonia, and methane) (Boztas, 2021).

Profitability

The increasingly tight price competition encourages many farmers to take measures to find the most lucrative practice. These farmers need reliable tools and detailed information to make the best decisions for their business.

Enjoyability

The pressure on price and the labour conditions requiring long swifts of manual work makes the profession decreasingly appealing to new generations. These farmers want increased flexibility and work-life balance.

Lely cares about farmers by taking care of their herds (Figure 10). **Cow-centeredness is at the core of the company**. They provide direct solutions for cow welfare but they also ensure that all products contribute to creating an animal-friendly environment.
It was a unique experience to observe the dynamics of an automated farm where cows decide when to get milked, robots call cows when it is feed time, and the animals naturally learned to share space with automation stepping away when a cleaning robot is passing.

Figure 12. Cow-centeredness

Figure 13 illustrates a Lely robot and a tool related to cow feeding, a Vector and a Welger. Lely has innovation and continuous development embedded in its values and practices, making products evolve frequently. For that reason, I chose to study their portfolio based on the tasks they cover instead of the products they develop. To ease readability, I placed details and specifications on the characteristics and functionalities of the products in Appendix D. It is crucial, nonetheless, to acknowledge the **disparity in complexity and maturity among all products**. For instance, the AMS Astronaut is already at its 5th version and has been in the market for way over 20 years, unlike the Vector feeding system that has been barely ten years in functioning and distribution. They have different capabilities and tasks, but they all work towards the same shared goal. The same applies to the employees and company structure at Lely. The company accommodates employees from a variety of disciplines, but its remarkable growth makes it highly complicated to move as one. Consequently, there is a lack of unity in their robot behaviour and communications. Lely is already working hard to improve this situation in the UI with projects like Horizon (management app), or by making components and processes standard.

"There is a big lack of overview. We would love to have a command point where we could check the status and manage all products"

Lely Technician

While developers work intensively in building cohesiveness on tools, the goal of this project is focused on interactions, **how to behave as a cohesive whole**. It is noticeable that aesthetically, Lely has excelled in creating and maintaining a strong visual identity (Figure 13). This is only possible thanks to documents which the entire company uses and respects.

Figure 13. Lely strong visual identity

The **Red Rules** (Figure 13) fulfill this duty as design guidelines to assist developers in creating products for the entire current and future portfolio that:

- Fit Lely style and values
- Are immediately recognizable visually
- Are pleasant to look at

Following a similar line, this project aims to guide developers in creating products for the entire current and future portfolio that:

- **Represent Lely style and values with their actions**
- **Are immediately recognizable by their behaviour**
- **Are pleasant to interact with**

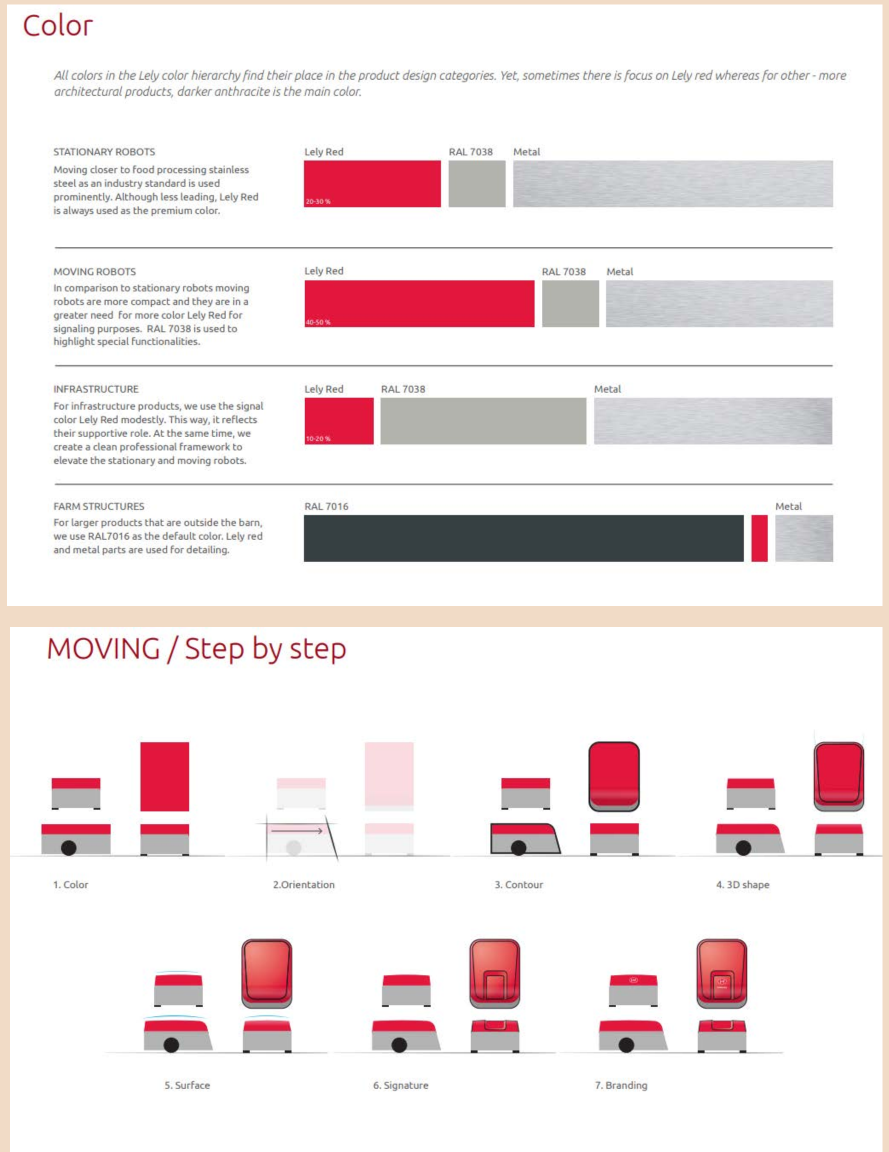


Figure 14. Red Rules

The need to achieve this clear communication and common language is present in many documents within Lely (e.g. Brandbook, Code of Conduct, or Employee Handbook) This was always envisioned from the human perspective, now this thesis took a step towards exploring whether that is also important for the smart agents.

Before diving into the analysis of the robots, I will first briefly introduce the other factors affecting the interaction: users and context.
The term **"user"** in this project will refer to **all agents with intent interacting with the robot (Figure 15).** This categorization includes animals, a large variety of human stakeholders, and even other robots. During the interviews, I discovered that it is not always straightforward which is the user persona they are designing for. Misalignment on the concrete target group does not only hinders the development process but also negatively affects the quality of the result.

Animals

Some important factors that I learned about cows that have actual implications in the design of the robots are their curiosity, intelligence, and group dynamics. Sensors need to be designed and situated strategically to prevent cows from tricking the system. Cows form groups and have their own hierarchy of power being the most dominant cows often on top.

Humans

The target user is the farmer who will manage and maintain the robots. However, it is essential to acknowledge that many more people will be around the robots with different degrees of frequency (e.g. vets, children, visitors…). Even when focusing on the farmers' the needs and motivations can greatly differ. At the beginning of the chapter, I describe different farmer motivations but they can also differ depending on their relationship with technology.

> *"Often after a long discussion about the user we realize that we are talking about completely different personas. Knowing your "farmer persona" can help you prevent some problems"*
>
> **Lely Farm Management Support**

The robots carry out tasks in the real world while they are programmed, controlled, and managed through digital platforms. I studied the direct interactions with the robotic systems in the real world as well as the mediated interactions through the virtual interfaces (Lupetti et al., 2015).
I will convey my main insights about the current interactions through four scenarios. These scenarios include examples from both types of interactions, as well as intentional and unintentional (active/passive). Scenarios are used in design because storytelling is a powerful communication tool. They are often user-centred, showing the user's needs and actions in a particular context interacting with a product ("User Scenarios", n.d.). I chose to aim the attention at the robot instead to depict the knowledge obtained about them. The scenarios will illustrate some of the most relevant interactions and point to some of the current functions and frictions.

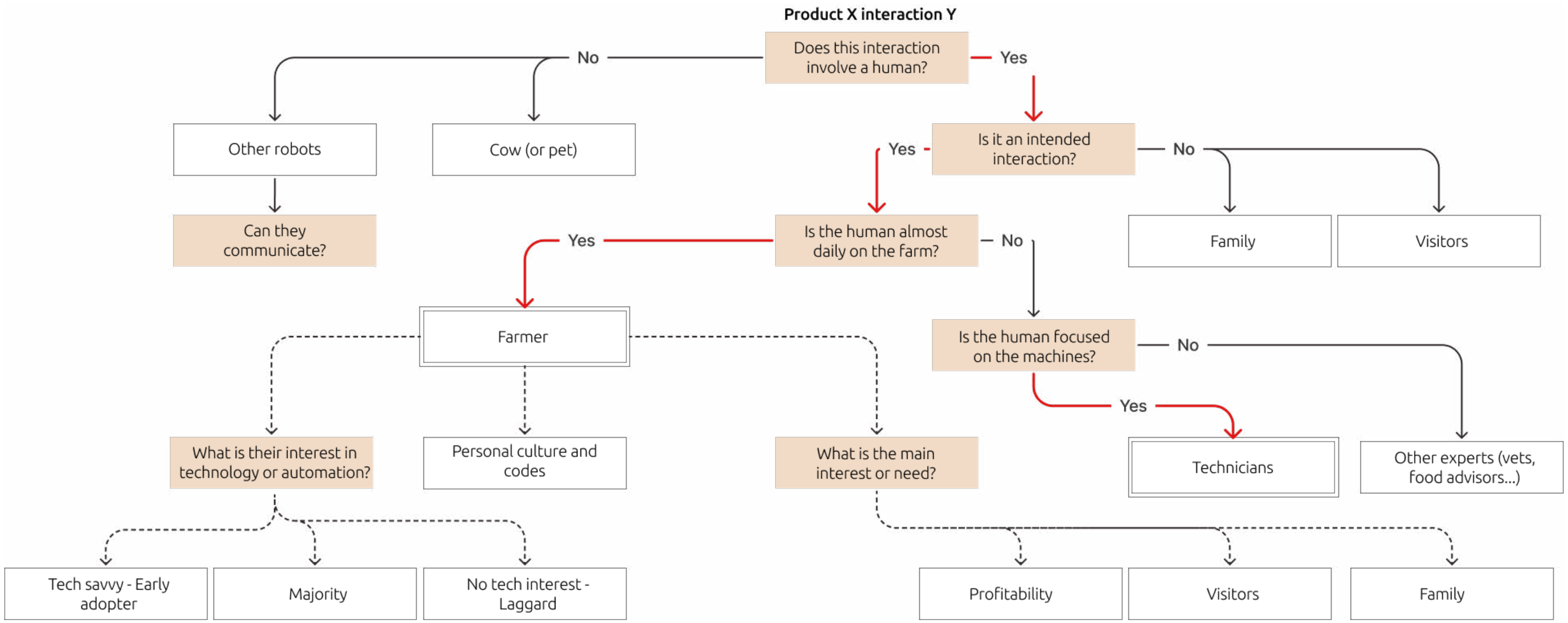


Figure 15. Potential users

For the physical agents "the narrative of the interaction emerges from joint action and intention between the user and the robot" (Mutlu, 2021).

- Scenario 1 "Active Direct Interactions". The robots physically communicate mainly by sounds and lights. These are sometimes neither intuitive nor consistent. The robots are real agents physically present, moving (some of them) and sharing space with the users. Due to that, robots sometimes invade one's personal space, "human's buffer zone of protection against perceived threats" (Jossee et al., 2021), but they move very slowly for safety reasons. Robots have sensors like bumpers to detect obstacles, but it is complicated to find the right balance between respecting the users and surroundings and preventing unnecessary work interruptions.

"Sometimes safety refers to the safety of the robot from external threats. How to make the machine more visible?"

Lely Tester

- Scenario 2 "Passive Direct Interactions". Some robots move around the barn using different sensors to orientate along a map pre-set by a technician. They follow walls or calibrate using metal strips. The robot conveys information just by being present and by working. Sometimes environmental conditions can obstruct the functioning of the sensor like a spider covering it or a wet floor making wheels slip. If the robot gets disoriented, it needs to be manually driven to the charger by the farmer.

"Users look at the robots more than we think and they can immediately notice very subtle changes of behaviour"

Lely Product Owner

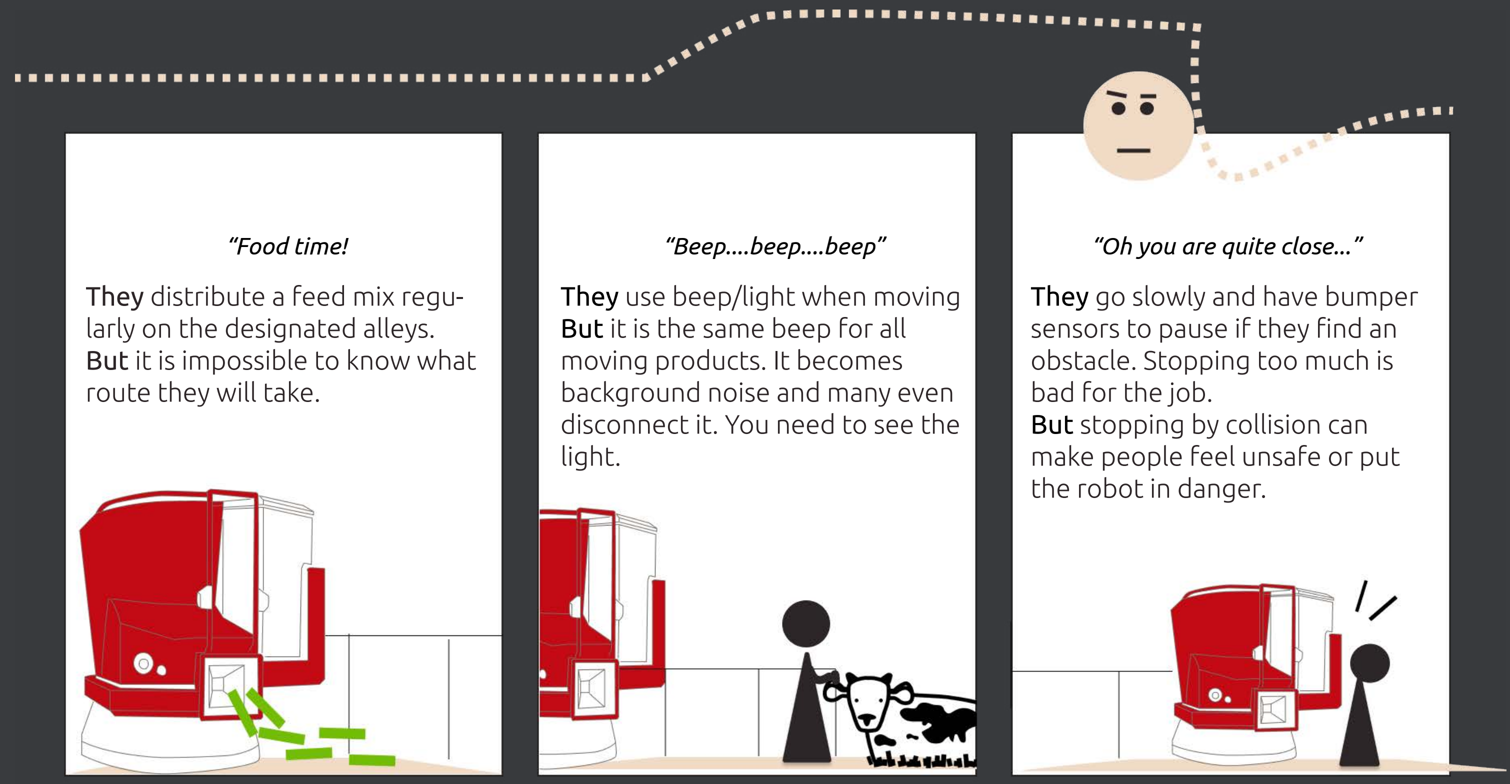


Figure 16. Scenario 1

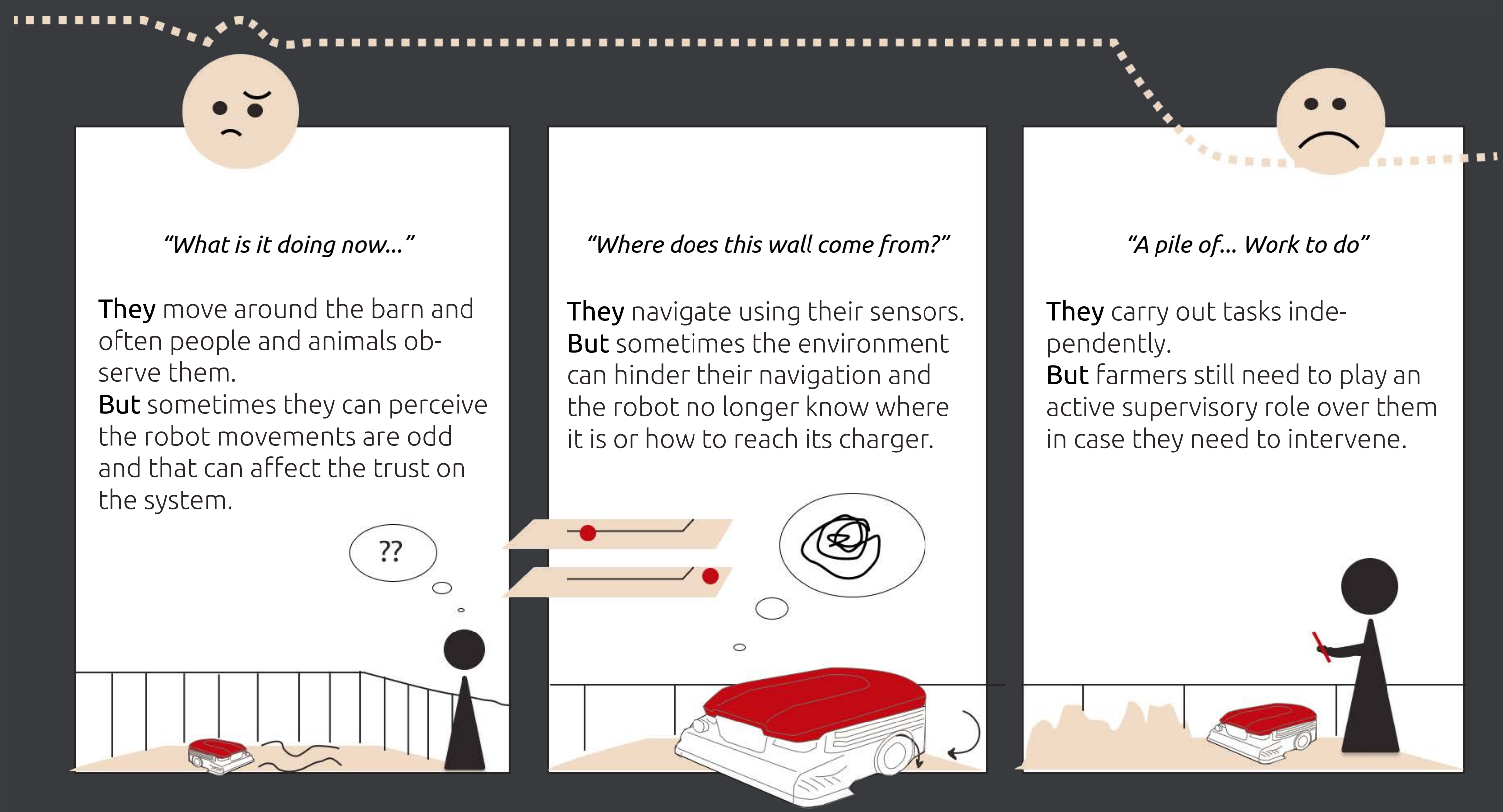


Figure 17. Scenario 2

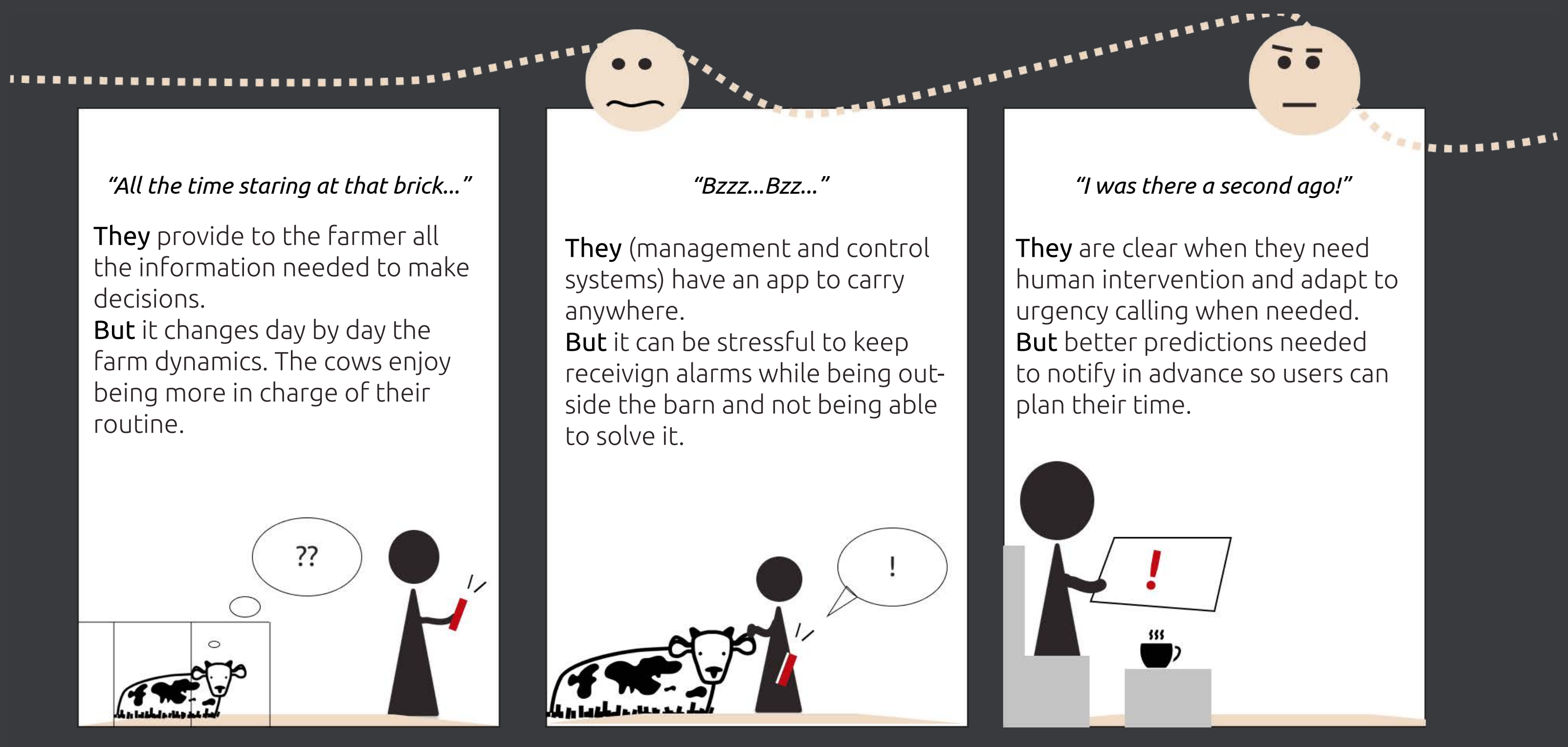


Figure 18. Scenario 3

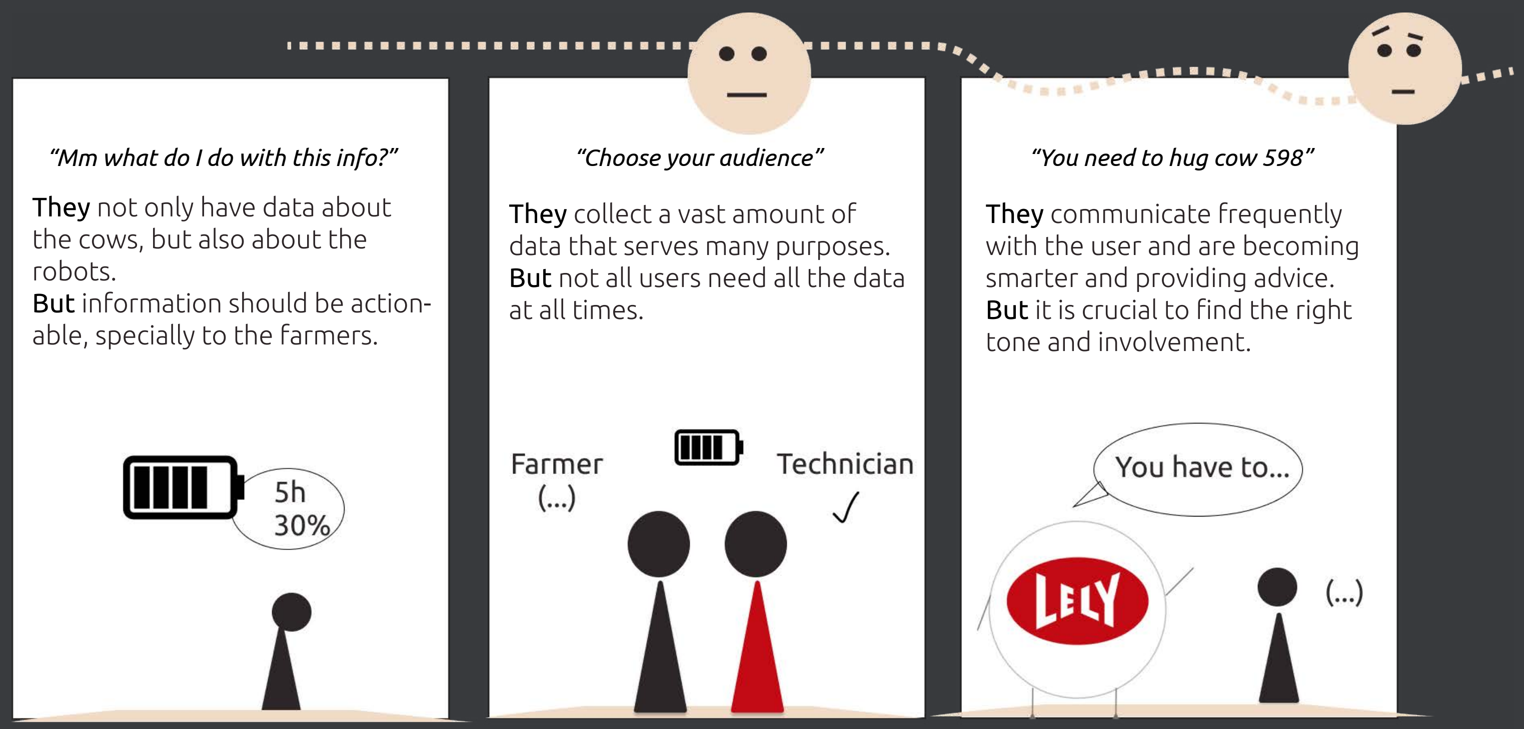


Figure 19. Scenario 4

For the digital agents "(in the interaction) the user participates in a narrative crafted for engagement in the virtual environment" (Mutlu, 2021).

- Scenario 3 "Active Mediated Interactions". The digital platforms are the main channel of back-and-forth communication and intervention. The farmers get alarm notifications when the robots need them. They also get feedback on the problem, the status, next steps, etcetera. Lely works hard to improve diagnosis, explainability, and reduce the number of alarms. However, it is still a challenge. **Working with automation has changed the farm dynamics**, and checking the alarms on the phone has become the first thing farmers do in the morning.

"Even if each robot has only one alarm, all that farmers see is that Lely is calling them"

Lely Farm Management Support

- Scenario 4 "Passive Mediated Interactions". The management system provides continuous feedback and information to the user from the robots. It is a challenge to find the right amount of data to communicate and an optimal way to visualize it. Users need to be properly informed to make decisions without being overwhelmed, and they need to perceive the information as trustworthy. Lely already makes a great job displaying data but is progressively working on it with projects like Sense and towards the implementation of AI.

"There are around 150 data points per milking time" "The more sensors the fewer data shown to the farmer"

Lely Engineer

The physical embodiment of all these robots is functional, designed to best complete their tasks (Fosch-Villaronga & Millard, 2019)(Figure 13). Likewise, the large majority of them contain both digital and physical presence. The exceptions are simple tasks covered by robots that we can almost categorize as infrastructure. Figure 20 illustrates the Horizon management system in different devices. This is one of the platforms used by the products. Horizon is a big project and future bet for Lely that integrates many new features and aims to bring unity digitally to the portfolio.

In addition to interviewing Lely employees and reading the manual of the available products, I also tested some of the robots myself. **I created a table to analyse the similarities and discrepancies among the products in terms of communication**. This helped me go beyond the obvious frictions in the interaction and obtain a holistic view. For that, I created a 14x18 table to map how Lely communicates a list of messages in each of the different tasks (complete version attached in Appendix E).

- In the **Columns.** I distributed the **tasks covered by the robotic systems** on the portfolio. In the last columns, I located some products not yet available in the market (my information about them was limited). Some examples of tasks are: **Distributing Feed, Milking the Cow, Charging the Robot, etcetera**.

- In the **Rows**. I placed potential **interaction points between the robot and a human/animal**. This list emerged from the knowledge obtained through the initial research stage. Some examples are: **Show State, Ask for Help, Allow Intervention, etcetera.**

The complete table is slightly overwhelming to study. For that reason, I decided to use colour labels to ease its analysis and discover patterns and discrepancies. The black squares represent the categories, and the coloured cells bring attention to the concrete parameter being analysed.

Figure 20. Horizon management system

2.4 Current Frictions

Global analysis

In Figure 21 I highlighted the interaction points and messages that were not covered by any expression at the moment of the analysis. For example, when cleaning cows (a product like the Lely Luna brush) the robot has hardly any expression embedded.

- At first sight, the table shows that **some communications are more often integrated into the products than others**. For example, while asking for assistance is widely used (8/13), suggesting actions is only recently being introduced (2/13). I argue that the reasons for many expressions not being yet covered could be that those interplays are not needed, not desired, or do not have priority in the development

- From the other axis, it is clear that **some tasks are highly expressive while others are basic in terms of communication**. For example, milking cows is a rich expressive task (11/15) while cleaning the cows falls behind (5/15). I argue that following this method we could classify the products per complexity depending on the richness of their expression.

Specific analysis

Figure 20 illustrates, in this case, the different platforms use to control and manage the robot systems and use the stroke to select those that are exclusive to the phone or hand interface. Some discoveries were the following:

- Use of digital platforms. Lely Control Plus,, Lely T4C and Horizon are the main platforms for farmers. The **lack of an overview** hinders the clarity and efficiency of the process.

- Type of device. The **lack of integration** is also physical, due to the diversity in control devices.

Insights from other specific analysis are (Appendix E for concrete examples):

- The buttons for direct intervention (stop, play and pause) have some consistency in the design but differ in location, and which of them is present depends on the robot.

- Lights and sounds are sometimes used too intricately and inconsistently.

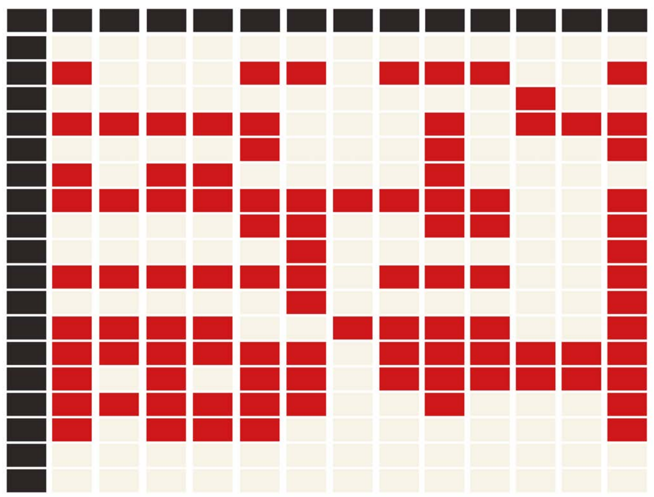


Figure 21. Table - Robot/task complexity

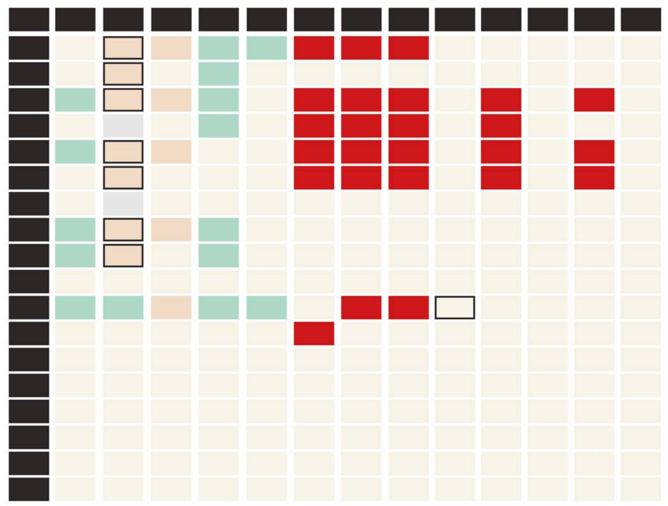


Figure 22. Table - Virtual cohesiveness

Lely has a clear future mission (Figure 23 shows some examples), and this project is only a natural next step to work towards it. Aiming for cow centredness and allowing the farmer to focus on what matters the most to him or her. Lely **solutions do not only need to work, they need to work for the farmers and what matters to them**. To achieve that, we do not only need to improve current interactions, but we need to learn to work and progress as one towards this shared goal.

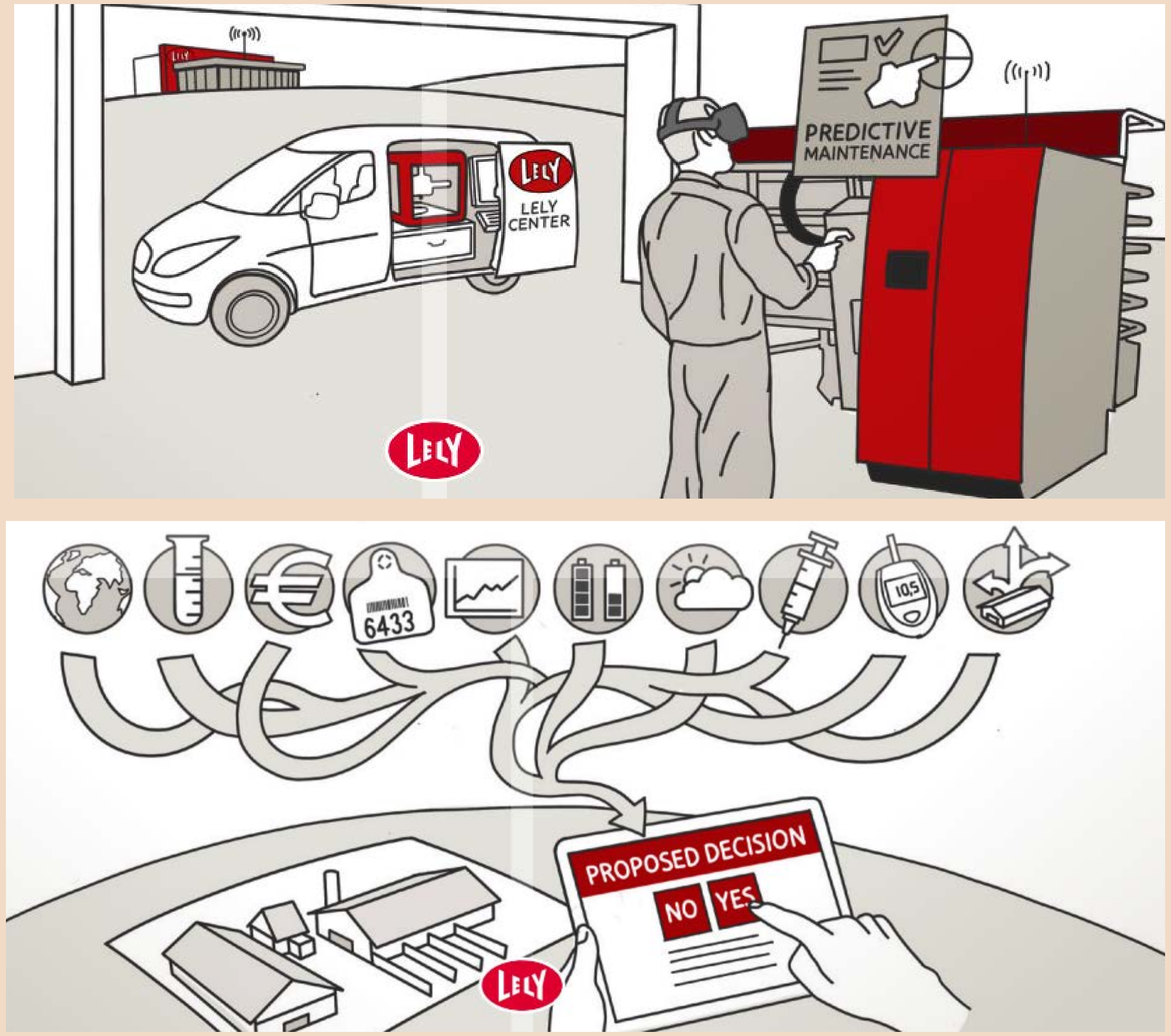


Figure 23. Future vision - 100% uptime and decision support

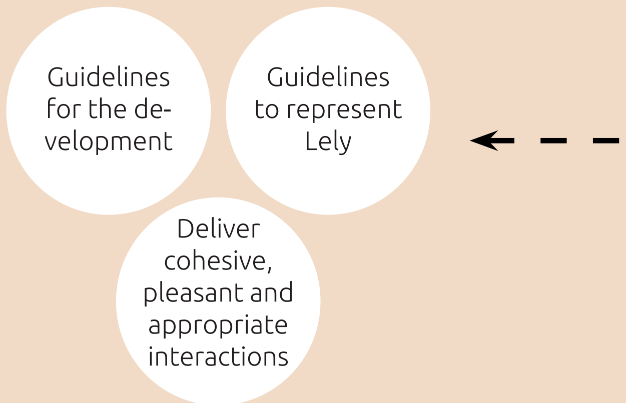
2.5 Research Question

During this cycle, I learned about robotization, dairy farming, and Lely. But most importantly I learned about the vision and relevant factors of HRI. I got the following takeaways:

- Robots do not exist in a vacuum, they communicate and collaborate with other agents. They are moving from the notion of tools that we use to become **partners that we collaborate with**.
- Human-robot interactions should be guided and designed responsibly. Many factors play a role in doing so, but I am focusing on how the robots perform to work best alongside users. For that, creating **trust in the systems** is essential, so I explored how to achieve that by improving explainability, predictability and expectations.
- To understand, and eventually trust, these robots, we can start by **consciously designing the way these entities express and communicate**.
- Lely has a diverse robotic portfolio with a strong visual identity but not yet cohesive robotic behaviour. **They look like one but how can they act like one?**
- Lely robots take over people's home, business and assets, but they lack overview and consistency in their communications, and **sometimes fail to adapt to the needs of its users**.
- There are many developers involved in designing these products who are too busy with their particular challenges. There is no measure in place to guide them into accounting for the robot interactions.

This thesis aims to provide tools for the company developers to design agents with pleasant and representative communication applying knowledge from the field of HRI.
I framed this goal into a **Research Question** and to answer that I carried out two Research activities:

- **Activity 1**: Investigating how Lely wants its products to represent the company.
- **Activity 2**: Studying how can an intervention assist the company developers into design these behaviours.



Which set of guidelines could best guide the development of a dairy farming robot portfolio delivering an ecosystem of robots with cohesive, pleasant, and appropriate interactions that represent the company through their actions?

3

REPRESENTING LELY

3.1 Workshop 1 - Defining robot qualities

There are many measures in place to orientate how employees should act to represent Lely. However, ultimately the robots are the ones that work daily around the users. How should they behave to honour that logo and bright red?

To answer my Research Question, I needed to involve different stakeholders. I planned two workshops, and I carried them out collaboratively with Lely employees from many disciplines and departments. The first workshop aimed to discover how the company wants the robots to act and be perceived by the users. Therefore, I created a set of sub-questions from the main research question and focused on how the robots should act to best represent Lely.

1. Can the current company guidelines on behaviour also apply to the robot?
2. How do you communicate/interact as Lely?
3. How should you communicate as Lely?
4. Is there value in creating guidelines for robot conduct?
5. What should these guidelines look like?

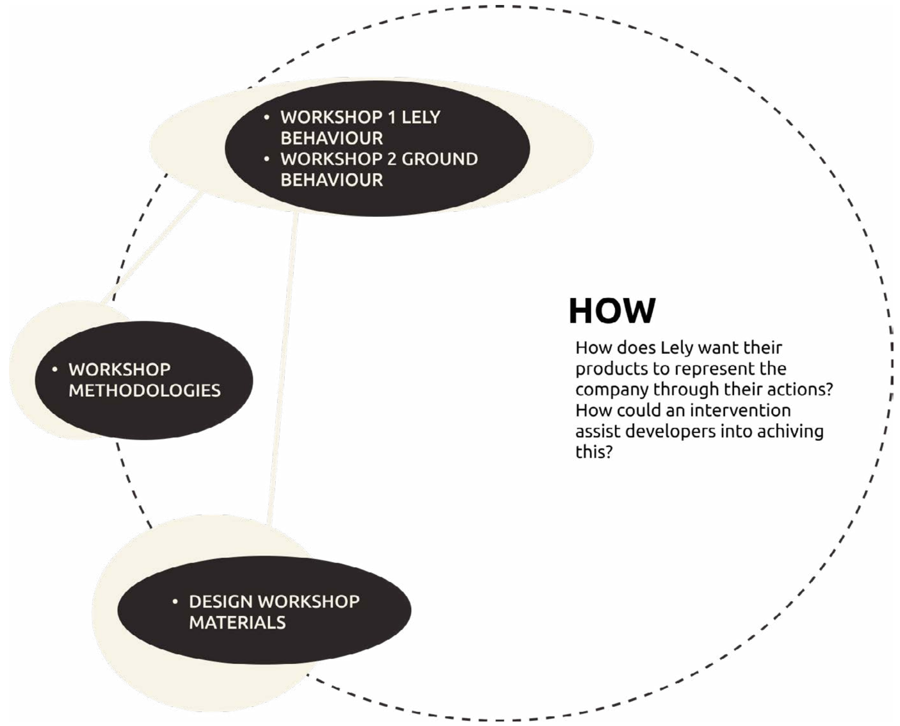


Figure 24. Workshops overview

Guidelines to represent Lely

A mixed group of nine participants took part in an on-site workshop. No robotic knowledge was required during the recruitment. The preferred target group for the participants were creative Lely personnel familiar with the brand, company and customers.
The workshop took part at a conference room in the company headquarters for approximately two hours (Figure 25). Appendix F contains further information on the setting and all the materials provided during the workshop. **The path of expression inspired the workshop flow**. A sensitizing phase started the session, then participants reflected on current and past actions. The activities lead to the exploration of future opportunities (Sanders & Stappers, 2012).

1 Marketing department
2 Technical support service
2 Product manager
2 Human Resources`
1 Software Architect
2 Expert third parties

Figure 25. Workshop 1 - Setting

To ease identifying and communicating the reasons and motivations behind our actions, I created **cards with values and topics from different documents at Lely (Appendix F)**. The cards were envisioned as an assisting tool for them to evaluate how well the current documents apply to the robots, and to trigger ideas (Figure 26). I supported the main activities with a PowerPoint presentation containing clips from videos and questions. That way, I created a storyline to encourage discussion and provoke participants, opening their minds to the topic we were analyzing. For future explorations, I used situated enactments as a form of body-storming to immerse the participants in the context and provide them more freedom in creating and testing different scenarios (Arvola & Artman, 2006).

Icebreaker "Guess the Value". Warming up exercise in pairs to loosen up with each other, and get comfortable expressing thoughts out loud and physically.

Activity 1 "Your Lely values". They brought along their personal experience as humans and Lely employees and reflected on it.
[***RQ1***][***RQ2***][***RQ3***]

Activity 2 "Robotic values". I provided them with situations to role-play. The descriptions were very detailed for them to focus on **exploring the qualities of the interactions**. They carried out a non-scripted play in groups of three: one being the robot, another the user, and a third person being simultaneously an observer, judge and orchestrator.
[***RQ1***][***RQ3***][***RQ5***]

Activity 3 "Final reflection". Wrapping up moment to reflect on the set of ideal values, reaching agreements and triggering discussion.
[***RQ3***][***RQ4***][***RQ5***]

From the workshop I collected the filled cards and templates as well as qualitative data from discussions. Of particular interest were the comments and reflections shared while carrying out the activities. Right after the workshop ended I also noted down any relevant observations. It all came together at the analysis. I started mapping the cards per group, value, and how were they used. Additionally, I clustered and studied their comments and notes. (Appendix F).
Preparing and facilitating this workshop I learned a lot about making simple and aimed activities, and the collection of data from their discussions which I implemented in the second workshop.

Altogether, I answered my research questions, concluding on a first set of values, and I also got additional insights. Coming pages describe these takeaways which I labelled as "Current guidelines", "Abstraction", "Adaptation and influencing factors", and "Robot guidelines"

Figure 26. Workshop 1 - Value triggering cards

Current guidelines

The scheme in Figure 27 shows the topics discussed and whether participants used them to refer to humans or robots. Concepts that imply **emotions like ownership or care were solely deemed as relevant for humans**. On the other hand, **robot-related topics were more computational and measurable, for instance, accuracy or effectivity**. Despite some of the values extracted from the current guides at Lely being found applicable for robots, they were understood differently for robots than for humans. For example, in human guidelines, safety refers to: "taking care of oneself and reporting accidents and unsafe situations which can endanger the health or safety of any person". Nonetheless, during the workshop safety for robots was conceived as preventing harming others. **There was a clear mismatch of meaning. Additionally, human guidelines on behaviour do not have mechanisms that guide others into creating those actions.** I concluded that there is a need for a new set of regulations tailored to the steering behaviour of robots.

Can the current company guidelines on behaviour also apply to the robots?
RQ1

How do you communicate/ interact as Lely?
RQ2

Abstraction

Values are abstract by nature. Thanks to that, they are flexible and **can adapt to different situations and people.** Unfortunately, that also makes their **meaning subjective and sensitive to misunderstandings and frictions**. In the charades, the participants guessed 4/7 values because they were already familiar with them, but it was clear that they interpreted them differently.
During the discussion, they agreed that Lely excels in applying some of the values presented on the cards while other values have room for improvement at an institutional level (top values on canvas Figure 28). Generally speaking, they all agreed that they make a good job representing Lely as employees, pointing as core values their teamwork and innovative mindset.

"We spent some time discussing because we understand different things when reading these values"

Lely Technical Support

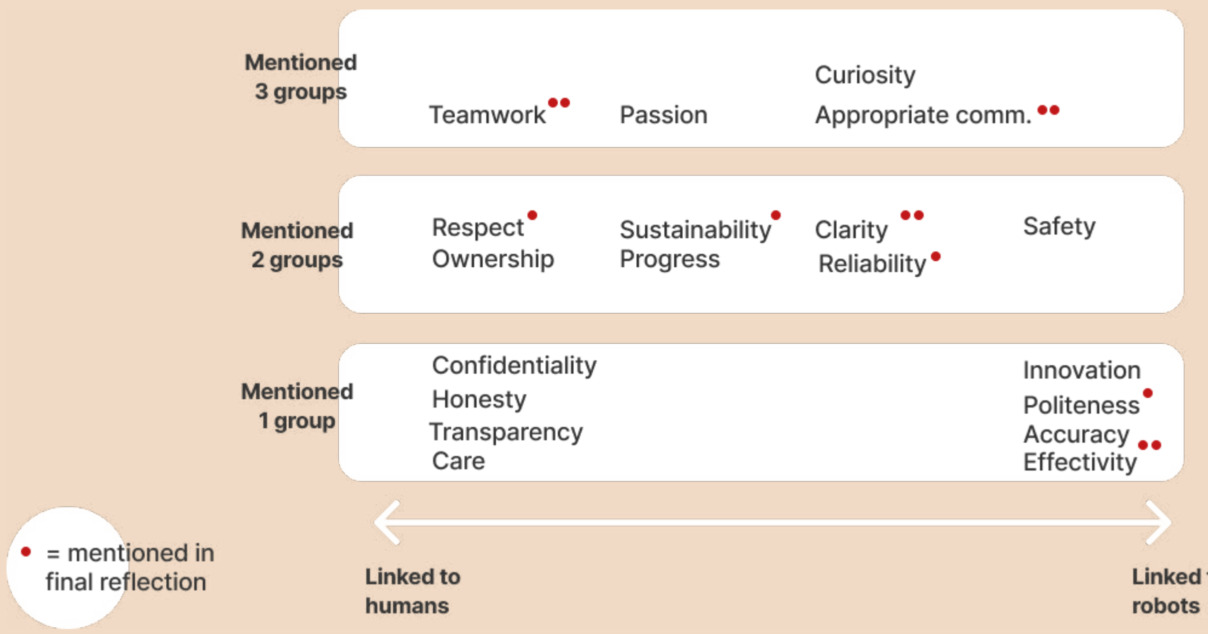


Figure 27. Workshop 1 - Testing current guidelines

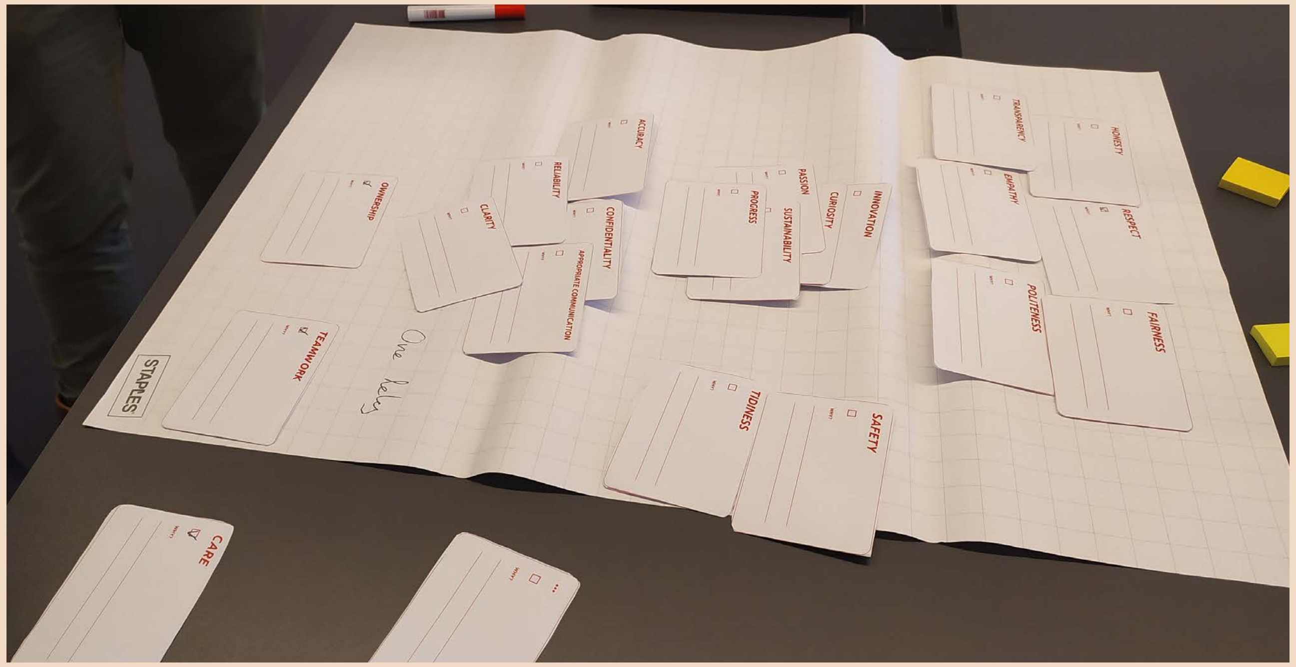


Figure 28. Workshop 1 - Discussing Lely values

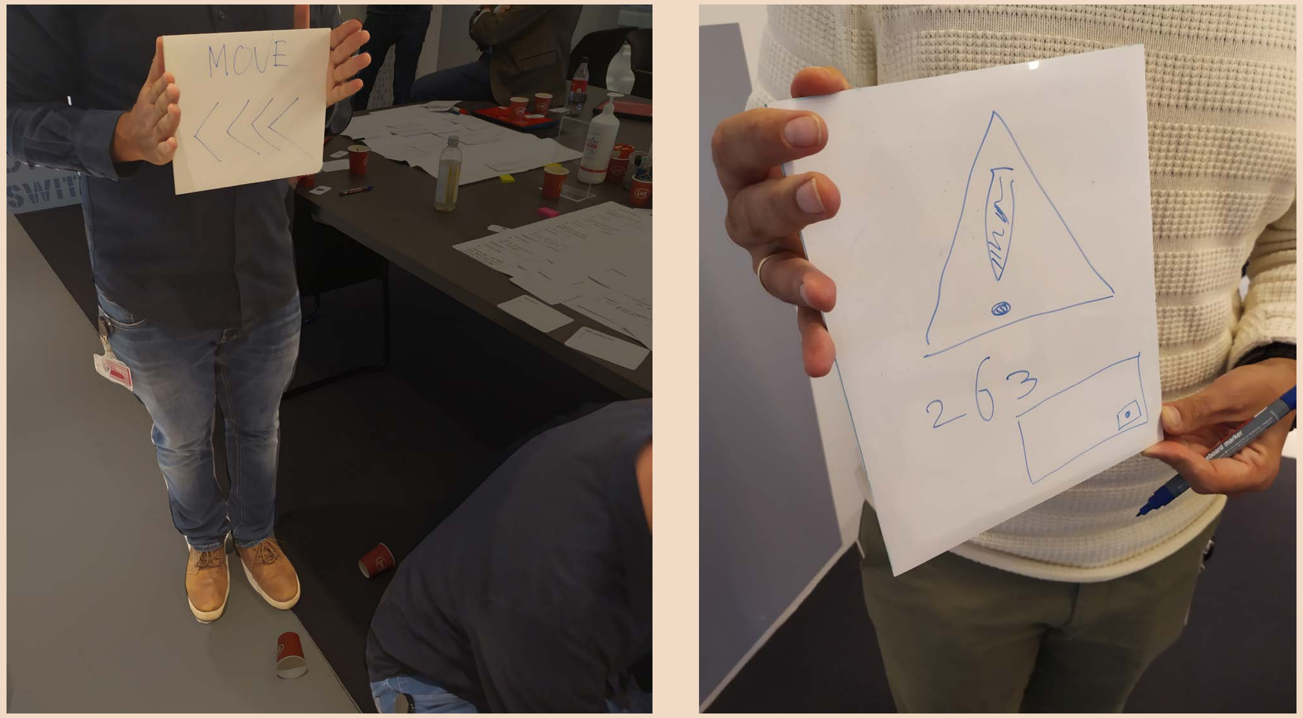


Figure 29. Workshop 1 - Testing communication

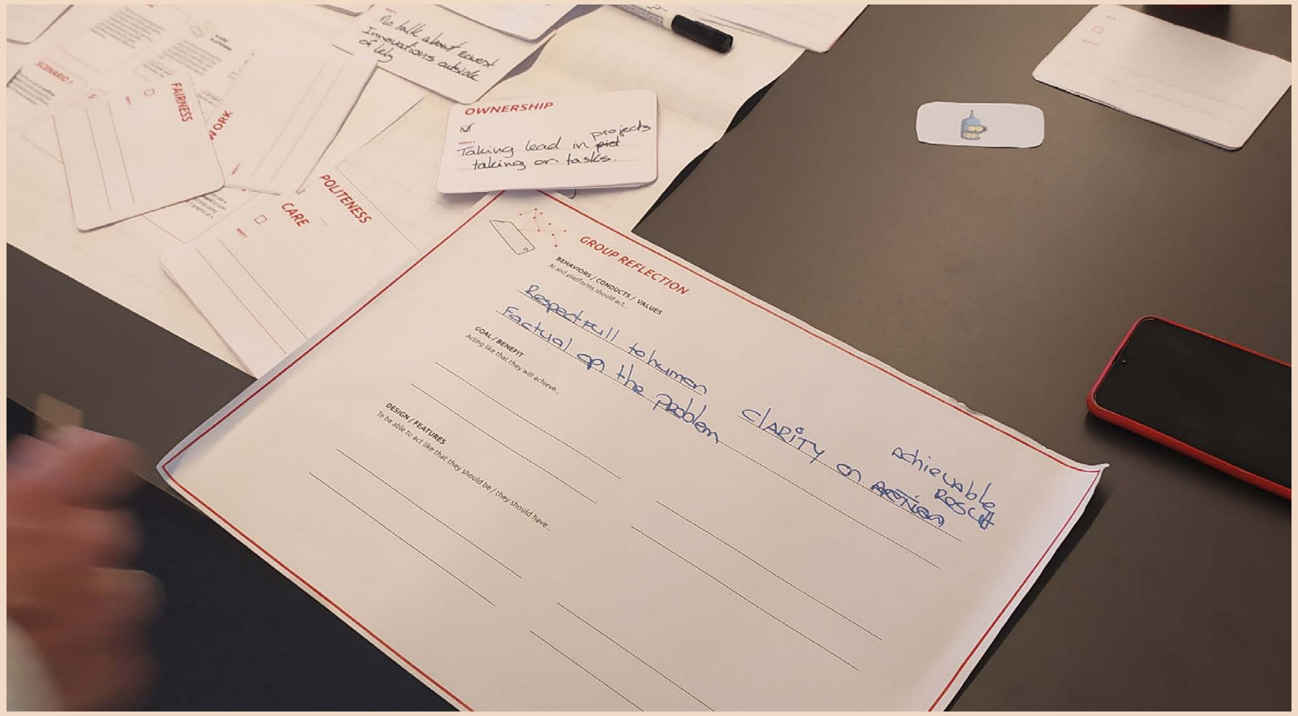


Figure 30. Workshop 1 - Final reflection

Adaptation and influencing factors

Every team concluded how they want the robots to act (Figure 29) and what they need to be able to do so. Through these enactments, I also gathered additional insights regarding applying these values and how "in different situations, you behave differently and have varying interests" (Situationalization, n.d.) If the goal is for the robot to be "honest", even if everyone agrees on what being "honest" means, it still needs to adapt to the situation:

- Is honesty the same when showing the robot state and when explaining a problem? (**stage of the communication**)
- When calling the farmer, is honesty as more or less important than efficiency? (**priorities among values**)
- Should the robot always be completely honest? (**thresholds and ranges**)

"If there was a problem and the robot caused it, if it is too honest about it, in this situation, I feel a bit betrayed."

Lely Third Parties Expert

How should you communicate as Lely?
RQ3

Is there value in creating guidelines for robot conduct?
RQ4

What should these guidelines look like?
RQ5

Robot guidelines

They concluded by reflecting and summarizing what a robot needs to represent the company (Figure 30). After the analysis, I mapped those reflections (Figure 28) and found everything covered under the theme **"achieving appropriate communication"** through certain qualities. There is a need for a new set of guidelines tailored to robots, which leave less room for personal interpretation and can assist developers to steer the designs in the early stages. These guidelines should also be clear about what all these values entail and how they translate into features and improved interactions. This is a great challenge. Many things need to be considered such as technical feasibility, desirability, and costs. They also need to be written with the right tone and structure to apply to the entire portfolio while remaining actionable.

Workshop 1

Initial set of values that will represent Lely in the desirable way which need to be re-defined as it do not mean the same as to humans.

Only dealing with “values” is complex, people tend to understand them in different ways. Their materialization will also depend per product.

Depending on the situation values should apply in different ways. Urgency, stage of the communication and responsibility of an error were factors mentioned.

Workshop 2

3.2 Workshop 2 - Robot nature and its design

The first workshop concluded with chosen behavioural qualities for robots to represent Lely. The goal of this second workshop was twofold. First, I aimed to evaluate together with a representative sample of engineers **whether implementing these values in the robots and platforms was feasible and desirable**. Secondly, I wanted to identify the best way to help them implement these values and design for improved human-robot interactions. To succeed in designing behaviours for intelligent agents it is not enough to aim to elicit meaningful interactions, it is also important to consider technical feasibility (Rozendaal et al., 2021).

1. Which of the values identified are feasible to apply for current and future robots and platforms?
2. Are these the desired values? Can they steer the design responsibly?
3. What does it need to be taken into account to apply these values to different products?
4. How could it become consistent among the whole portfolio?

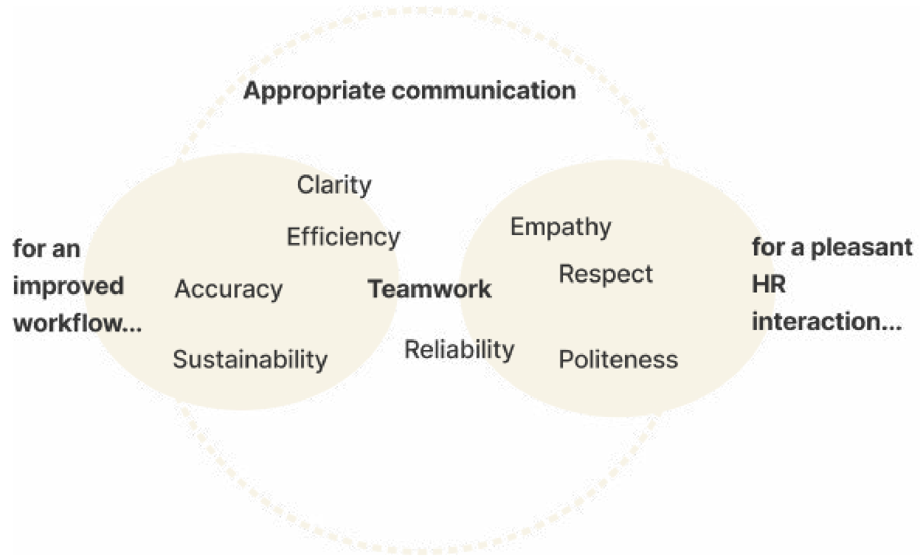


Figure 31. Conclusion values Workshop 1

Guidelines for the development

Also for this workshop nine participants took part in a two-hour on-site workshop at Lely. This time, it was crucial for them to have engineering knowledge and understanding of the different products within the portfolio. Their goal was to assess and iterate on the qualities of the robotic behaviours generated in the previous workshop. For this workshop, the flow intended to progressively immerse the engineers in the given values and challenge them in terms of feasibility, desirability and user-friendliness.

2 Product specialist
1 Discipline architect
1 Front end developer
1 Hardware test engineer
1 Lead test engineer
1 Expert third parties
1 Software engineer

Ice-breaker "Guess-the-robot". Brief warm-up round supported by videos introducing the topic and opening participants' minds to the complete current and future portfolio.

Activity 1 "Speed Evaluation". The participants had to quickly evaluate whether the resulting qualities from the previous workshop (Figure 28) could be, or were already, integrated into the robot and platform behaviour.
[***RQ1***][***RQ2***]

Activity 2 "Situational brainstorming". The participants had to assess and discuss how they would integrate the values into the agents' behaviour for a given scenario.
[***RQ2***][***RQ3***]

Activity 3 "Final Reflection". Developers were asked to discuss their workflow and reflect on how to incorporate considerations on human-robot interaction in their practice. They displayed their conclusion on a canvas.
[***RQ2***][***RQ3***][***RQ4***]

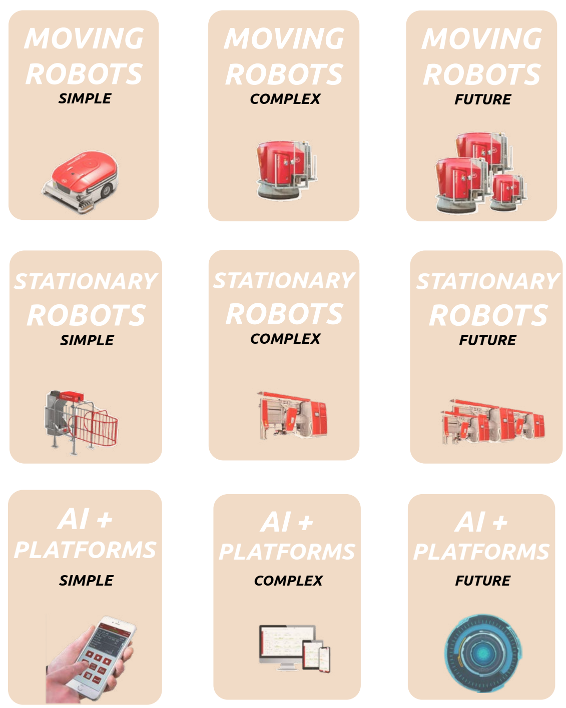


Figure 32. Workshop 2 - Robot and platform groups

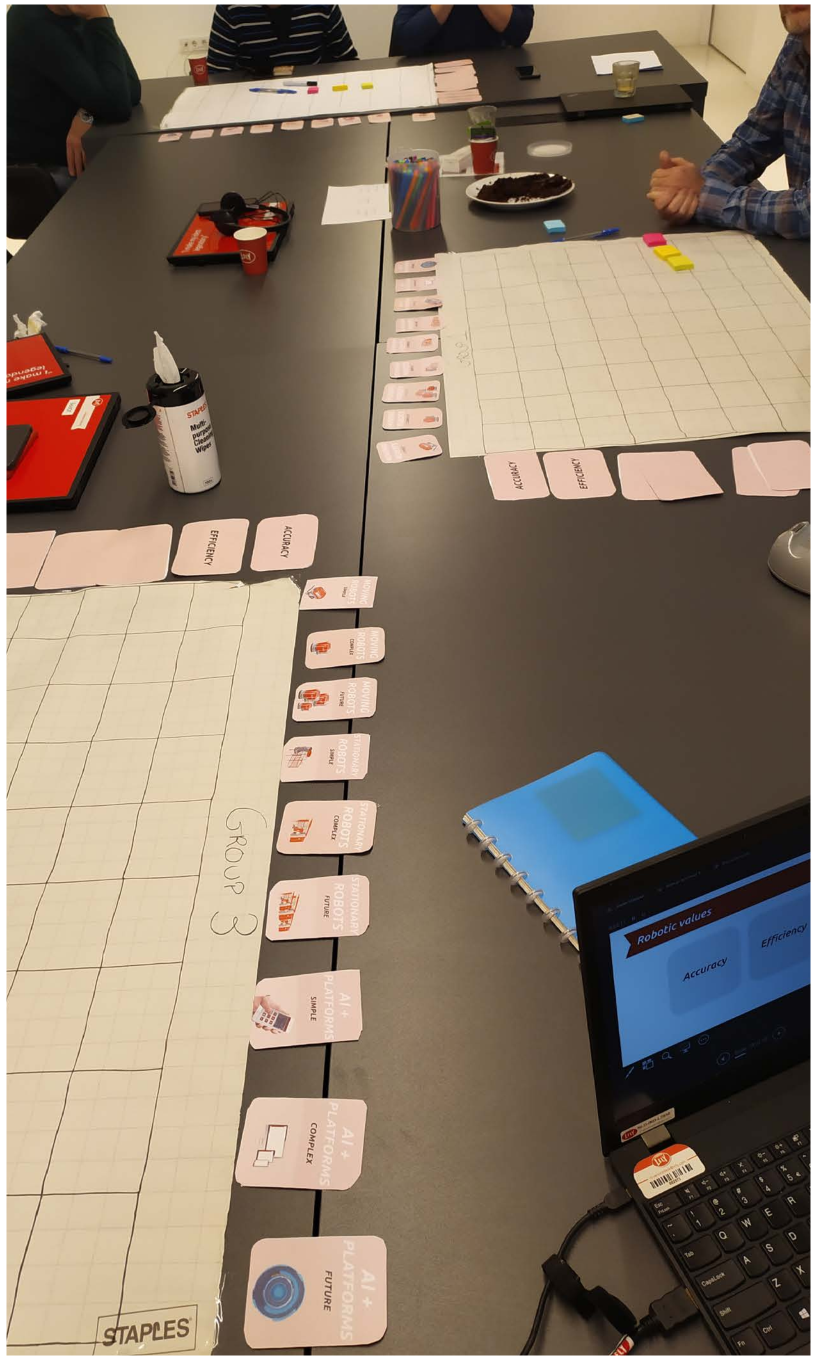


Figure 33. Workshop 2 - Setting

All activities were designed to trigger and accommodate discussion. They evolved around a **big table with 72 cells combining the eight resulting values from workshop 1 with examples of robots and platforms** (Figure 30). The values were categorized and displayed based on their level of perceived abstraction, whereas the robots were grouped as illustrated below (Figure 29). Appendix G contains more information on the setting and materials used during the workshop.

The rows contained the values ordered from Accuracy to Respect. The participants mapped their thoughts using colour code post-its. Green and yellow are those considered relevant to apply, being the second on more complex (Figure 31 represents them respectively as Turquoise and Cream).
The red cells indicated values impossible to implement. Participants ticked the cells when they considered that the robot or platform was already succeeding in expressing that quality through its actions.

The workshop resulted in three partially filled tables where participants mapped their assessment of the feasibility of implementing the given values. I also collected canvases with their individual final reflection on what they need to design robots delivering desirable behaviours. Finally, I recorded the intermediate and final discussions for a later transcription. I mapped and cluster all the insights obtained.
This workshop preparation taught me the importance of tailoring the activities to the characteristics of the participants.
Content-wise I learned about many factors influencing the design of robot systems, their development work-flow, and their needs. Coming pages describe these findings and introduce the final list of "Robot qualities". The complete analysis can be found in Appendix G

Robot values

Figure 34 visualizes the results of the evaluation mapping the flow of responses. **All values were considered relevant and feasible to apply in the robot design**. The topics framed as "impossible" were almost exclusively related to AI, an astounding field that raises many questions and hesitations.
It was interesting to learn that they believe most values are not yet covered in the desired degree by the products. The workshop discussions revealed that the blank cells at the bottom of the table were due to a lack of time and increased complexity of visualizing the concrete meaning of abstract values such as "Empathy" and "Respect". For the values to be useful, they need to be understandable.
One of the main outcomes was learning two strategies to convey these values: **finding the right phrasing and providing clear examples**. Another outcome was obtaining the final list of values. I re-arranged the original ones as some could fall under the same or a clearer category.

"You need to rely on the robot being your ally, know it won't hurt you"

Lely Product Developer

Examples assist us in visualizing the meaning of the word in the context. Additionally, participants conceived these values ranging from "essential" to "next steps". I exploited that perception to connect and structure them into a **final list of values (Figure 35)**. During the activities, they ideated a solution for a concrete interaction making use of these values. The three groups created a different solution but all of them improved the overview of the products in the barn. Answering RQ2, the values were useful to steer and strengthen their reasoning in the decision process. However, they are not strong enough on their own to create cohesiveness as they still designed different expressive solutions.

Which of the values are feasible to apply for current and future robots and platforms?
RQ1

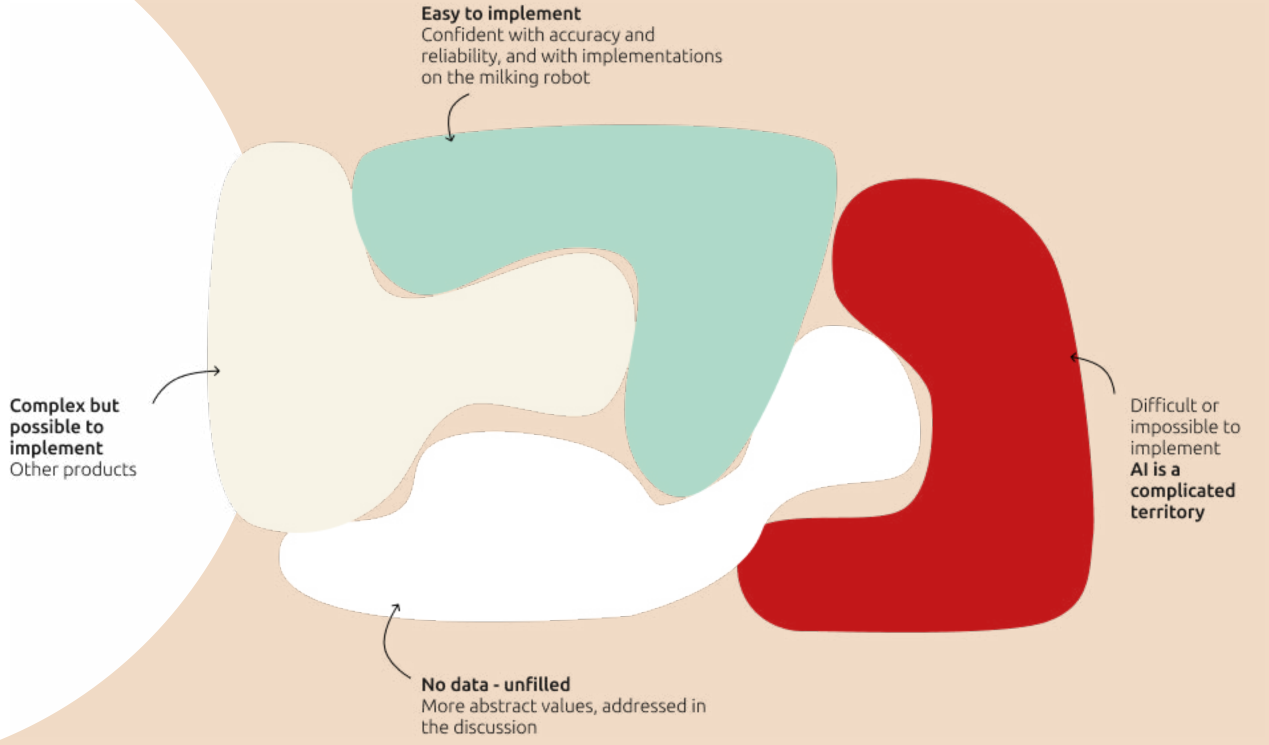


Figure 34. Workshop 2 - Result evaluation tables

Are these the desired values? Can they steer the design responsibly?
RQ2

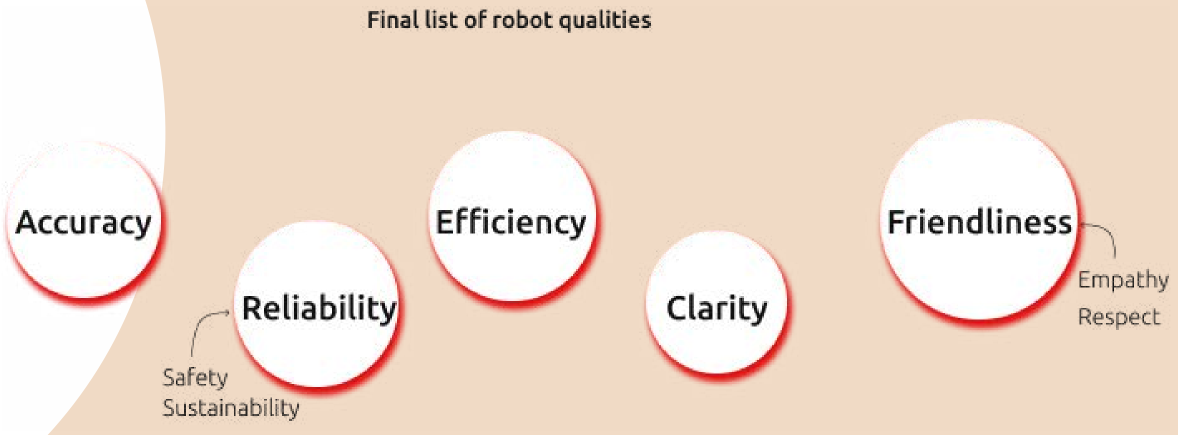


Figure 35. Workshop 2 - Resulting values

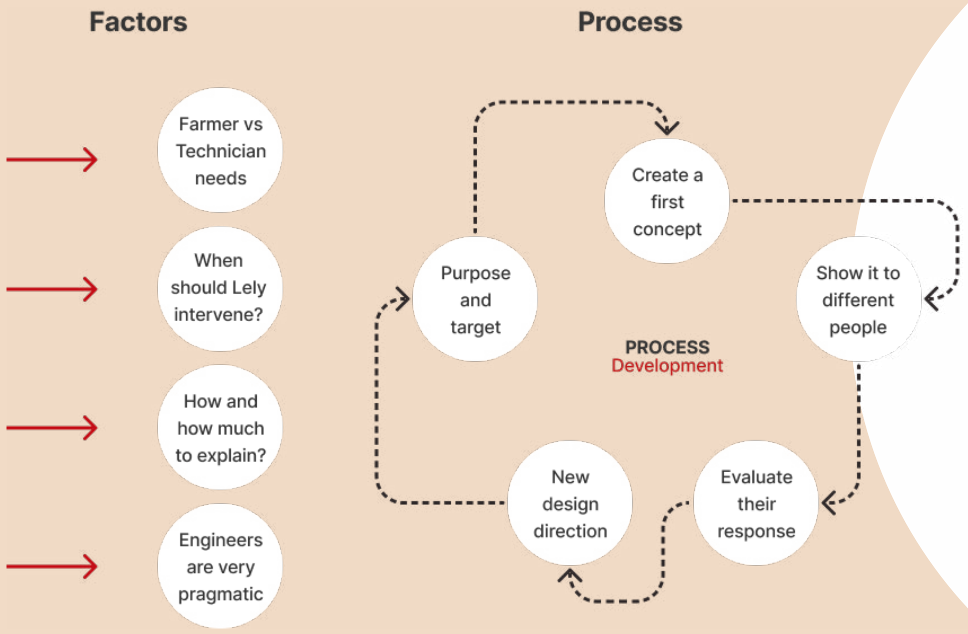


Figure 36. Workshop 2 - Development process and takeaway factors

What does it need to be considered to apply these values to different products?

RQ3

Development robot behaviour

From the final discussion I learned about their development process, and identified two types of needs.

Concrete to the decision-making during the design of the robots (finding the most fitting solution among a set of options). Guidelines like this will help them achieve a consistent set of desirable expressions and prevent them from re-thinking robot behaviour in each project.

General aspects to improve their overall development process. Figure 36 illustrates a simplified scheme of that process and factors mentioned as relevant. Guidance could play a role at different stages on their process for a variety of purposes from getting inspiration to easing the decision-making or assisting the evaluation. Participants agreed on the need to be triggered into taking action and **establish a connection to the reason behind a design and the target group**. Being clear with the goal of a design prevents problems when different stakeholders are involved in its development.

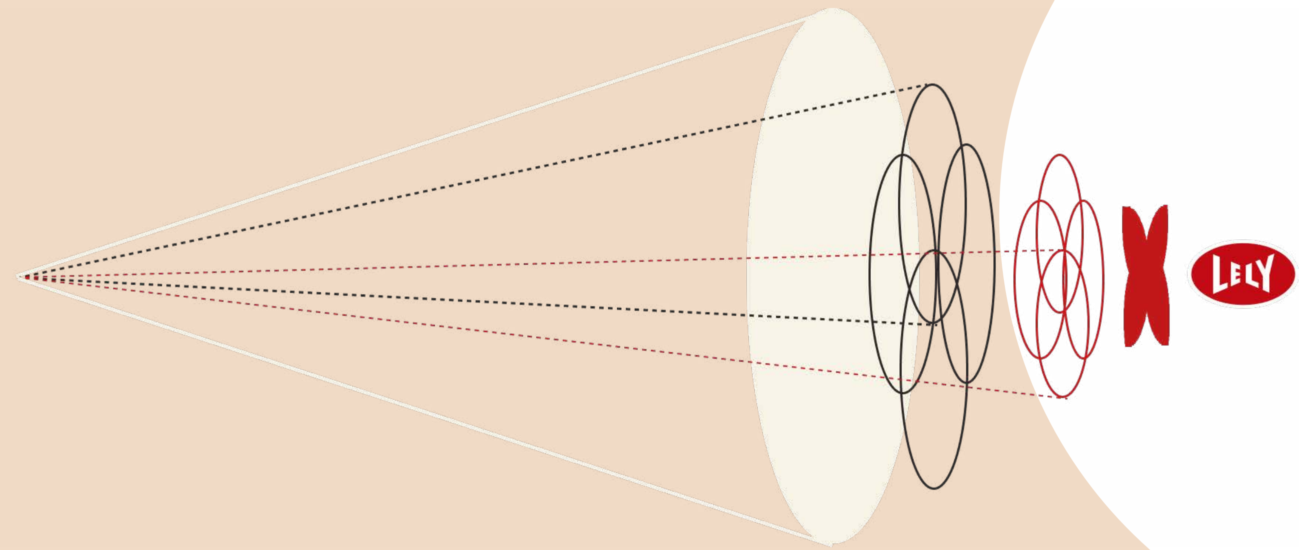


Figure 37. Workshop 2 - Goal of future guidelines

How could it become consistent among the whole portfolio?

RQ4

Robot guidelines

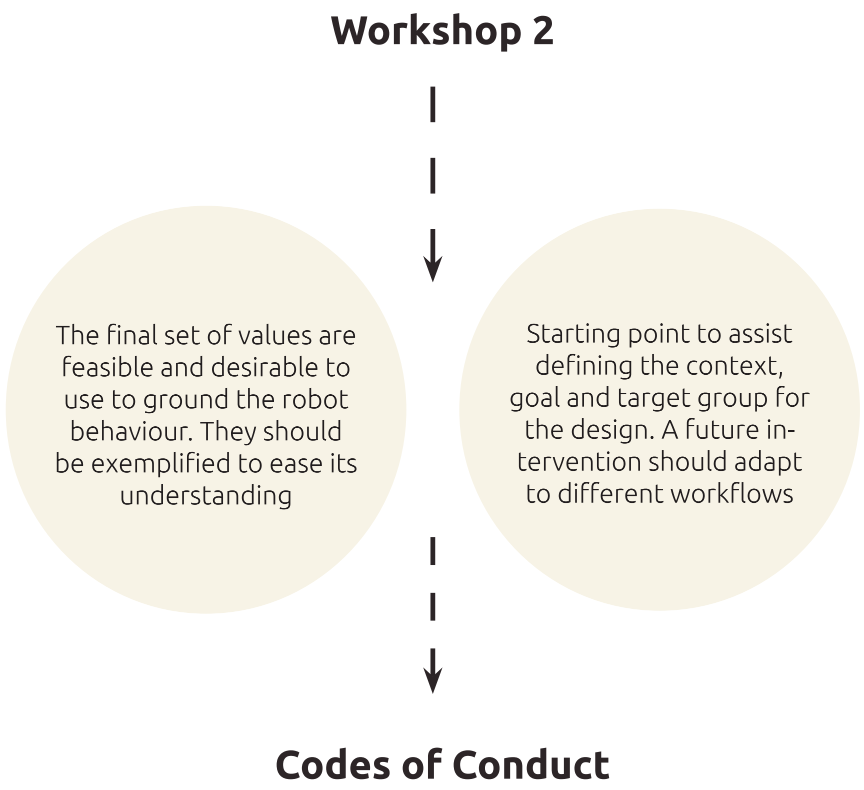
These guidelines can guide the process from the beginning. The robot values/qualities are abstract. Thanks to that, as aforementioned, they can accommodate all different products and goals and inspire with topics to consider in the first stages of the design. Later, more defined guidelines can bring consistency between products, how they express and how to evaluate them. They can do that by showing the current expressive mechanisms used by Lely. I argue that it will smooth decision-making, in the manner illustrated in Figure 37. From all possible solutions, and what can be done according to every type of product, providing a direction that would deliver better interactions and an overview to be able to move and communicate as Lely.

3.3 Design requirements

Through these workshops, I identified a set of values (Figure 35) to ground the robotic behaviours and other factors affecting HRI (Figure 36). Together with that, I drew insights on the development workflow and strategies to make this knowledge accessible and relevant to developers. I compiled all my insights into a design direction. This direction is ultimately a guiding intervention that should achieve the points described in Figure 35. There are many challenges involved in creating this intervention.

- How to find the style that would best convey all the information to the developers?
- How to accommodate and balance abstraction and actionability?

At this stage, I explored how I should shape the guidance accordingly. The next chapter introduces the concept of a "Code of Conduct" and describes why it is a fitting format for a future design intervention to fulfil the requirements of this project. Finally, left to research is whether applying the insights obtained on guiding the developments of robot behaviours representing Lely actually translates into pleasurable, fitting and cohesive interactions.



To fit the scope of the project the intervention should:

- Accommodate **all current products** in the Lely portfolio and be flexible to new developments.
- Set a desirable direction to ultimately **deliver improved interactions.**

To deliver improved interactions it should:

- Guide them to **account for all (or most) factors influencing** the interaction or **user experience.**
- **Improve unity** and overview among the products. Fitting Lely and working as one.
- Be **clear and pragmatic** enough to create a common understanding of the message.

To adopted among the developers and used, it should:

- **Make the development** of robot behaviours **easier.**
- Written in the **language of the developers** that will use it
- **Fit the** development **process** (always enhancing, never disrupting)
- **Be perceived as valuable**. Readers finding it relevant, real and applicable
- Be an **engaging** document that people enjoy reading. Be **interactive and inspiring.**

Figure 35. Design direction

4

CODES OF CONDUCT

4.1 Current interventions

The research stage concluded in a clear need for an intervention that would guide the development of robotic behaviours and specific requirements for this intervention. I research current solutions on frameworks grounding robot behaviour.

Many articles state the need for guidelines steering the design of robotic systems (Boesl et al., 2018) (Fosch-Villaronga & Albo-Canals, 2019)(van Wynsberghe, 2012). However, few are those taking the step to develop an actual set of guidelines or framework. Figure 37 illustrates a compilation of the ones found (Appendix H contains an additional study I made on relevant topics addressed by these guidelines). To highlight is the project SIENNA where Tamborino et al. assessed the representation of (among others) AI&Robotics in documents internationally.
From their thorough research, the SIENNA project identifies values and principles relevant to the development of AI&Robotic technologies. They also concluded with **criteria that future codes should follow**, which I adopted later in my design requirements (Tamborino et al., 2019).

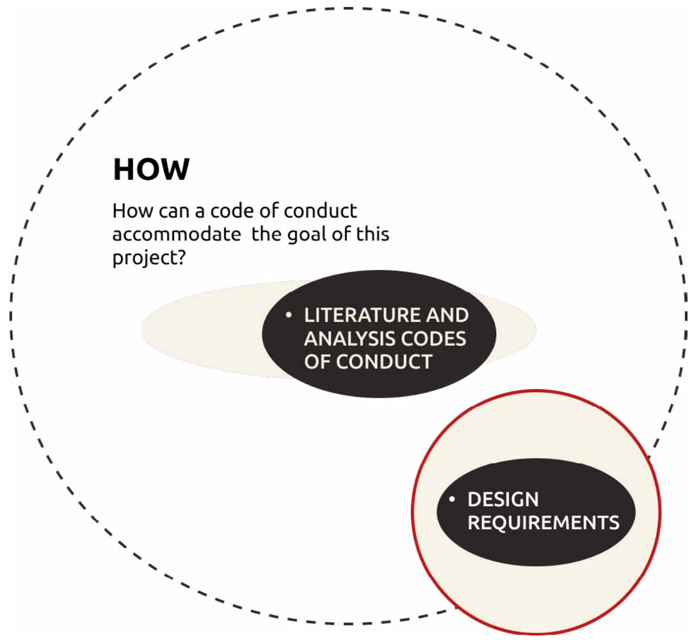


Figure 36. Overview defining the intervention format

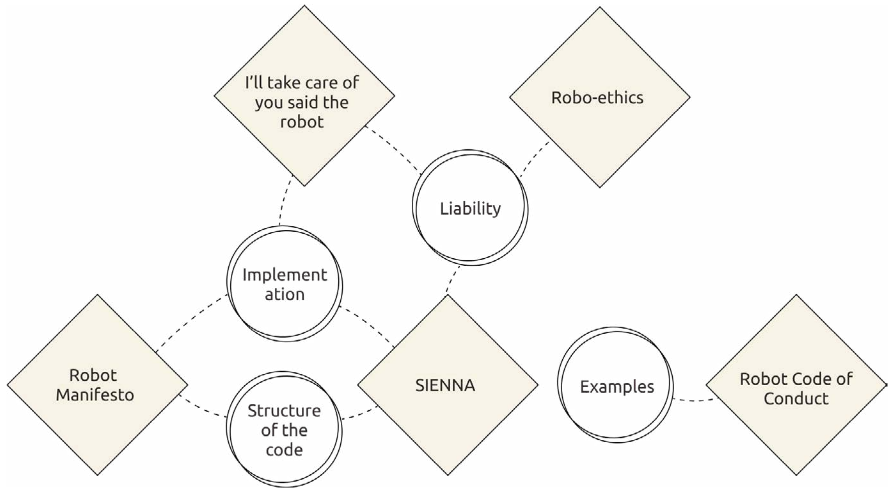


Figure 37. Compilation of robotic guidelines

This criterion draws attention to the fact that such guidelines need to be either:

- Broad enough that accommodate different applications
- Or tailored to a concrete application. In this case, it would be already focused on dairy farming. In the future perhaps different guidelines should emerge per task or product type.

The need of having guidelines developed per application also emerged when carrying out a brainstorming session with Roboticists from the RoboHouse at TUDelft. Being exposed to how differently they work in robotic contexts outside Lely only strengthen this belief. From the few attempts made to develop these guidelines, Kapeller et al. demonstrate the feasibility of establishing "domain-specific recommendations" for guiding the responsible design of wearable robots (Kapeller et al., 2021). Additionally, Boesl et al. contribute with a "roboticist wish-list" in their Robot Manifesto. It highlights the importance of communication and involving society. They propose a "shared vision for Roboethics or a Code of Conduct" (Boesl et al., 2018). Framing it as well as a Code of Conduct, Fosch-Villaronga & Albo-Canals describe seven principles for these "set of rules outlining principles and values to be respected by a profession". They reiterate the importance of developing such documents and binding them (Fosch-Villaronga & Albo-Canals, 2019).

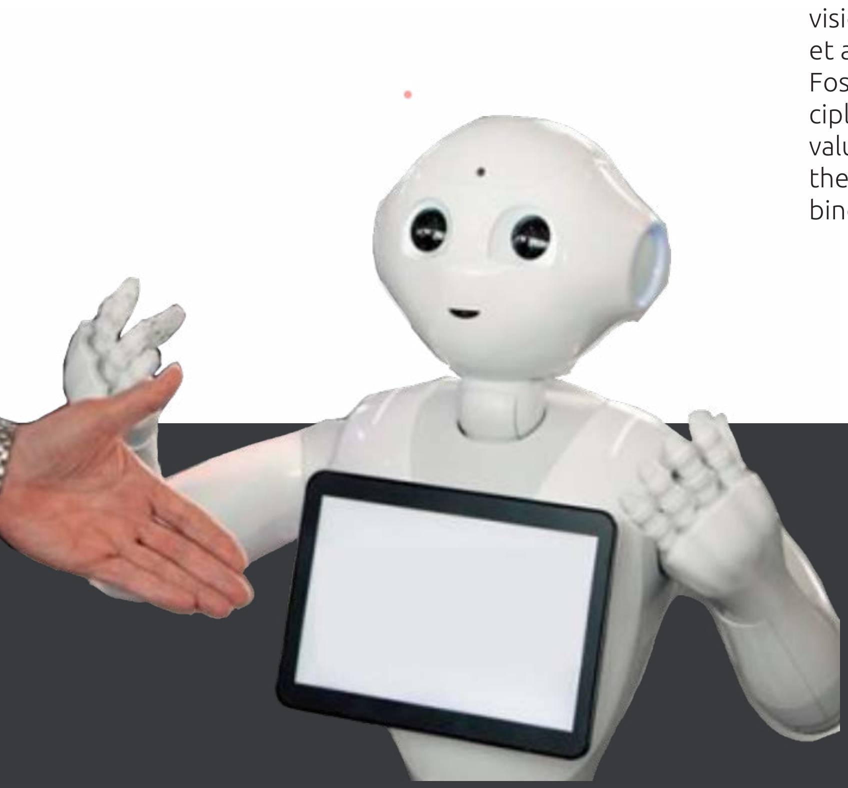


Figure 38. Guidelines to interact with smart products

4.2 Conventions, norms and guidelines

What is exactly a Code of Conduct? Why would it be a fitting solution?

"The roboticist is responsible for high-level planning while the company is responsible for having a code of conduct for employees"

(Van Wynsberghe, 2012)

The concept of a Code of Conduct goes beyond a mere set of company rules. This chapter describes more extensively their characteristics illustrating it with the example of how humans establish physical contact through the hands. In the end, this chapter will address the application of Codes of Conduct to HRI, showing its potential to improve trust in the systems and work towards a common understanding with robots.

Conventions, norms and laws govern individual behaviour. Of significant interest for this project are conventions and norms. A "conduct that is a convention suggests a stable pattern of behaviour, a societal regularity like people choosing to walk on the right, even when indoors" (Sarathy et al., 2019). Norms take a step further, as breaching them can lead to more severe consequences.
These norms and conventions both govern and are governed by social interactions that happen in a certain context (Hawkins et al., 2018)(Figure 39).

For example, depending on the culture people would either shake hands or bow at a distance when introduced to strangers. Several interpersonal interactions shaped this convention in a particular context.

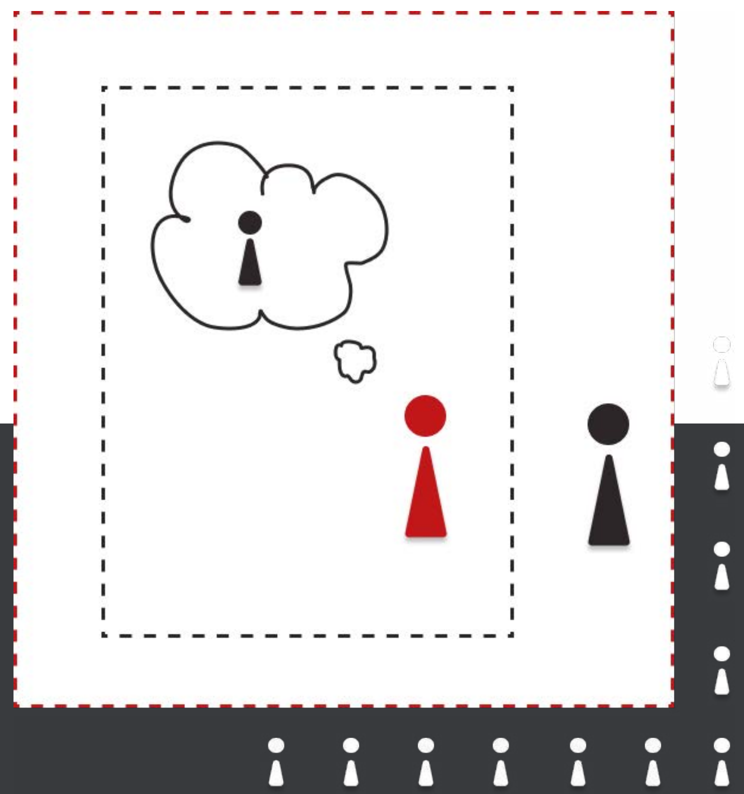


Figure 39. Representation of Conventions and norms (Hawkins et. Al., 2018)

Members of a group or organization with specific values and folklore usually reflect that in their behaviour. They are to an extent expected to respect the ideas of the group and act accordingly to them. Through Codes of Conduct, they refer to already existing or new societal norms encouraging or discouraging practices. These codes exist in many contexts, such as religion (the Ten Commitments), martial arts (Muay Thai) or even science fiction (the Jedi Code). Following the same example, many martial art disciplines follow a code that includes bumping fists or globes as a sign of respect before and/or after a match.
On the other hand, companies may encourage shaking hands with clients while dissuading any other unsolicited hand contact. A strongly defined code that members of the group respect will become representative. Through time, the consistency of their behaviour will make **observers identify the patterns and link them to the particular group they belong to**.
Norms and conventions "provide stable expectations to navigate the social world" (Hawkins et al., 2018). If they represent a certain group for which, through experience, we have created mental models on their behaviour, **we can expect and predict actions from them**. Figure 40 shows different ways of hand contact. Identifying that holding hands (top left) can represent a romantic relationship sets expectations for other actions, like the possibility of the couple kissing, which are not per se anticipated in the other five contexts.
Despite their undeniable differences, most Codes of Conduct share structural similarities.

Figure 40. Example - Hand physical contact conduct

4.3 Potential and characteristics

- **Core**. The group culture and the values grounding it.
- **Flexibility**. They use different levels of abstraction, being general in many cases to fit various situations and individuals while being more concrete for more absolute rules.
- **Bi-directional.** "We judge others based on their compliance to prevalent social norms, and we are perceived depending on our compliance to the social norms of others" (Jossee et al., 2021)
- **For everyone, for you**. They can contain general rules for all members and particular rules depending on your position within the group or organization.
- **Responsibilities, rights, consequences.** They can have more or less relevance depending on the document, and they "might function as either "a carrot" (an incentive [...]) or "a stick" (an enforcement)" (Bennett et al., 2017).

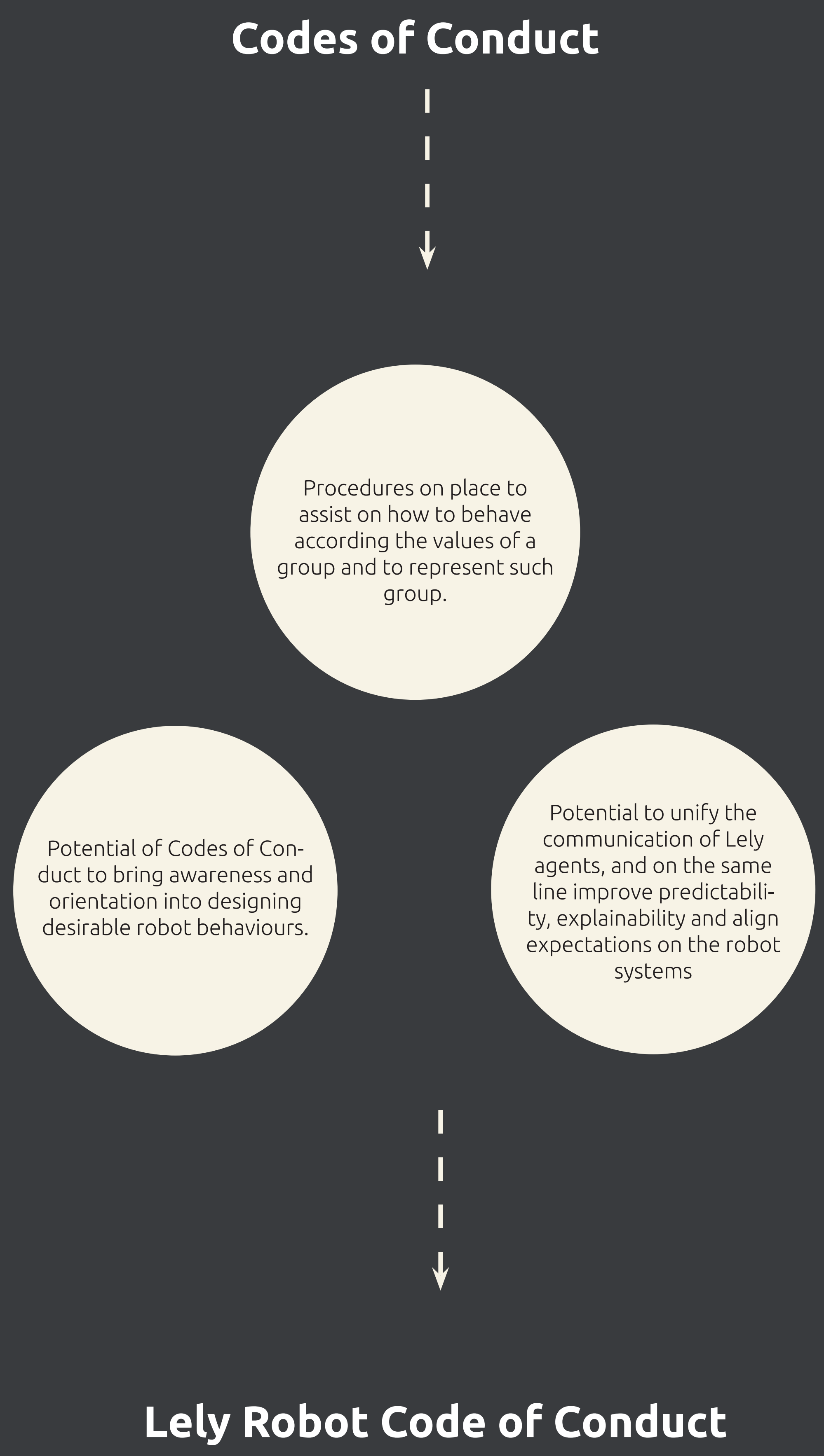
Robots joined our lives relatively recently, and because they are in development and tailored to their application, their behaviours differ from each other and are in continuous change.
Thus, **robots do not present consistency in their behaviour as a "race"** or even group. There are **no conventions or norms on how to interact with them**.
How would you know how to greet Pepper (Figure 38)? Even if some social humanoid robots try to replicate our human conventions, at least currently, they also do not know how to interact with us. Creating a Code of Conduct to steer robot behaviour will set the basis towards a common understanding with robots. As learned during the research activities, this document will need to accommodate and address different dimensions compared to the one addressed for humans.
Nevertheless, I argue that it will bring awareness and direction to the developers while aligning expectations, improving predictability, and ultimately creating trust in the robotic systems.

A Code of Conduct aligns with my previously defined design direction and challenges. It will be especially beneficial for a company like Lely to unify its broad robotic portfolio. Such a document will fit in the current picture of Lely like **a merge concept-wise between the employee Code of Conduct (behaviour) and the Red Rules (product-oriented rules for developers) but unique in its content**. It will strengthen the brand identity, taking a step toward achieving the company vision of communicating as one and expressing values through actions.

Figure 40 lists additional points to complement the design requirements integrating the knowledge from the literature on Codes of Conduct
The final design will be a Robot Code of Conduct tailored to Lely. Once the direction is clear, each of the requirements constitutes a challenge to solve. The following chapters described the iterative process that I undertook to design the Robot Code of Conduct according to my previously set goals.

- [ ] Include and define the values of the group
- [ ] Show the purpose and target audience of the code
- [ ] Raise awareness over the desirable and undesirable behaviour
- [ ] Include everybody (everything) and concrete guide per group if needed
- [ ] Contain a guide of how to sustain the code and responsibilities

Figure 41. Design requirements



5

DEVELOPING THE CODE

5.1 Methodology code design

Through the previous primary and secondary research, I identified many considerations relevant to improving HRI at Lely. These activities also lead me to identify Codes of Conduct as a potential strategy to implement this knowledge and use it to assist the development of current and future Lely robots and platforms. This chapter describes the final concept of the Robot Code of Conduct. I present its composition and the reasons behind the design decisions.

During the design stage, I included a variety of user perspectives and performed many activities to deliver a one-fits-all design tailored to Lely and fulfil the requirements set. The chapter touches very briefly upon the process followed during the development of the codes. The main focus of this section is to showcase and explain the result and its final evaluations. The full version of the code is available in the TU Delft education repository as an additional document.

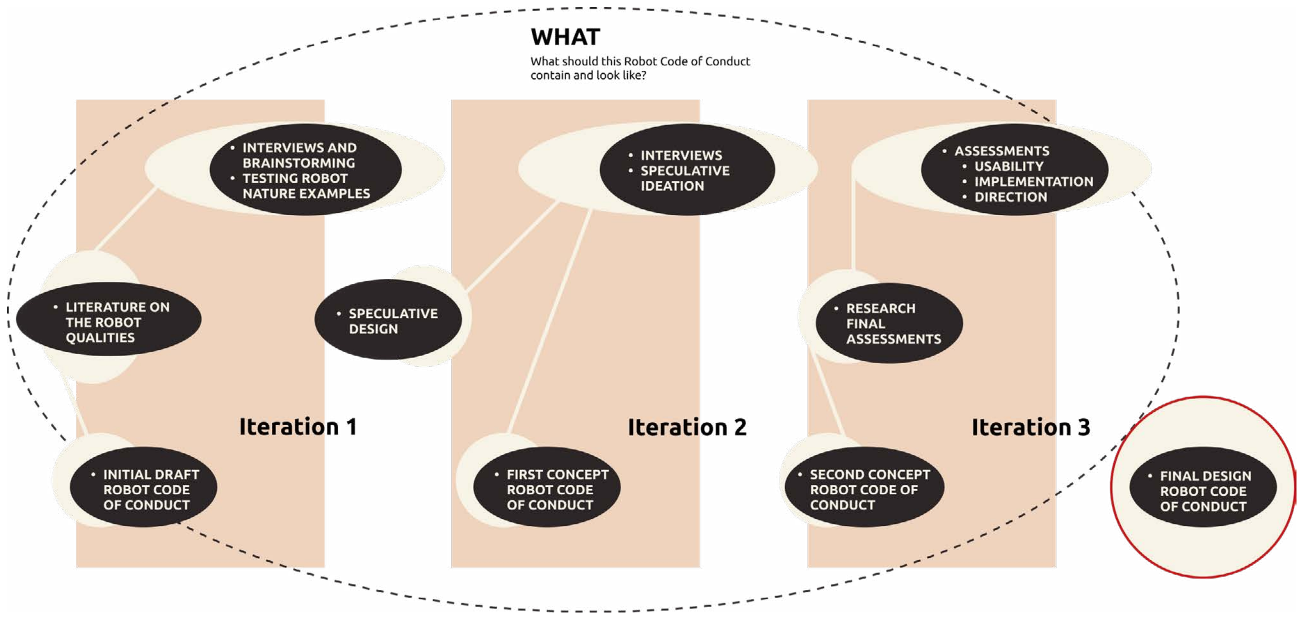


Figure 42. Activities and iterations

At the second workshop, I learned that developers conceptualize their ideas early in the process to gather feedback from colleagues and users. I followed a similar strategy and involved stakeholders throughout the design process. They did not participate in the actual design of the codes. However, the involvement of the stakeholders was so crucial and personal that I perceived the process more as a co-creation. This rather participatory methodology culminated in the following benefits:

- The multiple discussions helped me identify the best design directions to follow and topics to focus on. After every iteration, the satisfaction of the participants improved noticeably.
- It inspired me and allowed me to fundament the codes on real experiences and problems.
- It helped once again to spread awareness on the topic around the company.
- I argue that involving developers in the design of the codes will ease their adoption. FlexDelft used a similar approach to design the Red Rules, and it indeed succeeded in creating ownership and involvement with the document.

Figure 44 maps some of the people involved in the design stage of the project and the main insights drawn. I carried out different activities with experts from Lely and external to the company. This process went through three design iterations. In each, I not only enhanced the overall style (Figure 43) and concept, but I also incorporated a new part of the structure until concluding with three main chapters. Similar to the interviews, the tests were also semi-structured and flexible to adapt to the diversity of participants. I designed the concept using Figma and made the final version with the implemented feedback in InDesign for better control over the layout and print.

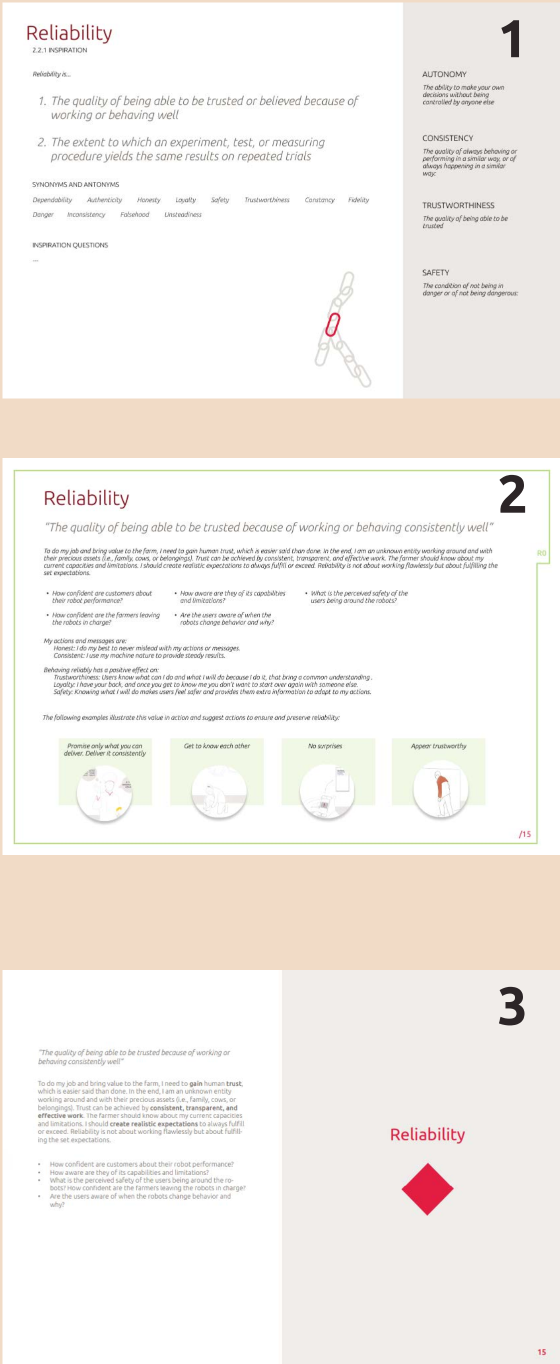


Figure 43. Examples iterations on style

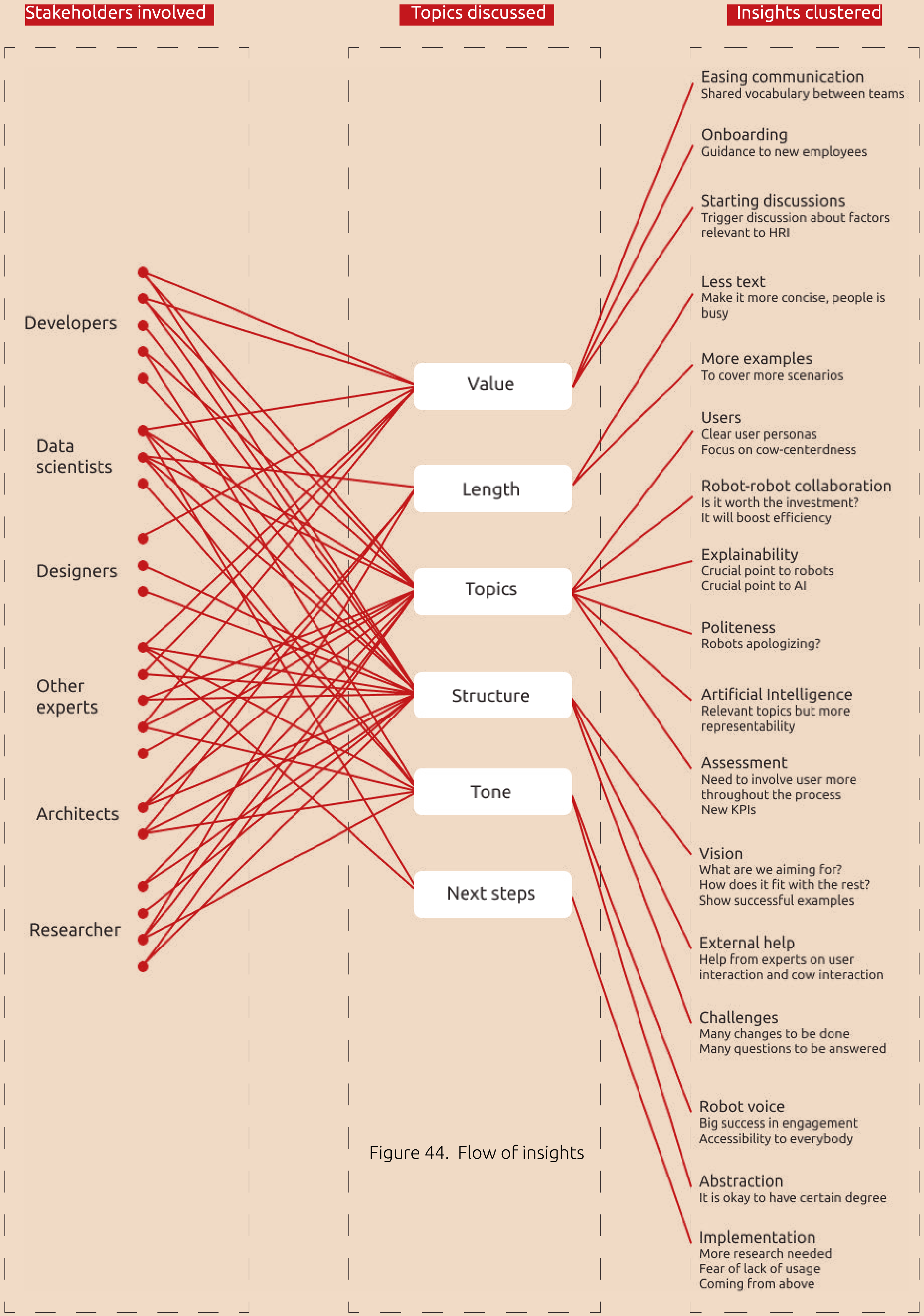


Figure 44. Flow of insights

Iteration 1

Exploring how to shape the codes and balance the abstraction

My starting point was knowledge of the basic structure of a code of conduct (introduction, usage, and sustainability of the code) and the list of robot qualities resulting from the Research Activities. I created a mock-up document containing these points aiming to gather feedback for the first round of tests. The focus of this round was to answer the following questions:

1. Which **format and tone of voice** fit the best for these guidelines? How can they be engaging? How can I explain the robot qualities?

2. **What should these guidelines contain**? How extensive should they be? Which of the many points of interest should I include and how?

3. How can the Code **balance abstraction with actionability** to allocate all products in the portfolio while remaining considerably pragmatic?

"These examples are interesting but how can I proceed with this?"

Lely Researcher

From this initial round I learned about the complexity of conveying abstract messages. It is difficult to step out from one's perception of a concept to see the bigger picture. For that it was essential to involve additional angles. I also learned that accounting for human-robot interaction and consciously steering the behaviour of the robots is not a natural part of the development process out Lely neither. Although interest is being paid in the latest years.

HRI Guild test

I had the first opportunity to show the draft of my document and get feedback during a meeting with Lely employees interested in HRI (Figure 45). I created a short survey to discuss some points of interest for developing the codes.

1 UX Researcher **2** Lead engineers
1 Hardware test engineer **1** Software architect

Robohouse lunch brainstorming

I joined an ideation lunch with a team from the research centre of robots "RoboHouse" at TUDelft. It was inspiring, and they showed me a different set of conduct guidelines they had developed in a previous project. Their scope was broader, and they targeted the enhancement of the role of humans in future collaboration with robots.

2 Robohouse management **2** Robohouse developers

Discussions stakeholders

Similarly to the methodology followed in the research stage, I arranged several 1-1 meetings with employees, HRI experts, and designers. During those meetings, I shared the version available of the document but discussed the overall concept and application.

4 Designers **4** External researchers
2 Data scientists **1** HR manager
2 Product owners **1** Learning specialist

Testing examples

Support the abstraction with clear examples was essential. I carried out extensive research on the five different robot qualities and ways to describe them. Once I had a set of examples that seemed clear to me, I anonymized them to evaluate with three external participants if they could recognize the qualities I intended to convey. It was highly useful to open my eyes and discover how to correct, re-organize and simplify them (Figure 46).

3 External designers

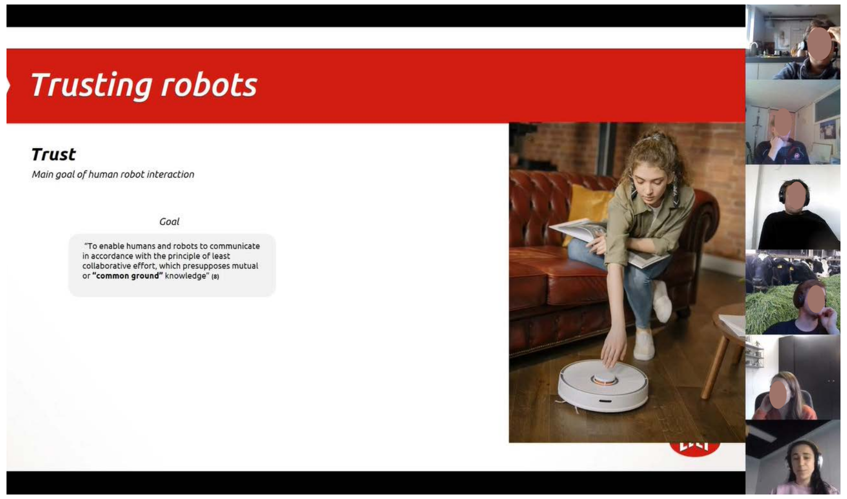


Figure 45. Human-Robot Interaction Guild test

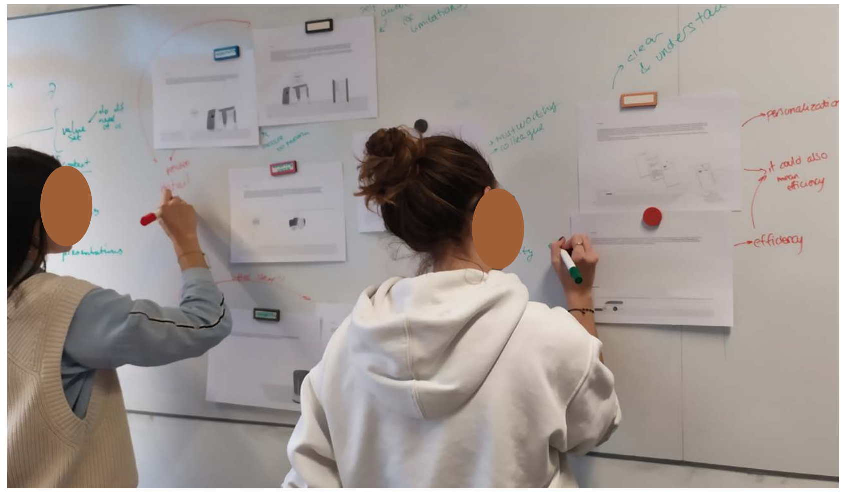


Figure 46. Assessing the examples to describe the robot nature

Iteration 2

Taking a next step. Pragmatism and searching for the tone

After this first cycle, the Robot Code of conduct evolved and incorporated an initial version of the defined list of current behaviours and expressive mechanisms used by the company. The main goal of the second round of tests was to solve the following questions:

1. How can these guidelines assist you to tackle a current problem you are facing?

2. When in your workflow do you envision yourself using these guidelines?

3. What would be the most fitting tone of voice and exemplification for the target group aimed for?

4. How can they improve? Is there something missing?

"I really like the overview of solutions, but how can I create it? I feel like I miss a step"

Lely Product Developer

I obtained feedback from nine of the experts that received the code and it gave me a lot more clarity on how different developers make sense of the codes and which parts are more relevant to them. Distributing the codes to gather feedback also served to spread awareness and it was impressive how valued the code and its vision was by the different stakeholders.

Lely experts tests

I evaluated how developers would use the concept document to address current issues in their projects. The code was printed and distributed among 18 different stakeholders for review during the Christmas break. The draft contained a disclaimer clarifying that it was still a concept and encouraging the readers to write their feedback on the code (Figure 47).

2 Software architects
2 Software engineer
2 Test engineer
2 Product engineer
2 Legal department
3 Product manager
2 Software manager
1 Data engineer
1 Head HR
1 Marketing department

Speculative lunch session

This document is only the first step towards a bigger goal. I used theories on speculative design (Future Scan, n.d.) to create a session with designers and generate ideas on the future vision of the codes (Figure 48).

5 External designers

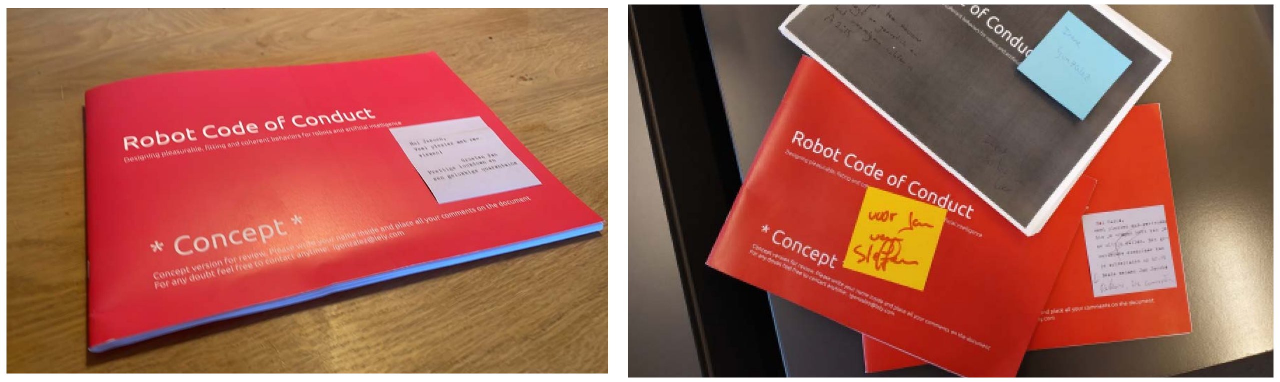


Figure 47. Collecting feedback through printed code

Figure 48. Speculative lunch

Final iteration

Completing the code. Evaluating usability, direction and implementation

Based on all the insights collected, I iterated once more in the design implementing middle guidance to bridge the gap between the most abstract and the most defined part. It allows the developers to account for the relevant factors important to design expressive mechanisms that convey the desired robot nature. The final version of the guidelines was a booklet with a complete first version of the content. For the final evaluation, there were three main goals which I tested separately:

1. Does this vision have the potential to deliver pleasant, fitting and consistent interactions? Would the designs supported by this code add value to the final user?
2. Do developers benefit from using this code? Does the document assist their process? How does it fit their workflow and style?
3. How can this code be embedded and introduced in the company? Which are the best next steps to take for it to be adopted?

"I would first scan through the content for keywords relevant to my work"

Lely Product Developer

From this initial round I learned that the full version of the code raises many questions that have not clear answer yet. However, I discovered that only triggering this discussion was highly valuable and opened up new spaces and opportunities. I could conclude answering my research questions after discussing with farmers about the proposed direction. The importance of the set vision on personalization was obvious when farmers living 10 minutes apart expressed different desires about their robot partners.

Usability assessment

I studied how a team of three product developers use the code to address a current design challenge (troubleshooting, Figure 49). This evaluation provided me with valuable information on the navigation and clarity of the code for the final design.

1 Product leader
1 Product manager
1 Lead engineer

Implementation assessment

A joined discussion with the Software Architects at the company to define the most suitable strategy to put the code into action.

2 Software architects

Direction assessment

I created showcases of the robot nature in Figma (Figure 50). Similar to the code those were short stories to test if they could identify the underlying qualities and start conversing about them. Two test farmers from the south of the Netherlands joined the evaluation. Appendix X contains all the screens for the farmer's test.

2 Test farmers

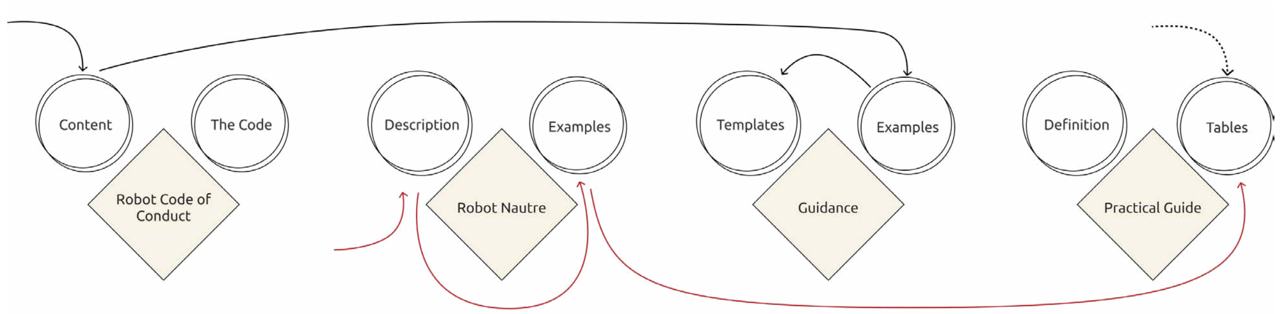


Figure 49. Navigation through the code

Figure 50. Interactive robot natures direction assessment

5.2 Design method

The Robot Code of conduct contains four different parts which progressively build upon each other. I will describe further each of these categories separately in the rest of this section.

To be adopted and used, Lely employees need to perceive this document as an integrated part of the company, a new puzzle piece, fitting the rest and progressing, strengthening each other.

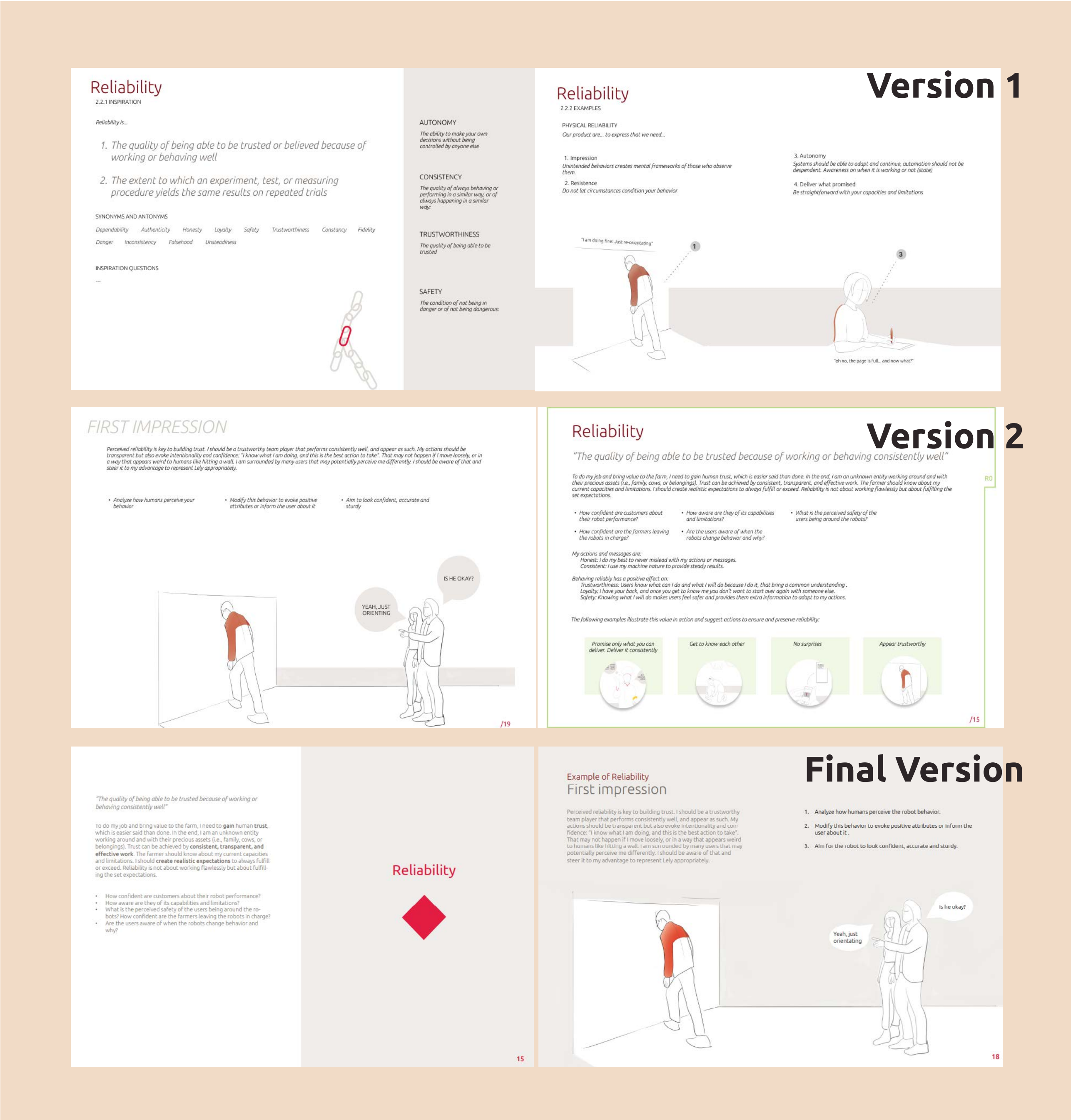


Figure 51. Visual design of the codes

For that, the style should comply with the corporate identity (Figure 52). Envisioning a coffee table book, glossy and attractive to the reader, I undertook three layout iterations (Figure 51). Content and style evolved together. I started with a strong inspiration in the Red Rules, and through feedback and personal exploration, I improved in readability and aesthetics.

Several experts complimented the style of the code. I could see through the iterations how as readability improve the readers navigated easier and got more information out of it. Consistency in the layout was key as well as a clear structure to efficiently find the piece of information needed.

Figure 52. Corporate identity

6

FINAL DESIGN

The Lely Robot Code of Conduct consist on four parts (Figure 53) from which three are the actual guidelines for the design of robot systems. These guidelines progress in abstraction from robot qualities until concrete mechanisms. This chapter will describe the four parts of the code in detail.

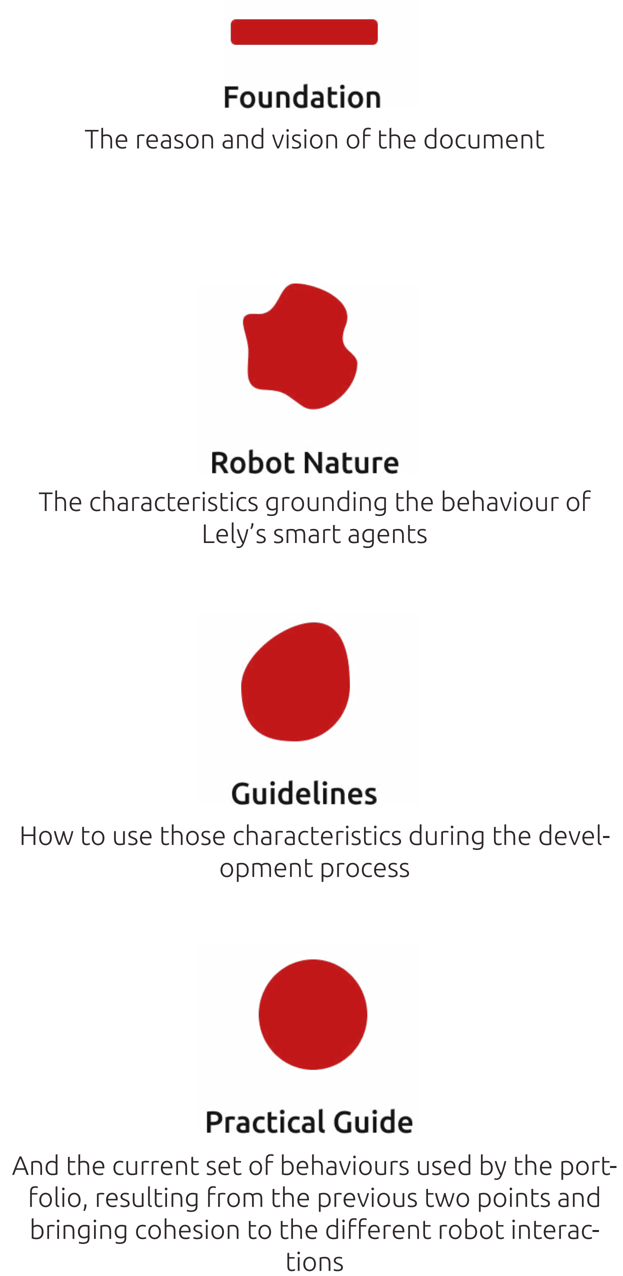


Figure 53. Structure of Lely Robot Code of Conduct

6.1 Foundation - Introduction and vision

The Robot Code of Conduct starts with basic information about its goal and use (Figure 54). Following other documents of the same kind, it defined a **purpose, target audience and their responsibilities** to comply with it and sustain the code. Developers should easily understand the goal of the code and what they can do/should do with it. The "Heritage" page (Figure 55) aimed to make obvious the **connection of this code to other documents in the company**. I argue this helps developers welcome the code and situate its function and relevance. I made an evocative graphic to trigger the reader into creating relationships without claiming any equivalence or causation.

I created a new Vision that depicts the future of fully automated farms (Figure 56), which I aimed to complement the strongly defined future Vision of Lely while tailoring mine to the goal of the document. I explored this future in the speculative lunch session. From a debate on extreme scenarios, I could distil the importance of maintaining the humans in a pivotal position **steering automation to fit evolving human needs.**

"Aiming for a future of work empowerment where robots enhance the human role"

Roboticist

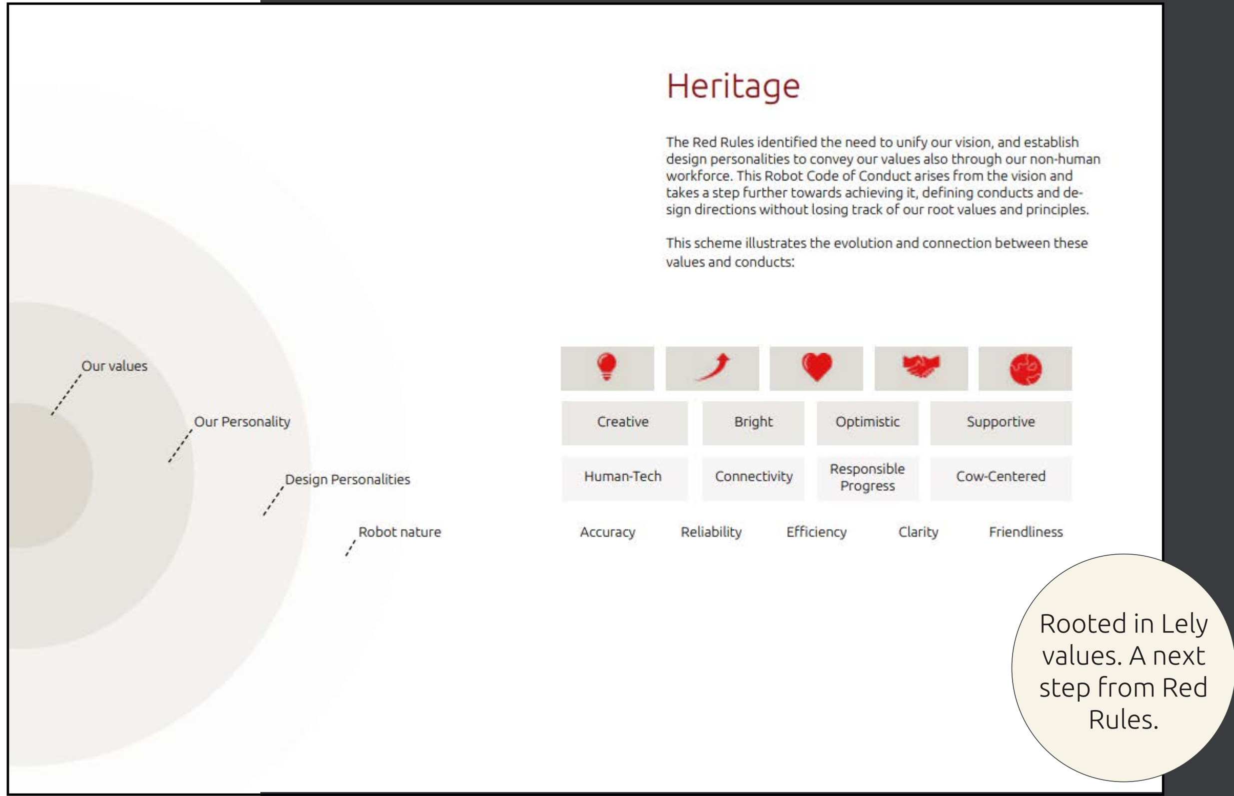


Figure 55. Design - Heritage

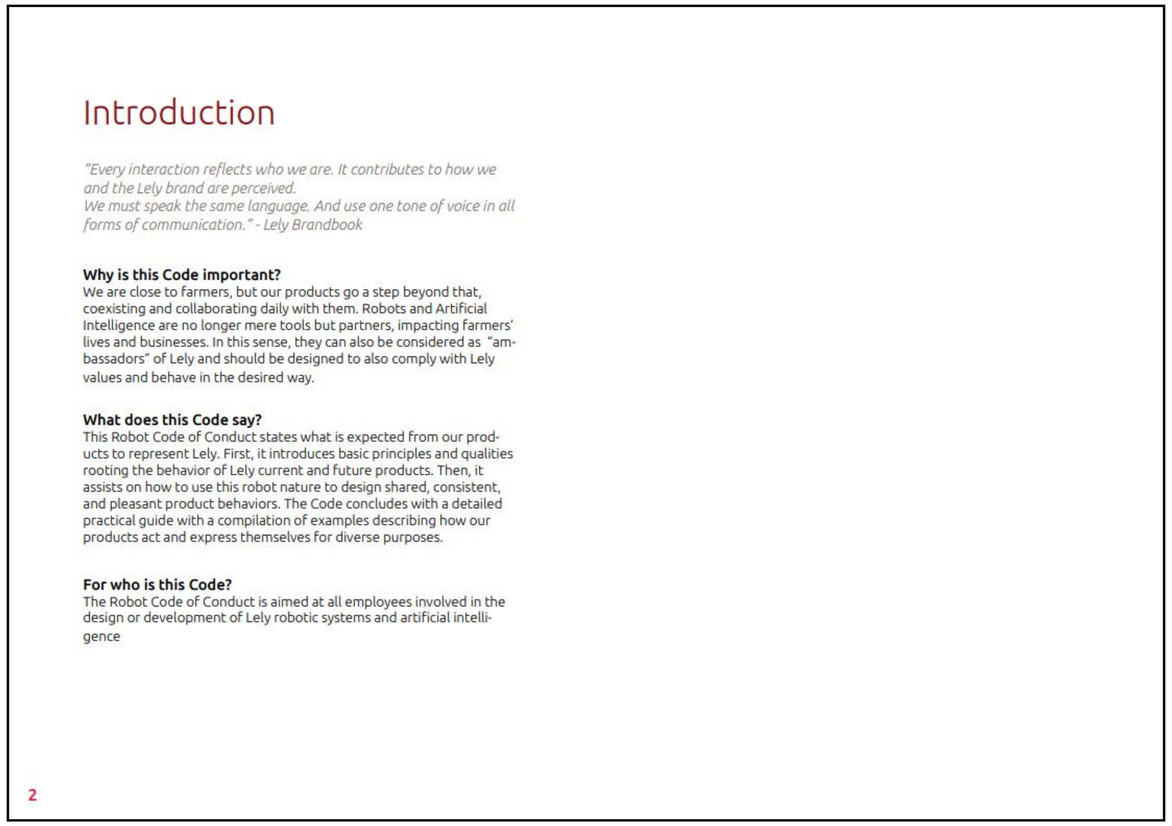


Figure 54. Design - Introduction

Figure 56. Design - Vision

6.2 Robot Nature - Grounding behaviour

How do we want Lely robots and platforms to behave?

I introduced the first and most abstract guidelines with two pages (Figure 58) to open the reader's mind on core aspects of human-robot interactions. I introduce the concept of an interaction, the importance of setting a goal and possible entities that could be fall under the category of user. These points will be further expanded on the later chapter "Guidelines".

Values grounding the recommended behaviours are also an implicit part of Codes of Conduct.
Liscio et al. clearly describe how values are relevant to steer technology and must be costumed to the needs of the context. "Since values are (high-level) cognitive abstractions, human intelligence is necessary to conceptualize a value and reason about its relevance to a context" (Liscio et al., 2021). The final list of values where the result of the research activities. I connected them together (Figure 57) and rephrased them as "Robot qualities forming the Robot Nature" to make a clear distinction with the "Lely values", well-known and human-related.

Similar to other codes of conduct, **abstraction allows these lessons to be followed by all**. This flexibility is a double-edged sword making it easy for readers to have their **unique understanding of them**. The challenge was describing these qualities to tame abstraction. I researched each quality individually and found that all of them can accommodate a variety of definitions and implications.

Each quality has its separate subsection, introduced by a definition (Figure 59) and supported by examples (Figure 60). I explored and tested techniques to describe the qualities and concluded that a mix of these three formates is the most effective when communicating the desired message.

Final qualities from Workshop 2

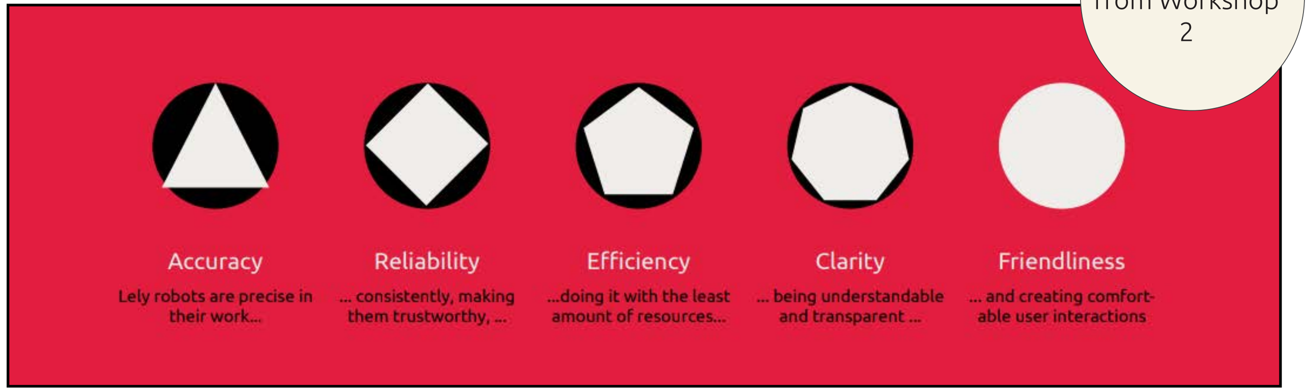


Figure 57. Design - Robot Nature

Interaction, goal and user

This chapter describes the desired qualities of robots and AI behaviour to represent Lely. It is described from the voice of a robot as follows:

Nice to meet you. I am a Lely robot. My task is to narrate this chapter for you, the reader, the developer, so you can immerse in my perspective. Thank you for taking the time and interest in learning how to improve our coexistence and collaboration.

What is an interaction?
I interact when I engage in activities with someone or something having a one-sided or reciprocal influence. Thus, if my existence or action affects a human, animal, an object, or vice-versa there is an interplay and a message transmitted. The message can be more or less explicit and the interaction can either have a purpose, i.e. alarming, or be unintended i.e. mere movement.
Takeaway: Identify and aim to foresee all potential interactions to design appropriate conduct accordingly.

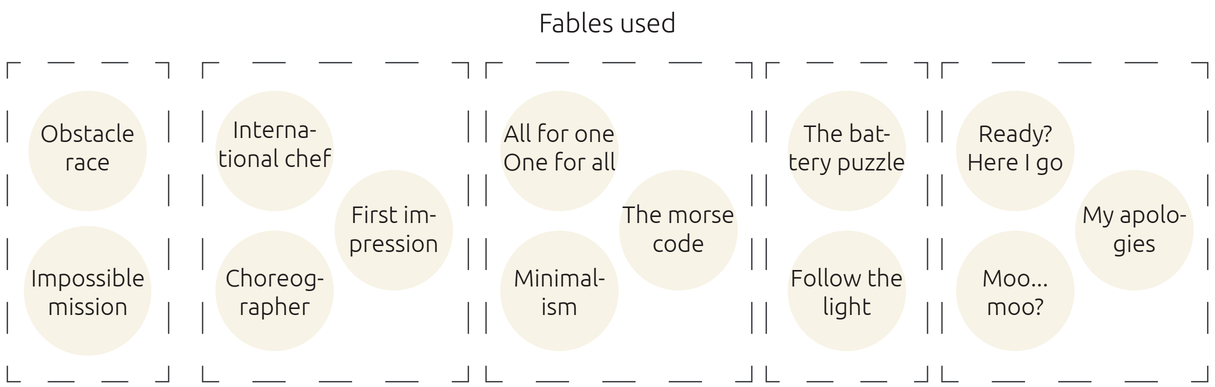
Which is your goal?
What do I want to achieve with this interaction? Should it happen in the real world or digitally? How should my actions be perceived? How should I communicate?
Takeaway: Define the context in which your interactions occur and the other users involved. Set your target and share it with your team.

10

Introducing concept of interaction, goal and user.

Figure 58. Design - Robot Nature

- Dictionary one-sentence neutral definition
- Description applied to the Lely context narrated by the robot. The idea originated from a common brainstorming with the UX team at Lely. Incorporating the robot tone of voice was a pleasant surprise to readers. It was not only more fun to read, but it also positioned them in the robot perspective and uncovered hidden frictions (Figure 53). It may seem unnatural at first but placing oneself onto the object lens is inspiring and relevant to acknowledge our ongoing interactions with them (Cila & Giaccardi, 2015).
- Question takeaways for the developer. What can you ask yourself when considering this quality?



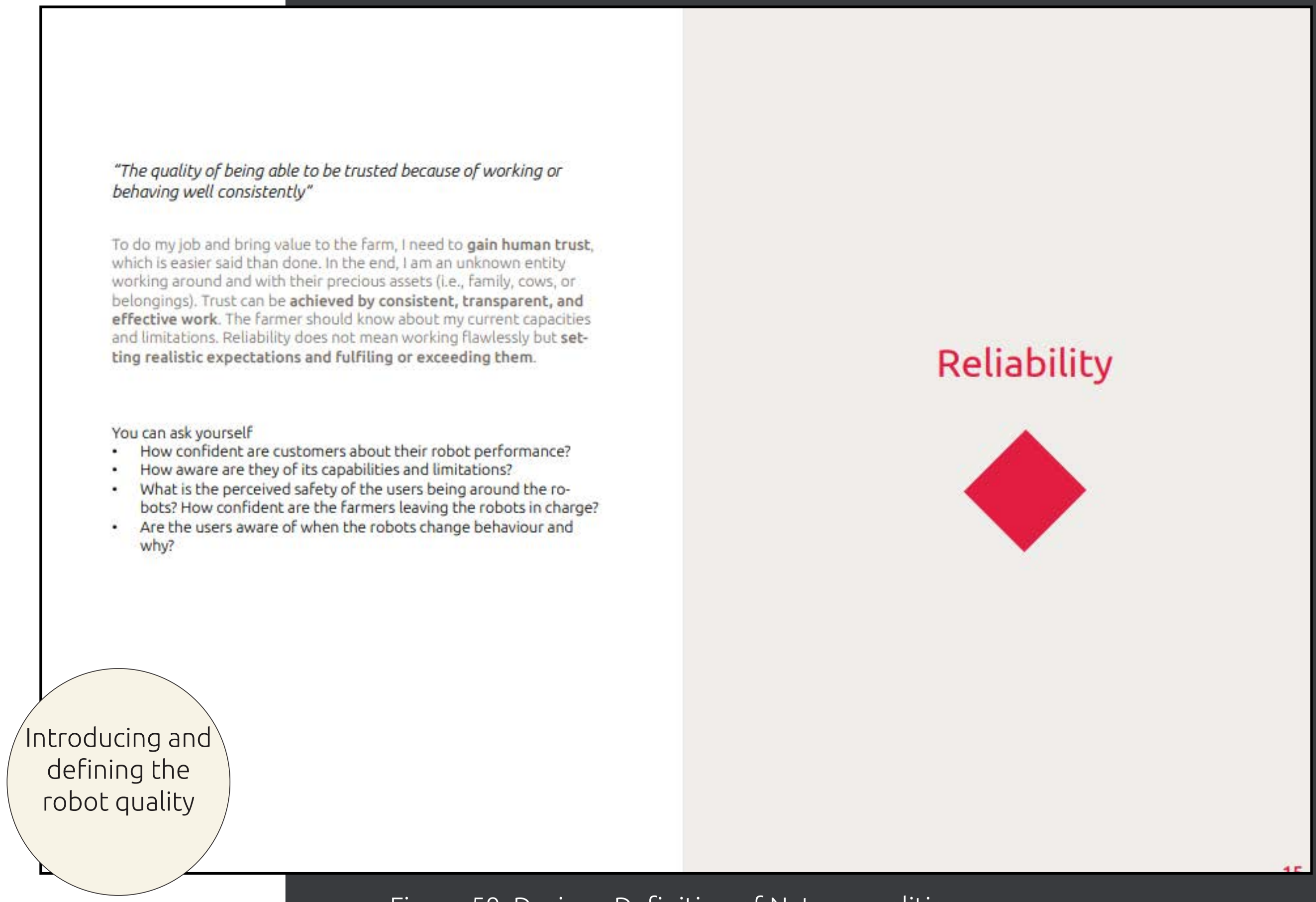
During the second workshop, I learned that examples ease the understanding of the values for the reader, placing them in context and making them easier to visualize. I shaped the Robot Code of Conduct examples as fables using storytelling techniques.

"Stories stick in people's minds"

Roboticist

By creating short visual stories, the reader navigates more comfortably through the document and can easily remember and reference the examples.

Inspired by fables and religious parables, I named each story with a title and created an overview of takeaways lessons. I found value in combining a serious neutral tone for advice to the developers and a relaxed and descriptive robot tone. Thanks to a visual change of fonts, I made a clear distinction to avoid confusion. The examples selected depicted situations from literature, observations, and conversation with experts. I went through several iterations to create these examples. After assessing them through external perspectives, I adjusted their complexity and composition. The final design contains five values supported by thirteen examples in total. This section succeeded beyond expected to convey the qualities even to non-developers at Lely. During meetings, I observed that it inspired developers, and they could easily reference back to the examples and extrapolate them to their problems and products.

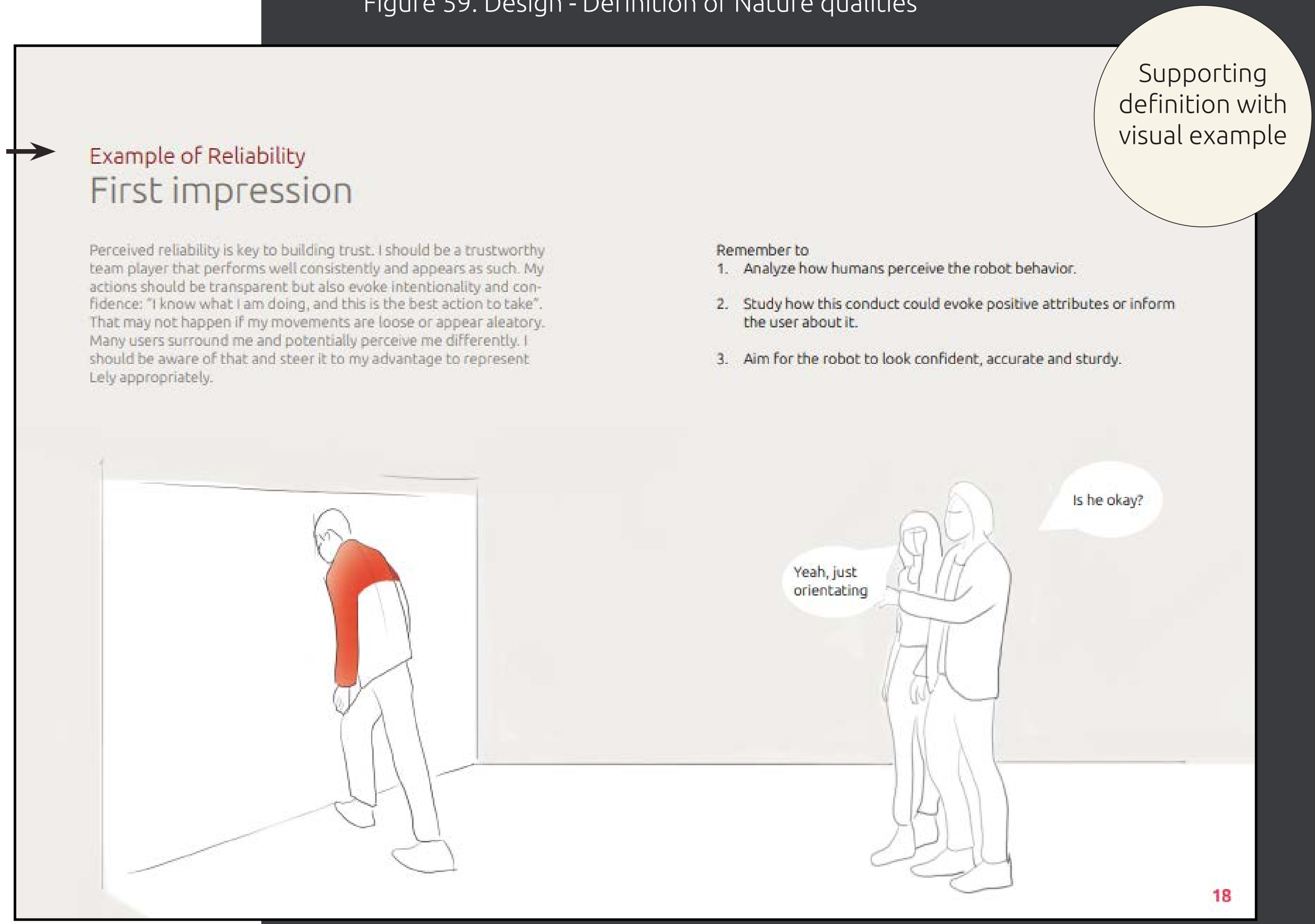

"The quality of being able to be trusted because of working or behaving well consistently"

To do my job and bring value to the farm, I need to **gain human trust**, which is easier said than done. In the end, I am an unknown entity working around and with their precious assets (i.e., family, cows, or belongings). Trust can be **achieved by consistent, transparent, and effective work**. The farmer should know about my current capacities and limitations. Reliability does not mean working flawlessly but **setting realistic expectations and fulfiling or exceeding them**.

You can ask yourself
- How confident are customers about their robot performance?
- How aware are they of its capabilities and limitations?
- What is the perceived safety of the users being around the robots? How confident are the farmers leaving the robots in charge?
- Are the users aware of when the robots change behaviour and why?

Reliability

Figure 59. Design - Definition of Nature qualities


Example of Reliability
First impression

Perceived reliability is key to building trust. I should be a trustworthy team player that performs well consistently and appears as such. My actions should be transparent but also evoke intentionality and confidence: "I know what I am doing, and this is the best action to take". That may not happen if my movements are loose or appear aleatory. Many users surround me and potentially perceive me differently. I should be aware of that and steer it to my advantage to represent Lely appropriately.

Remember to
1. Analyze how humans perceive the robot behavior.
2. Study how this conduct could evoke positive attributes or inform the user about it.
3. Aim for the robot to look confident, accurate and sturdy.

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Figure 60. Design - Example of Nature qualities

6.3 Guidelines - Developing behaviours

How could you (the developer) design such behaviours?

Normally, in codes of conduct is up to us humans to adjust our actions to adhere to them. For the Robot Code of Conduct it is not our actions, but the actions of third parties, the autonomous agents in this case, that we want to adjust. Apart from choosing actions, the developers need to foresee the situations and allocate responses that comply with the desired attitude and communication for the robot. This intermediate section connects the direction of the general values with the specific solutions. It guides developers into mapping the factors influencing the interaction and provides recommendations and examples on how those factors could translate to solutions being truthful to the robot nature. These guidelines are also meant to keep consistent long-term but are more susceptible to change than the robot qualities. The current version sets a baseline, bringing awareness, but extensive research is needed to point towards concrete and substantial recommendations. Thus, there are no ultimate right or wrong solutions in this section. Nonetheless, by framing the relevant factors in canvases, the development teams can implement them in their practice. It contains three canvases with 20 questions in total divided into "Goal", "User" and "Context" considerations (Figure 61). A use case example complements the canvases showing how they could be filled (Figure 62). This section guides the developers triggering reflection and discussion, bringing a shared vision and vocabulary, and giving some recommendations.

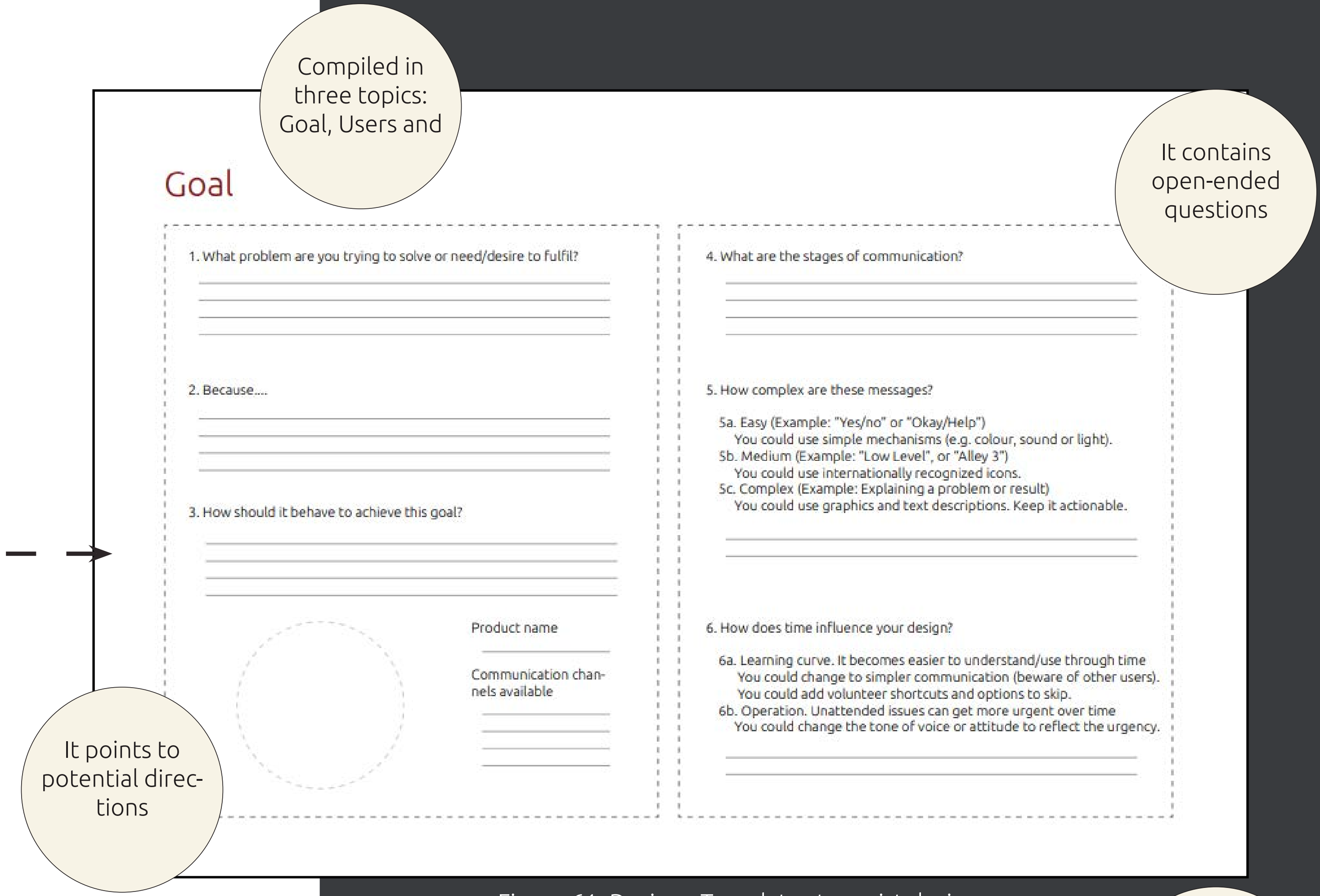
It triggers individual reflection. It brings attention to relevant points they may have not yet considered (e.g. whether an interaction should happen physically or virtually)

It triggers and allows team discussion. Filling it in, you need to share and find an agreement. It brings a shared vocabulary to be able to discuss these points.

It brings a shared vision. Teams are large, and some people do not belong to a fixed team. Having the templates filled allows the team to have a shared direction and makes visually clear the points where external help is needed.

It brings recommendations. Some of the points already points to potential solutions gathered from the research part of the project.

The factors and advice on these canvases evolve from the five robot qualities, but their link is implicit as there are no clear boundaries among them. For example, finding a mechanism that fits the complexity of the message brings clarity. But it also brings efficiency, accuracy, and ultimately friendliness. Developers are already experts in their field and very busy carrying out their roles, but these questions are relevant and valuable if they start triggering discussions or the need to reach out to others in the company with more knowledge about the topics addressed. Due to their busy schedules, readers must easily find what they look for on the codes.



Goal

1. What problem are you trying to solve or need/desire to fulfil?

2. Because....

3. How should it behave to achieve this goal?

Product name

Communication channels available

4. What are the stages of communication?

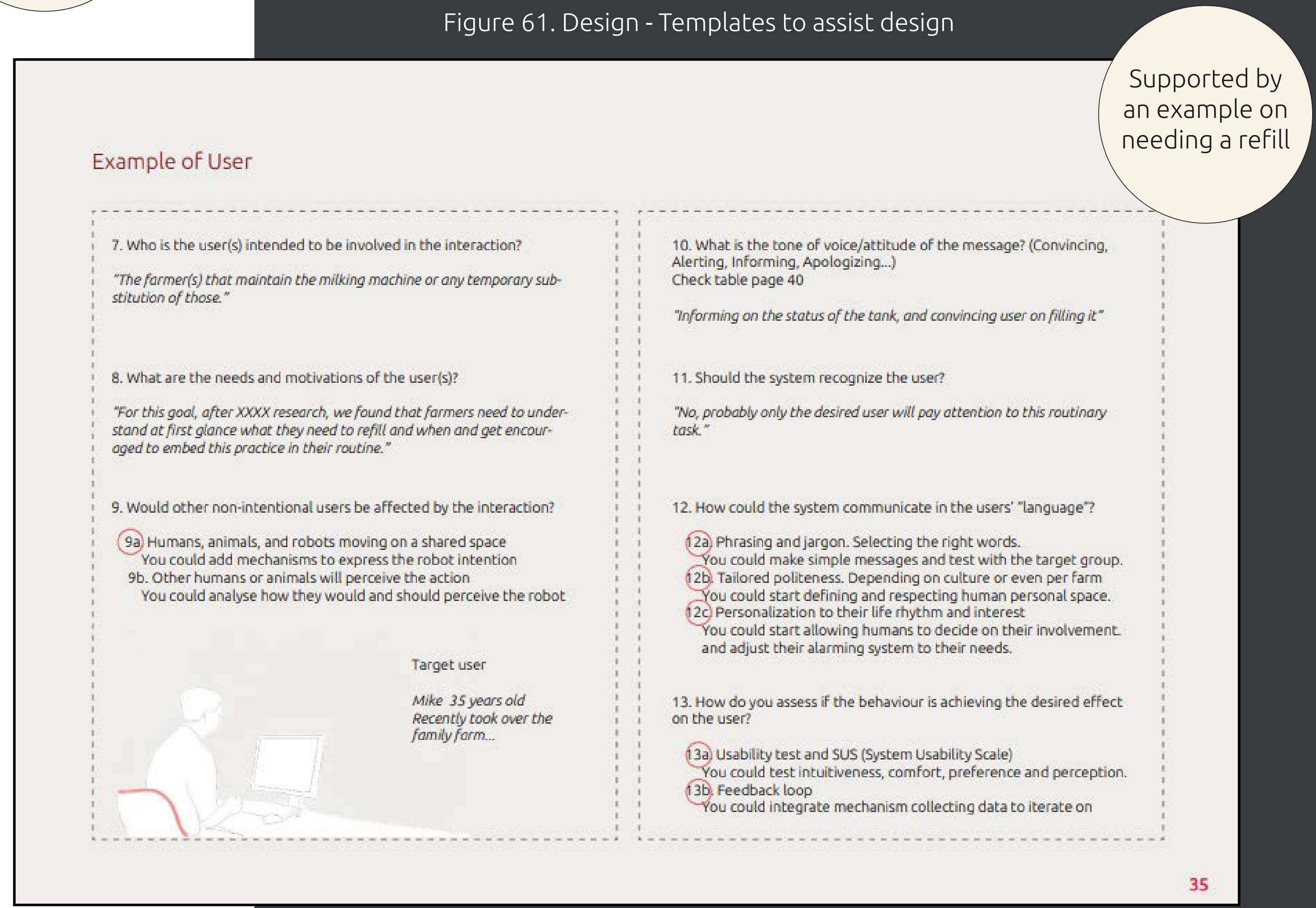
5. How complex are these messages?

5a. Easy (Example: "Yes/no" or "Okay/Help")
You could use simple mechanisms (e.g. colour, sound or light).
5b. Medium (Example: "Low Level", or "Alley 3")
You could use internationally recognized icons.
5c. Complex (Example: Explaining a problem or result)
You could use graphics and text descriptions. Keep it actionable.

6. How does time influence your design?

6a. Learning curve. It becomes easier to understand/use through time
You could change to simpler communication (beware of other users).
You could add volunteer shortcuts and options to skip.
6b. Operation. Unattended issues can get more urgent over time
You could change the tone of voice or attitude to reflect the urgency.

Figure 61. Design - Templates to assist design



Example of User

7. Who is the user(s) intended to be involved in the interaction?

"The farmer(s) that maintain the milking machine or any temporary substitution of those."

8. What are the needs and motivations of the user(s)?

"For this goal, after XXXX research, we found that farmers need to understand at first glance what they need to refill and when and get encouraged to embed this practice in their routine."

9. Would other non-intentional users be affected by the interaction?

9a. Humans, animals, and robots moving on a shared space
You could add mechanisms to express the robot intention
9b. Other humans or animals will perceive the action
You could analyse how they would and should perceive the robot

Target user

Mike 35 years old
Recently took over the family farm...

10. What is the tone of voice/attitude of the message? (Convincing, Alerting, Informing, Apologizing...)
Check table page 40

"Informing on the status of the tank, and convincing user on filling it"

11. Should the system recognize the user?

"No, probably only the desired user will pay attention to this routinary task."

12. How could the system communicate in the users' "language"?

12a. Phrasing and jargon. Selecting the right words.
You could make simple messages and test with the target group.
12b. Tailored politeness. Depending on culture or even per farm
You could start defining and respecting human personal space.
12c. Personalization to their life rhythm and interest
You could start allowing humans to decide on their involvement. and adjust their alarming system to their needs.

13. How do you assess if the behaviour is achieving the desired effect on the user?

13a. Usability test and SUS (System Usability Scale)
You could test intuitiveness, comfort, preference and perception.
13b. Feedback loop
You could integrate mechanism collecting data to iterate on

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Figure 62. Design - Example of Templates

6.4 Practical Guide - Current behaviours map

What are those behaviours?

The whole premise is that the previous guidance would derive from desirable robotic behaviour. Part of the behaviour is the communicative mechanisms aiming to convey a concrete message physically or through digital platforms. This communication should be kept consistent among all products. What the robotic systems use to communicate and how they use it is likely to change and evolve. Nonetheless, having an overview of the current expressions is valuable as a starting point. It will optimize the development process of more basic products, preventing teams from reinventing the wheel parallel.

"Humans are complex, but robots are simple, there is a limit to what they can do"

Software Architect

I first introduced the richness of expressiveness (Figure 63). Even simple mechanisms have many layers to experiment with that alter the message (start/stop, fade, tempo, intensity, etcetera). How you use the expressive mechanisms can greatly impact the experience and even influence users' behaviour. For example, the volume of a sound can nudge the listener into approaching or stepping away (Haddad et al., 2018). Most expressions covered are already deployed on the products using different mechanisms.
For this final part of the Robot Code of Conduct I start introducing the mechanism (Figure 65), then describe the hardware used by Lely, moving towards standardization (Figure 64) and end with tables including a detailed overview of how to use the mechanism tailored to the product and for different scenarios (Figure 66).

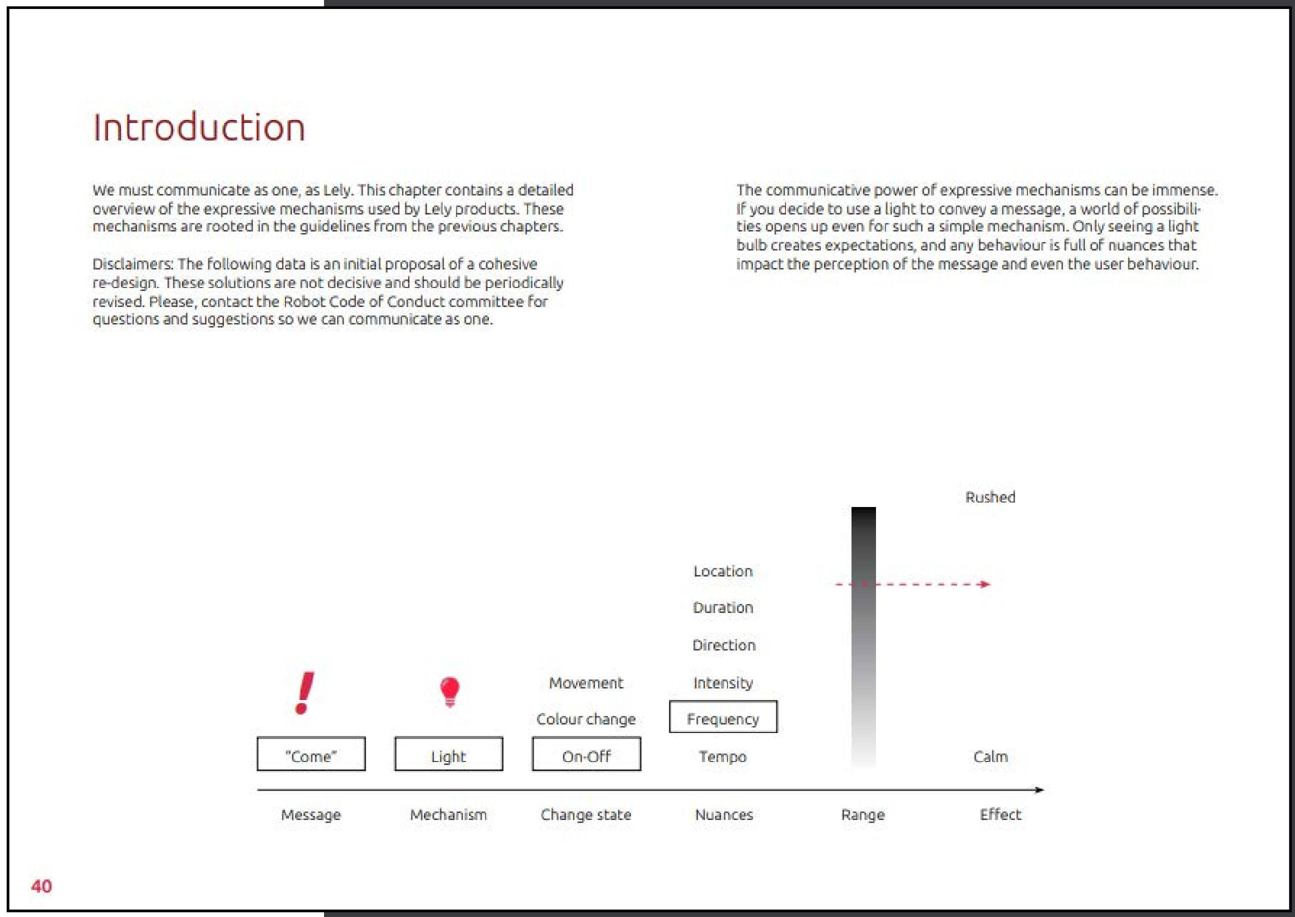


Figure 63. Design - Table of expressions

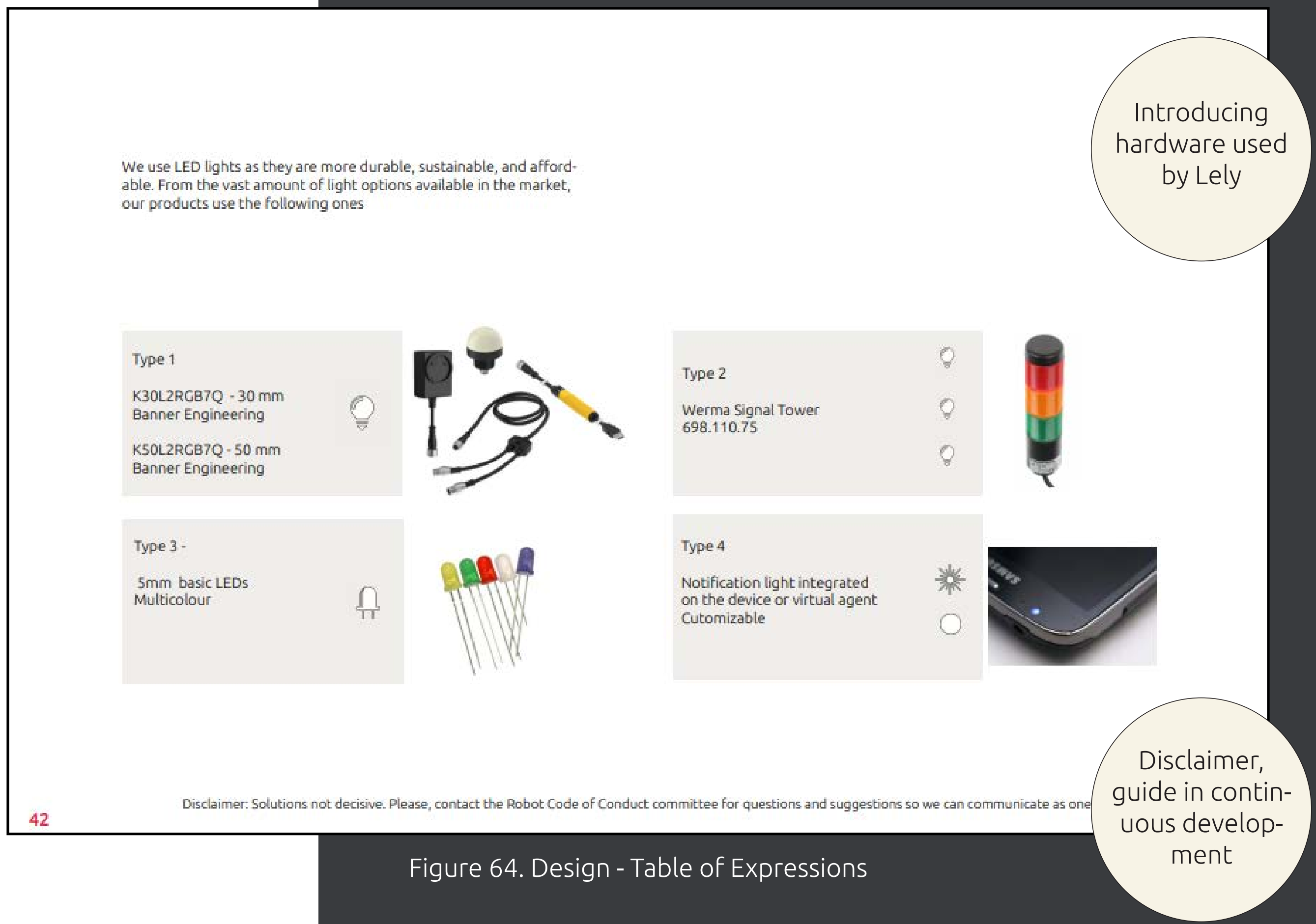


Figure 64. Design - Table of Expressions

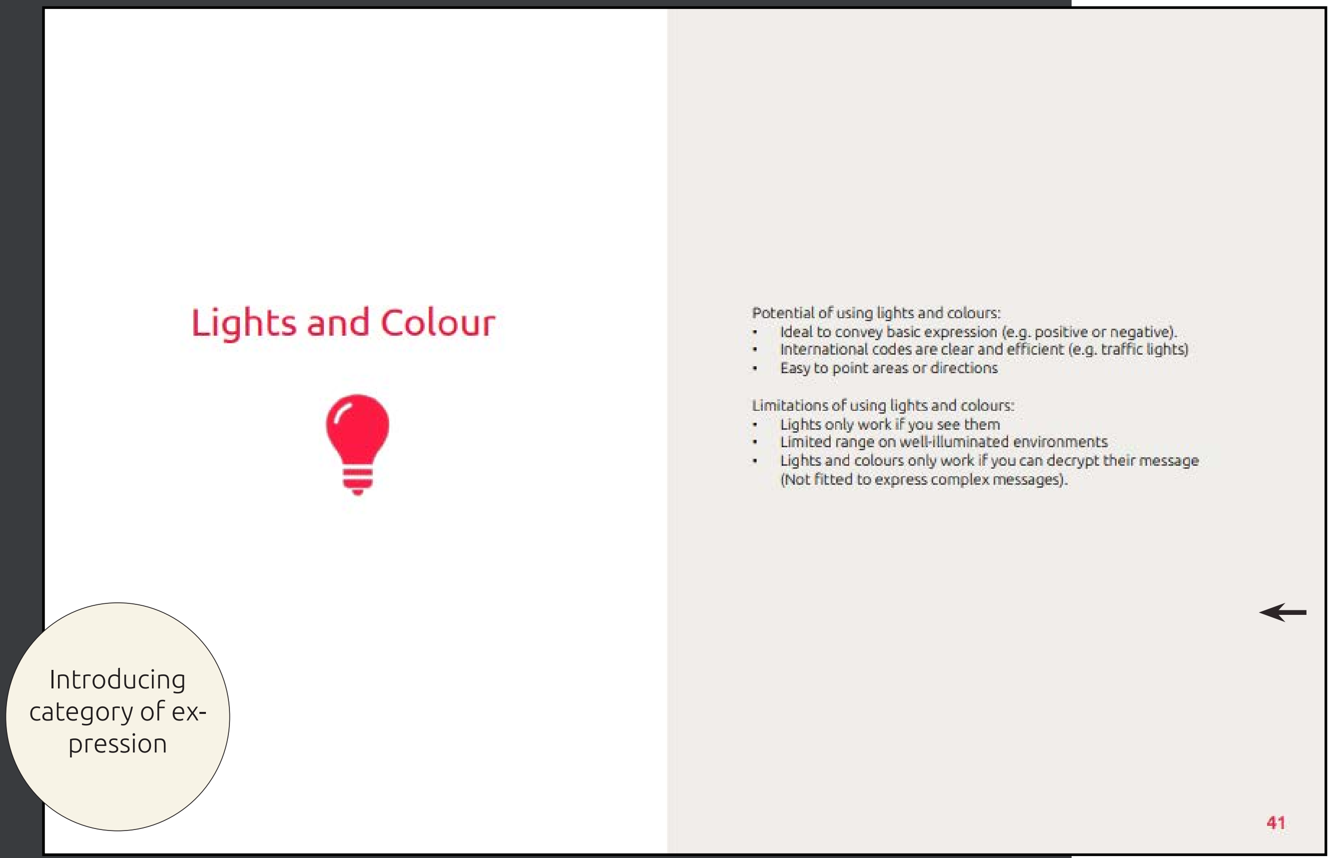
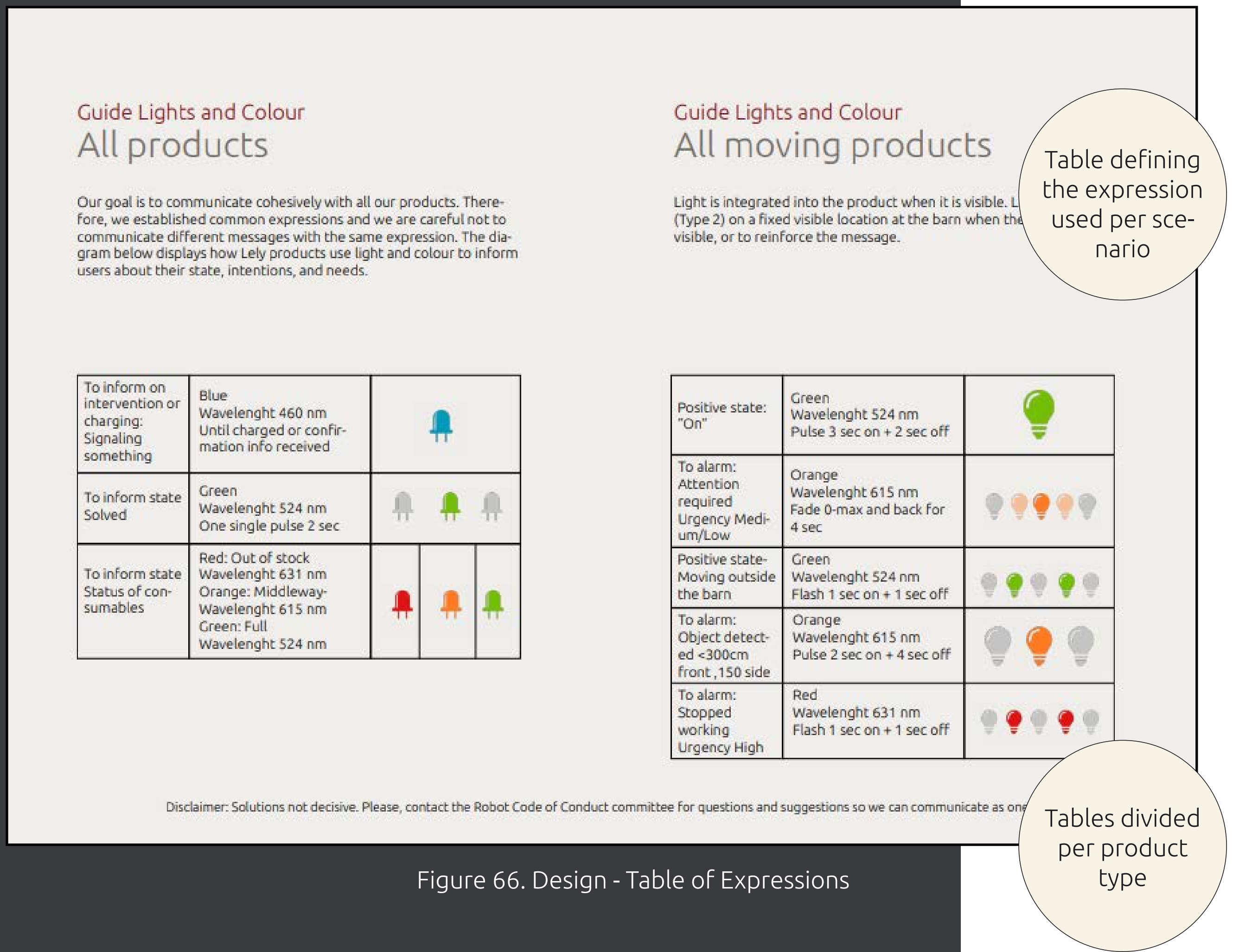


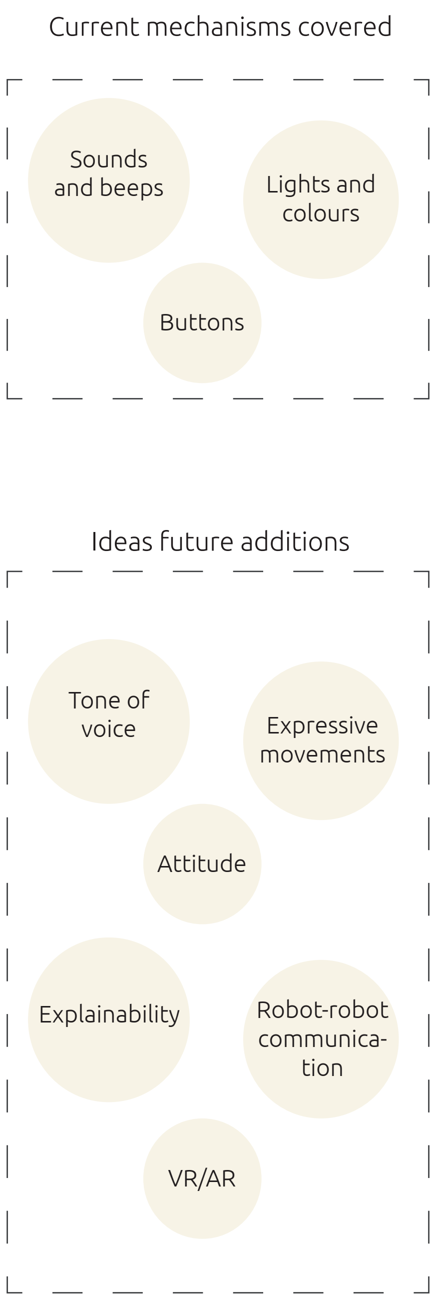
Figure 65. Design - Description expressive mechanism



To inform on intervention or charging: Signaling something	Blue Wavelenght 460 nm Until charged or confirmation info received	
To inform state Solved	Green Wavelenght 524 nm One single pulse 2 sec	
To inform state Status of consumables	Red: Out of stock Wavelenght 631 nm Orange: Middleway- Wavelenght 615 nm Green: Full Wavelenght 524 nm	

Positive state: "On"	Green Wavelenght 524 nm Pulse 3 sec on + 2 sec off	
To alarm: Attention required Urgency Medium/Low	Orange Wavelenght 615 nm Fade 0-max and back for 4 sec	
Positive state-Moving outside the barn	Green Wavelenght 524 nm Flash 1 sec on + 1 sec off	
To alarm: Object detected <300cm front ,150 side	Orange Wavelenght 615 nm Pulse 2 sec on + 4 sec off	
To alarm: Stopped working Urgency High	Red Wavelenght 631 nm Flash 1 sec on + 1 sec off	

Figure 66. Design - Table of Expressions



I proposed a re-design of the mechanisms and their use to align the current expressions). My first proposal of this re-design was only grounded on information gathered during the exploration stage. For the final version I iterated and include guidelines based on research carried out at TUDelft on communication of moving Lely robots (Bahlmann et al., 2021). Additionally, I incorporated some future-oriented expressive scenarios to cover some problems and needs mentioned in the expert interviews. For example, providing clarity and an overview of the robot state.

I added extra considerations when required. For example for the lights I specified also where are the recommended locations for the lights to be most accurate depending on the robot and its context of use. Hosting all the products within one set of guidelines was a real challenge. The wider the scope the more it limits its definition. Future iterations may consider dividing this guide in several documents as long as there are procedures in place to ensure overview and cohesiveness.

"Robots should communicate their state, even if it is "on hold", meaning the robot is not working but nothing is wrong"

Product Owner

This section contains a disclaimer to prevent developers from thinking that the expressions covered here are the ultimate truth. There should always remain the option and **flexibility to trigger and improve all these expressions**. Finally, as I discuss in the last part, the developers should appreciate the value of this tool and feed the knowledge they acquire to the system for the common benefit.

6.5 Assessment final design

The final assessment covered in the scope of the project were the last evaluation on usability, implementation, and direction explained in page 70. Those sessions went through a complete version of the code and I implemented the feedback obtained into a final iteration and future recommendations.

From the insights I obtained in the final sessions as well as in the previous discussions and interviews I could conclude that the final design succeeded in most of the design requirements I had established. Generally speaking, longer extensive tests would be needed to certify these results more confidently. Nonetheless, I established a criteria to determine their compliance based on the data I gathered.

Success would mean that
- It is clear by itself (e.g. showing purpose and target audience)
- I observed the event happening at least in two occasions from different data sources (e.g. different developers opening their mind to the option of robots apologizing).
- Or that at least three data sources reference to it (e.g. almost every expert highlighted the value of the project).

Some other points I consider to have potential but I lack enough data to be able to categorize them as a success yet.

Overall I believe the results are very positive and I propose strategies to evaluate and iterate on its design on the coming chapter.

"I never thought about whether robots should apologize"

Software Architect

"Yes, the robot could be more considerate. Tell me beforehand"

Test Farmer

- Include and define the values of the group
- Show the purpose and target audience of the code
- Raise awareness over the desirable and undesirable behaviour
- Accommodate **all current products** in the Lely portfolio and be flexible to new developments.
- Contain a guide of how to sustain the code and responsibilities

- Be **clear and pragmatic** enough to create a common understanding of the message.
- Guide them to **account for all (or most) factors influencing** the interaction or **user experience.**
- **Make the development** of robot behaviours **easier**
- Set a desirable direction to ultimately **deliver improved interactions.**
- **Improve unity** and overview among the products. Fitting Lely and working as one.

- Written in the **language of the developers** that will use it
- **Fit the** development **process** (always enhancing, never disrupting)
- **Be perceived as valuable**. Readers finding it relevant, real and applicable
- Be an **engaging** document that people enjoy reading. Be **interactive and inspiring.**

Figure 67. Evaluation - Checking requirements

7

CONCLUSION

7.1 Conclusion

It is only in recent years that the design of robot systems is considered beyond task completion and safety measures. We must also design robot behaviours to accommodate and enhance our coexistence and collaboration with those artificial agents.
The Lely Robot Code of Conduct sets the direction towards that goal by bringing awareness on the relevance and important factors to account in the design of Lely robotic systems. Despite the focus of the code being to improve the experience of users at the farm interacting with the robots, the focus of the project was to create a guide to boost the development process within Lely.

The final document is the result of extensive research with the active involvement of multidisciplinary stakeholders. A combination of primary and secondary research concluded in a list of qualities and considerations to design robots that represent Lely desirably. The final design integrates all the knowledge acquired and shapes it into guidelines progressing from abstract to actionable.
All Lely robots must be accurate, reliable, efficient, clear and friendly. Alike other codes of conduct, it points to desirable behaviours to comply with these values providing specifications per robot when needed. Unlike human codes, it concludes with a defined overview of the current expressions in the Lely portfolio.

Evaluating the document showed that it succeeded in raising awareness around the company on HRI and that it elicits diverse discussions and reflections among different stakeholders involved in the development of these entities. Many questions are left to answer, but this report shows how to start acting towards a desirable future. The main limitations encountered were the short time available to address the wide scope of the topic in detail and the scarce information due to the novelty of the intervention.

7.2 Next steps

As I mentioned throughout the text, the Robot Code of Conduct is only the first step. It is supposed to be a living document, and especially the most concrete parts should be revised and updated (I would recommend) approximately yearly. A committee would be responsible for the sustainability of the code. This committee should either include (or work closely with) experts who can assist the developers when in doubt, for example, on user experience. Ideally, after a design successfully improves the human-robot interaction, it will feed back to the system so the whole company can be inspired and benefit from it. Figure 68 illustrates two possible strategies to accomplish that, either the committee takes an active role to obtain the knowledge from the different teams (top part) or there is an mechanism in place for developers to contribute with their insights (bottom part).

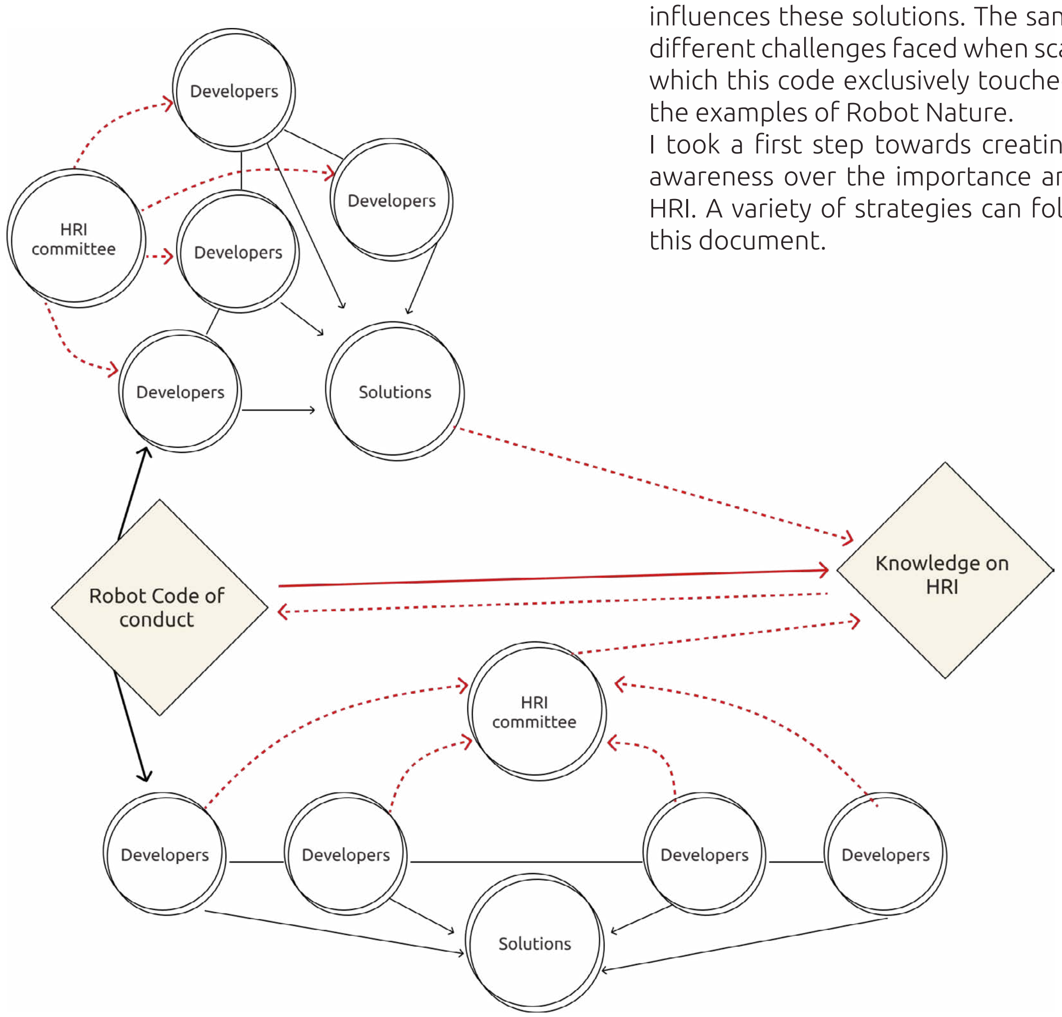


Figure 68. Feeding back to the system

Currently, many of the factors remain at the awareness level. We know they are relevant but have no concrete solutions. The committee or the affiliated experts devoted to HRI should continue the research to seek answers that would translate questions (factors) from the codes into recommendations and later into solutions to implement. These solutions should be tailored to the product and context. Perhaps the next steps could even explore the option of splitting this code per product or task, as the more you limit the scope, the more concrete you can get with the recommendations.
The code was designed in the Netherlands, involving dutch stakeholders. However, Lely products are distributed all over the globe, so the code should accommodate this diversity. The next steps on the codes should also be covering additional sectors of Lely that fell out of the scope of time and resources of this project. Lely works closely with third parties and integrates some products from external firms, it is be explored how the Robot Code of Conduct influences these solutions. The same applies to the different challenges faced when scaling to XL farms, which this code exclusively touched upon in one of the examples of Robot Nature.
I took a first step towards creating and spreading awareness over the importance and application of HRI. A variety of strategies can follow and support this document.

To continue with the flow of awareness, a follow-up activity could be to distribute calendars and mugs with the robot values as a reminder souvenir to the developers in the same way some designers do with user personas. The implementation of the code, according to several experts I discussed with (software architects, data scientists, and participants on the second workshop) should come from above. Meaning the top hierarchy of the company should introduce and encourage the use of the code.

Ideally, they will support it with formative sessions to instruct teams of developers on how to use it and which are their personal responsibilities.
I did not enter in detail on the regulatory aspect of the code regarding sanctions, rights and obligations. But I propose a differentiation on regulation within the code, being some parts conceived as recommendations while others should have a more binding character and be supported by repercussions in case of not complying with them. Although I believe these distinctions should be made by the company I suggest the following categories:

- Vision and robot nature are abstract concepts to work towards, which are long-term (not more than10 years) and serve as inspirations and to set directions. Their application is complicated and impractical to track. This part was essential for awareness and to open the mind of the reader to all the interactions happening outside the screen, as obvious during the second workshop, there exists a tendency to focus too much, even exclusively, on UI when thinking about HRI. Similarly, it also broadens the conception of a "user".

- The guidelines are more actionable, they should be updated more often (no more than 5 years) and the teams should be encouraged to use them, to ask these questions. That may happen by requesting the fulfilment of the templates at a certain point in the development process. A yearly reflection time could benefit developers to reconnect with these guidelines and explore ways to improve them. This part triggers actions in many directions which could inspire future plans and visions. For example in regards to including users throughout the development process and evaluating the quality of the interactions which could potentially lead to new KPIs.

- The practical guide contains concrete guidelines that are important to track to communicate as one. Before the deployment of a new feature of design there should be an evaluation moment to check its compliance with the practical guide and in case of discrepancy assess whether the guide needs an update or whether the development team chose not to follow the proposed communication. The compliance with these points is easier to evaluate and future iterations could explore the use of sanctions or prices to ensure the right practice.

I wanted to conclude this report with a call for action to all the companies and governmental institutions developing intelligent systems and products coexisting and collaborating with humans and animals. We may not have all the solutions yet but now is the time to start asking the right questions as we are progressively becoming more vulnerable to these entities.
Global initiatives like the SIENNA are crucial to bring attention over this topic worldwide. However, as previously recommended, the most effective interventions will be tailored to the context in which the robot will be deployed. I believe that it would be really valuable to everyone if more companies developing automation would undertake a similar process. More investment of HRI research would benefit all companies by building upon each others' knowledge, and it will benefit us all improving our experiences interacting with robot systems.
In this report I compiled the methodology I followed to create the final code which could serve as an inspiration to others willing to implement a Robot Code of Conduct in their practice. My final recommendation would be to always involve users. Whether your users are your team of engineers, farmers or even cows. Assumptions can only take you so far, reality lies on users experiences, actions and thoughts.

7.3 Discussion

Through this project, I discovered a passion for human-robot interaction and research on user experience. Designing robotic systems is compelling. They are the future, a part we have control over. We can define their actions, even create a whole new language.

From day one, I was astonished by Lely's thrive to enhance the dairy farming experience for humans and animals. They are innovators, and this project is yet another example. As aforementioned, there is a clear need for documents and procedures steering the design of robots and other smart agents, but few have developed such procedures. This project might be just a little, nonetheless crucial step towards a more responsible smart agent design. Carrying out this project as an exceptional opportunity where I acquired professional skills while developing personally. The frequent contact with stakeholders allowed me to improve my communication skills and face the challenging scope of the project.

Looking back at the initial mind map I made over the topic, it is impressive to see how much I have expanded my knowledge on robot interactions in such a short period. From knowing that they are "intelligent" agents to wonder why they are considered as such, how much we know about them or how much we should know about them.

If I had to define this process with one word, I would say "balance". Creating artificial solutions for living organic environments has no concrete answer. Adaptation is the key, and to achieve one must jiggle opposing and complementary forces. I had to balance qualities and abstractions. Having so many perspectives involved I also needed to find the harmony to learn from their expertise and feedback while remaining in control of the design and making informed decisions. To achieve that I reflected on the reasons behind the feedback, identifying whether it conflicted with other people's perspective or with the literature or personal opinion and why. This challenging journey has allowed be to improve on another personal goal which was dealing with complex and abstract goals.

After six years of development as a designer and being trained in the search for answers. I am proud to conclude the journey of my Master delivering the right questions.

BIBLIOGRAPHY

Alarcon, G. M., Capiola, A., & Pfahler, M. D. (2021). The role of human personality on trust in human-robot interaction. *Academic Press*, 159-178. https://doi.org/10.1016/B978-0-12-819472-0.00007-1

Arvola, M., & Artman, H. (2006). Enactments in Interaction Design: How Designers. Make Sketches Behave. *Journal Artifact*. Retrieved from https://www.ida.liu.se/~matar63/enactments-artifact.pdf

Bahlmann, J., De Reus, B., De Vries, J., Jimenez Arroy, I., Kamp, J., & Kumar, S. (2021). Feeding Robot with Object Detection. *Final Report Advanced Embodiment Design. TU Delft*

Bartneck, C., Belpaeime, T., Eyssel, F., Kand, T., Keijsers, M., & Sabanovic, S. (2019) *Human Robot Interaction* Cambridge University Press ISBN: 9781108735407

Bennet, N. J., The, L., Ota. Y., Christie, P., Ayers, Day, J. C., A., Franks, P., Gill, D., Gruby, R. L., Kittinger, J. N., Koehn, J. Z., Lewis, N., Parks, J., Vierros, M., Whitty, T. S., Wilhelm, A., Wright, K., Aburto, J. A., Finkbeiner, E. M., Gaymer, C. F., Govan, H., Gray, N., Jarvis, R. M., Kaplan-Hallam, M., & Satterfield, T. (2017). An appeal for a code of conduct for marine conservation. *Marine Policy 81 (2017) 411–418* http://creativecommons.org/licenses/BY-NC-ND/4.0/

Boesl, D. B. O., Bode, M., & Greisel, S. (2018). Drafting a Robot Manifesto – New Insights from the Robotics Community gathered at the European Robotics Forum 2018. *27th IEEE International Symposium on Robot and Human Interactive Communication, 448-451*, doi: 10.1109/ROMAN.2018.8525699.

Boztas, S. (2021, September 9). *Netherlands proposes radical plans to cut livestock numbers by almost a third*. The Guardian. Retrieved from https://www.theguardian.com/environment/2021/sep/09/netherlands-proposes-radical-plans-to-cut-livestock-numbers-by-almost-a-third

Darling, K. (2021, March 4). *Robotic Expert Kate Darling Breaks Down Robots From Film & TV* [Video]. Youtube. (https://www.youtube.com/watch?v=159yX-2zO2V8&ab_channel=PenguinBooksUK)

De Graaf, M. M. A., Dragan, A., Malle, B. F., & Ziemke, T. (2021). Introduction to the Special Issue on Explainable Robotic Systems. *ACM Transactions on Human-Robot Interaction*, Vol. 10, No. 3, Article 22. https://doi.org/10.1145/3461597

Delgosha, M. S., & Hajiheydari, N. (2020). How human users engage with consumer robots? A dual model of psychological ownership and trust to explain post-adoption behaviours. *Computers in Human Behavior 117 (2021) 106660*. https://doi.org/10.1016/j.chb.2020.106660

Driessen, C., & Heutinck, L. F. M. (2015). Cows desiring to be milked? Milking robots and the co-evolution of ethics and technology on Dutch dairy farms. *Article in Agriculture and Human Values*. DOI 10.1007/s10460-014-9515-5

Fosch-Villaronga, E. & Millard, C. (2019) Cloud robotics law and regulation: Challenges in the governance of complex and dynamic cyber–physical ecosystems. *Robotics and Autonomous Systems, Volume 119, Pages 77-91*. https://doi.org/10.1016/j.robot.2019.06.003.

Fosch-Villaronga, E., & Albo-Canals, J. (2019). "I'll take care of you," said the robot. *Paladyn. 10*. 77-93. 10.1515/pjbr-2019-0006.

Future Scan. (n.d.) Board of Innovation. Retrieved from https://www.boardofinnovation.com/tools/future-scan/

Guizzo, E. (2018, August 01). What is a robot. Retrieved from https://robots.ieee.org/learn/what-is-a-robot/

Howard, A., & Borenstein, J. (2018). Hacking the Human Bias in Robotics. *ACM Trans. Hum.-Robot Interact. 7, 1*(3) https://doi.org/10.1037/ppm0000185

Hawkins, R. X. D., Goodman, N. D., & Goldstone, R. L. (2018). The Emergence of Social Norms and Conventions. *Trends in Cognitive Sciences*. https://doi.org/10.1016/j.tics.2018.11.003

Implementing Mental models and Maps in your life (2019, October 25). Retrieved from https://brainytab.com/blog/implementing-mental-models-and-maps-in-your-life/

International Organization for Standardization. (2016). Robots and robotic devices — Collaborative robots (ISO Standard No. 15066:2016). https://www.iso.org/news/2016/03/Ref2057.html

Jamshed, S. (2014). Qualitative research method-interviewing and observation. *Journal of basic and clinical pharmacy*, 5(4), 87–88. https://doi.org/10.4103/0976-0105.141942

Jossee, M., Lohse, M., Van Berkel, N., Sardar, A., & Evers, V. (2021). Making Appearances: How Robots Should Approach People. *ACM Transactions on Human-Robot Interaction, Vol. 10, No. 1, Article 7*. https://doi.org/10.1145/3385121

Kapeller, A., Felzmann, H., Fosch-Villaronga, E., Nizamis, K., & Hughes, A. (2021). Implementing Ethical, Legal, and Societal Considerations in Wearable Robot Design. *Appl. Sci. 2021, 11, 6705*. https://doi.org/10.3390/app1115670

Lee, M. K., Kiesler, S., Forlizzi, J., Srinivasa, S., & Rybski, P. (2010). Gracefully Mitigating Breakdowns in Robotic Services. *2010 5th ACM/IEEE International Conference on Human-Robot Interaction (HRI), 2010, pp. 203-210*, doi: 10.1109/HRI.2010.5453195.

Ludström, C., & Lindblom, J. (2021). Care in dairy farming with automatic milking systems, identified using an Activity Theory lens. *Journal of Rural Studies 87 (2021) 386–403*. https://doi.org/10.1016/j.jrurstud.2021.09.006

Lupetti, M. L., Zaga, C. & Cila, N. (2021). Designerly Ways of Knowing in HRI, Broadening the scope of design-oriented HRI through the concept of intermediate-level knowledge. *ACM/IEEE International Conference on Human-Robot Interaction (HRI'21)* doi.org/10.1145/3434073.3444668

Lupetti, M. L ., Rosa, S., & Ermacora, G. (2015). From a Robotic Vacuum Cleaner to a Robot Companion: Acceptance and Engagement in Domestic Environments. *HRI'15 Extended Abstracts, March 2-5, 2015*. http://dx.doi.org/10.1145/2701973.2702004

Mayer, R. C., Davis, J. H., & Schoorman, F. D. (1995). An integrative model of organizational trust. *The Academy of Management Review*, 20, 709-734.

Moon, A., Hashmi, M., Van der Loos, H. F. M., Croft, E. A., & Billard, A. (2021). Design of Hesitation Gestures for Nonverbal Human-Robot Negotiation of Conflicts. A*CM Transactions on Human-Robot Interaction*, Vol. 10, No. 3, Article 24. https://doi.org/10.1145/3418302

Mutlu, B. (2021). The virtual and the physical: two frames of mind. *iScience 24*, 101965. https://doi.org/10.1016/j.isci.2020.101965

Maslow, A.H. (1943). "A Theory of Human Motivation". In *Psychological Review*, 50 (4), 430-437

Philips, E., Schaefer, K. E., Billings, D. R., Jentsch, F., & Hancock, P. A. (2016) Human-Animal Teams as an Analog for Future Human-Robot Teams: Influencing Design and Fostering Trust. *Journal of Human-Robot Interaction, Vol. 5, No. 1*. DOI 10.5898/JHRI.5.1.Phillips

Rozendaal, M. C., Ghajargar, M., Pasman, G., & Wiberg, M. (2018). Giving Form to Smart Objects: Exploring Intelligence as an Interaction Design Material. *Springer International Publishing AG, part of Springer Nature*. https://doi.org/10.1007/978-3-319-73356-2_3

Rozendaal, M.C., Boon, B., Vroon, J., & Cila, N. (2021) Designerly ways of exploring Human-Agent Interactionsat the Expressive Intelligence Lab. RtDxHRI2021. Retrieved from https://rtdxhri.com/papers/RtDxHRI2021_Rozendaal_et_al.pdf

Sarathy, V., Arnold, T., & Scheutz, M. (2019). When Exceptions Are the Norm: Exploring the Role of Consent in HRI. ACM Transactions on Human-Robot Interaction, Vol. 8, No. 3, Article 14. *ACM Trans. Hum.-Robot Interact. 8, 3, Article 14*. https://doi.org/10.1145/3341166

Sanders, E. B. N., & Stappers, P. J. (2012). *Convivial Toolbox Generative Research for the Front End of Design*. BIS Publishers. ISBN 978 90 6369 284 1

Situationalization: The New Dimension of Personalization (n.d.). Odoscope. Retrieved from https://www.odoscope.com/situationalization/

Stuck, R. E., Holthausen, B. E., & Walker, B. N. (2021). The role of risk in human-robot trust. *Trust in Human-Robot Interaction, Academic Press, 179-194*. https://doi.org/10.1016/B978-0-12-819472-0.00008-3

Thellma, S., & Ziemke, T. (2021). The Perceptual Belief Problem: Why Explainability Is a Tough Challenge in Social Robotics. *ACM Transactions on Human-Robot Interaction, Vol. 10, No. 3, Article 29*. https://doi.org/10.1145/3461781

Tamborino, L., Lanzerath, D., Rodrigues, R., & Wright, D. (2019). SIENNA D4.3: Survey of REC approaches and codes for Artificial Intelligence & Robotics (V1.0). *Zenodo*. https://doi.org/10.5281/zenodo.4067990

User Scenarios. (n.d.). Interaction Design Foundation. Retrieved from https://www.interaction-design.org/literature/topics/user-scenarios

Van den Brule, R., Bijlstra, G., Dotsch, R., Haselager, P., & Wigboldus, D. H. J. (2016). Warning Signals for Poor Performance Improve Human-Robot Interaction. J*ournal of Human-Robot Interaction, Vol. 5, No. 2, 2016, Pages 69-89*. DOI 10.5898/JHRI.5.2.Van_den_Brule

Van Wynsberghe, A. L. (2012). Designing robots with care: creating an ethical framework for the future design and implementation of care robots. *Enschede, University of Twente*. ISBNs978-90-365-3391-1

APPENDIX A

Project brief

DESIGN FOR our future

TU Delft

IDE Master Graduation

Project team, Procedural checks and personal Project brief

This document contains the agreements made between student and supervisory team about the student's IDE Master Graduation Project. This document can also include the involvement of an external organisation, however, it does not cover any legal employment relationship that the student and the client (might) agree upon. Next to that, this document facilitates the required procedural checks. In this document:

- The student defines the team, what he/she is going to do/deliver and how that will come about.
- SSC E&SA (Shared Service Center, Education & Student Affairs) reports on the student's registration and study progress.
- IDE's Board of Examiners confirms if the student is allowed to start the Graduation Project.

USE ADOBE ACROBAT READER TO OPEN, EDIT AND SAVE THIS DOCUMENT

Download again and reopen in case you tried other software, such as Preview (Mac) or a webbrowser.

STUDENT DATA & MASTER PROGRAMME

Save this form according the format "IDE Master Graduation Project Brief_familyname_firstname_studentnumber_dd-mm-yyyy". Complete all blue parts of the form and include the approved Project Brief in your Graduation Report as Appendix 1 !

family name: Gonzalez Gonzalez 5250
initials: I given name: Irene
student number:
street & no.:
zipcode & city:
country:
phone:
email:

Your master programme (only select the options that apply to you):
IDE master(s): IPD / DfI (selected) / SPD
2nd non-IDE master:
individual programme: - - (give date of approval)
honours programme: Honours Programme Master
specialisation / annotation: Medisign / Tech. in Sustainable Design / Entrepeneurship

SUPERVISORY TEAM **

Fill in the required data for the supervisory team members. Please check the instructions on the right !

** chair: Nazli Cila dept. / section: HICD
** mentor: Marco Rozendaal dept. / section: HICD
2nd mentor: Jan Jacobs
organisation: Lely Farming Innovation
city: Maassluis country: The Netherlands

comments (optional): Despite sharing department, each member of the team have their approach and expertise in regards to the topic. Additionally, the project will also be supervised and suported by Lely's experts from different disciplines.

Chair should request the IDE Board of Examiners for approval of a non-IDE mentor, including a motivation letter and c.v..

Second mentor only applies in case the assignment is hosted by an external organisation.

Ensure a heterogeneous team. In case you wish to include two team members from the same section, please explain why.

IDE TU Delft - E&SA Department /// Graduation project brief & study overview /// 2018-01 v30 Page 1 of 7

Procedural Checks - IDE Master Graduation TU Delft

APPROVAL PROJECT BRIEF

To be filled in by the chair of the supervisory team.

chair: Nazli Cila date: 16 - 09 - 2021 signature: Nazli Cila - IO Digitally signed by Nazli Cila - IO Date: 2021.09.16 11:25:27 +02'00'

CHECK STUDY PROGRESS

To be filled in by the SSC E&SA (Shared Service Center, Education & Student Affairs), after approval of the project brief by the Chair. The study progress will be checked for a 2nd time just before the green light meeting.

Master electives no. of EC accumulated in total: 31 EC
Of which, taking the conditional requirements into account, can be part of the exam programme: 28 EC
List of electives obtained before the third semester without approval of the BoE

YES (selected) all 1st year master courses passed
NO missing 1st year master courses are:

name: C. van der Bunt date: 17 - 09 - 2021 signature:

FORMAL APPROVAL GRADUATION PROJECT

To be filled in by the Board of Examiners of IDE TU Delft. Please check the supervisory team and study the parts of the brief marked **. Next, please assess, (dis)approve and sign this Project Brief, by using the criteria below.

- Does the project fit within the (MSc)-programme of the student (taking into account, if described, the activities done next to the obligatory MSc specific courses)?
- Is the level of the project challenging enough for a MSc IDE graduating student?
- Is the project expected to be doable within 100 working days/20 weeks ?
- Does the composition of the supervisory team comply with the regulations and fit the assignment ?

Content: APPROVED (selected) / NOT APPROVED
Procedure: APPROVED (selected) / NOT APPROVED

comments

name: Monique von Morgen date: 28 - 09 - 2021 signature:

IDE TU Delft - E&SA Department /// Graduation project brief & study overview /// 2018-01 v30 Page 2 of 7

Initials & Name: I Gonzalez Gonzalez 5250 Student number: 4938364

Personal Project Brief - IDE Master Graduation

TUDelft

Robot Code of Conduct in Automated Dairy Farming — project title

Please state the title of your graduation project (above) and the start date and end date (below). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

start date 05 - 09 - 2021 — 05 - 02 - 2022 end date

INTRODUCTION **

Please describe, the context of your project, and address the main stakeholders (interests) within this context in a concise yet complete manner. Who are involved, what do they value and how do they currently operate within the given context? What are the main opportunities and limitations you are currently aware of (cultural- and social norms, resources (time, money,...), technology, ...).

A world powered by robotics is no longer science fiction but a soon-to-be reality. In the last year, there has been a substantial increase in automation in a wide variety of applications from manufacturing to personal care [1] Robots are showing their potential in assisting humans at a physical, emotional, and cognitive level [2]. Thus, it is now the time to steer wisely these technologies towards the most desirable future outcome.

The emerging field of human-robot interaction (HRI) draws from different disciplines researching on "issues related to the social and physical design of technologies, as well as societal and organizational implementation, and cultural sense-making" [3]. The conception of HRI is as old as the notion of robots themselves, coined in the 1940s by Isaac Asimov [3]. Nonetheless, it is a young field embedded within the high-pace changing scene of technology.
"Whereas the human race is changing very slowly, computers and robots are evolving at a very rapid pace" [4] There are vasts of questions to be answered, from task dynamics to lifestyle, fear and human values, and many possibilities to learn about humans, robots and their interplay.

This project is set in the context of automated dairy farming as part of Lely's farming innovation, and in collaboration with the Delft University of Technology. Lely provides a robot workforce that performs various tasks such as animal feeding and milking on farms all over the world. Farmers rely on these products to generate good revenue and take the best care of their cattle, their facilities, and the environment. Currently, farmers share physical space with the robots and obtain information from them through an application on their phones. Further analysis is required to get a proper understanding of the qualities of these interactions.
These non-anthropomorphic robots have a shared brand identity and comply with regulations and Asimov's laws. However, a human workforce, in this case Lely employees, generally follows a code of conduct that states the rules for workplace behavior. These rules are grounded in shared values, and are meant to guide those within the organization in how to act and what to expect from others based on them. Some aspects addressed are communication, safety or integrity, and they have been proved to be very valuable. Research shows a positive correlation between high-quality codes of conduct and company levels of "corporate citizenship, sustainability, ethical behavior, and public perception" [5].

Therefore, the question to address is, should robots have more than just regulations and do they need to follow a behavioral code? and if so, how should this code be? This question opens the door to research on interactions between robots, humans, and other entities in the context (animals, environment). It is an ideal opportunity to study both functional and social behaviors facing the challenge of creating a shared vision between the robots, even when each has a different agenda and level of maturity.

The aim of this research is to create a set of guidelines on robotic code of conduct to contribute to the literature in the field of HRI and which are valuable for Lely's experts. Using these guidelines to steer future designs and strategies, the company would potentially be able to improve the experience of farmers interacting with their current and upcoming products. Employing automation to enhance work attributes will translate into better user physical and mental wellbeing, and brand loyalty [6]. Additional stakeholders involved in the process will be experts in different disciplines related to the field of HRI, and farmers and cows as end-users in direct contact with the robots under study.

space available for images / figures on next page

IDE TU Delft - E&SA Department /// Graduation project brief & study overview /// 2018-01 v30 — Page 3 of 7

Initials & Name I Gonzalez Gonzalez 5250 Student number 4938364

Title of Project Robot Code of Conduct in Automated Dairy Farming

Personal Project Brief - IDE Master Graduation

TUDelft

introduction (continued): space for images

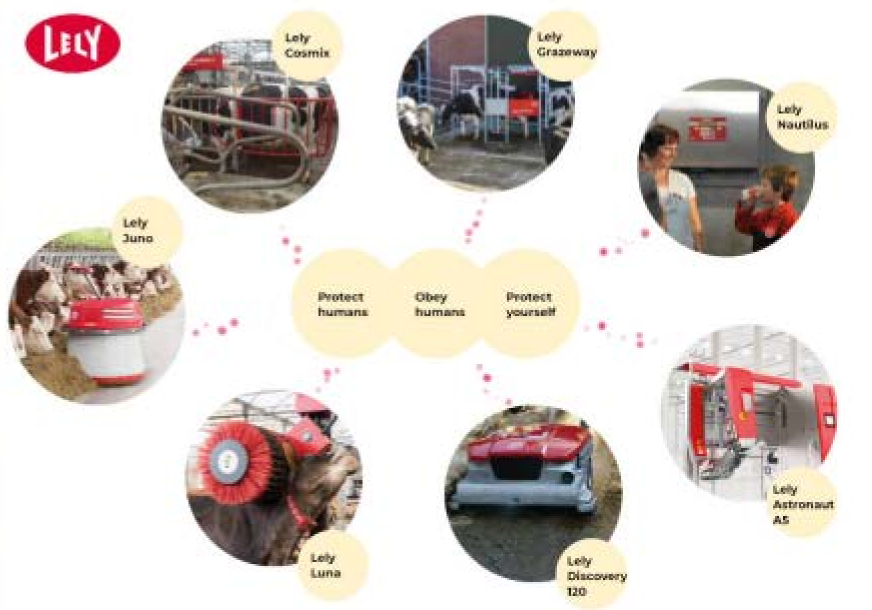


image / figure 1: Some examples of Lely's robotic portfolio which comply with 3 Asimov's laws

image / figure 2: Digital and physical human robot interactions

IDE TU Delft - E&SA Department /// Graduation project brief & study overview /// 2018-01 v30 — Page 4 of 7

Initials & Name I Gonzalez Gonzalez 5250 Student number 4938364

Title of Project Robot Code of Conduct in Automated Dairy Farming

Personal Project Brief - IDE Master Graduation

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PROBLEM DEFINITION **

Limit and define the scope and solution space of your project to one that is manageable within one Master Graduation Project of 30 EC (= 20 full time weeks or 100 working days) and clearly indicate what issue(s) should be addressed in this project.

The main question to address in this project is whether robots should adopt a specific code of conduct and how would these behaviors be. I will research on these behaviors aiming to enhance human-robot collaboration and building knowledge towards optiimizing and improving robotic integration in the workspace, concretly on the context of dairy farming. The ultimate goal is to make the most responsible and profitable use of automation to boost the working environment and better assist humans functionally and emotionally.

Creating a robotic code of conduct is an extensive task to undertake. For it to be feasible within the scope of the graduation, the project will be limited to Lely's robot portfolio. I will study either the entire portfolio or a representable sample in its context of use. The context and interactions present will be addressed from different perspectives considering the most technical and psychological factors.
I will draw on existing literature on human-robot interaction/communication, codes of behavior/ethics and social/affective robotics. Parallel to it, I will be working with experts from the company and in the field of HRI, and with users in direct contact with Lely's robotic workforce.

The final goal is not to create a new product neither to design a fully functioning feature ready to be implemented or launched to the market. I aim to explore the human-robot interactions and subsequently translate the findings into guidelines or even potential design directions. These should assist Lely's product and software developers when faced with choices regarding interaction and product design, with the final aim to implement behavioural cohesion, responsibilty and representability to the robotic portfolio.

ASSIGNMENT **

State in 2 or 3 sentences what you are going to research, design, create and / or generate, that will solve (part of) the issue(s) pointed out in "problem definition". Then illustrate this assignment by indicating what kind of solution you expect and / or aim to deliver, for instance: a product, a product-service combination, a strategy illustrated through product or product-service combination ideas, ... In case of a Specialisation and/or Annotation, make sure the assignment reflects this/these.

I will investigate how to create an identifiable behavior within a robot portfolio. Therefore, I am to create design patterns that will define human-robot interaction and make Lely©s robots respectful to values, effective and pleasant to work with.

For this project, I will research both human and robotic behavior which includes the study of:
- Present and future technological opportunities and limitations. The future of dairy farming.
- Codes of conduct of different kinds, and robotic interactions in working and social environments.
- Physical and digital interactions.

The expected outcome is a compilation of guidelines to implement desirable behaviors in Lely's robot portfolio. How these guidelines would be shaped is yet to be determined, but it could potentially be a brochure with instructions, workflows or ideas meant to assist and inform on opportunities, directions and risks. They will be a clear overview of the insights obtained and future paths. However, I would like to supplement this with a more interactive deliverable . It could be either a conceptual design example of an application, a prototype demonstrator or an exhibition/workshop for Lely's development team.

This project intends to contribute to the literature on human-robot interaction and to the future of Lely's innovation bringing connectedness and a shared vision to their dairy farming automated solutions.
To achieve that, I will first explore the context and literature and use the information acquired to then dive into ideating on future possible scenarios and interactions. After an iteration, I will further define the most promising ideas and directions. Finally, I will conclude testing these and reflecting this knowledge in actionable guidelines.

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Initials & Name I Gonzalez Gonzalez 5250 Student number 4938364

Title of Project Robot Code of Conduct in Automated Dairy Farming

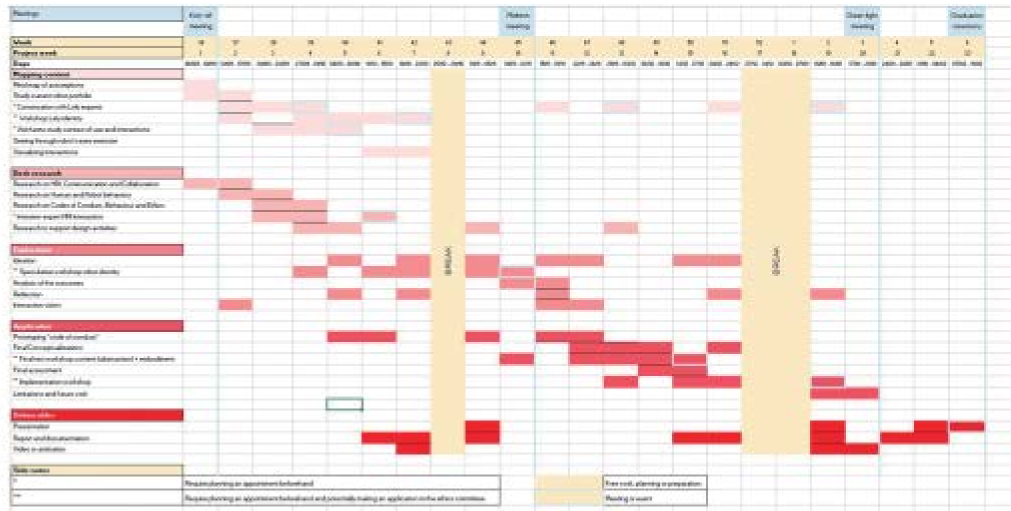
Personal Project Brief - IDE Master Graduation

TUDelft

PLANNING AND APPROACH **

Include a Gantt Chart (replace the example below - more examples can be found in Manual 2) that shows the different phases of your project, deliverables you have in mind, meetings, and how you plan to spend your time. Please note that all activities should fit within the given net time of 30 EC = 20 full time weeks or 100 working days, and your planning should include a kick-off meeting, mid-term meeting, green light meeting and graduation ceremony. Illustrate your Gantt Chart by, for instance, explaining your approach, and please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any, for instance because of holidays or parallel activities.

start date 5 - 9 - 2021 5 - 2 - 2022 end date



This project will consist of simultaneous (primary and secondary) research, and design. During the project I will carry out several interdisciplinary workshops within the company. I have structured it in three main phases, each concluding on a moment of reflection and iteration.

Firstly, learning from context and literature, a cycle to get acquainted with the context, the topic of robot conduct and all the entities involved that will conclude with a map illustrating the conclusions dragged. This visualization will provide an overview of the elements involved in the context. It will also represent the present (and potentially some missing) interactions and the effects they have.

Secondly, I will create and explore future scenarios based on previous insights. It will start with extensive ideation mixing and experimenting with interactions and their characteristics (e.g. setting, channel or interlocutors). I will also challenge other relevant aspects such as future technologies (AI or AR), ethics and sustainability. The results will be reflected in the design of a speculative workshop. After the session(s) there will be an in-depth analysis for which the most promising ideas and insights will converge into final concepts in the last phase.

Therefore, during the final stage, I will test these directions and carry out a subsequent analysis, reflection and iteration leading towards actionable guidelines.

Some activities will be recurrent throughout the project, for example, meetings and interviews with experts of other disciplines [3] (engineering, psychology or robotics). Protyping and mapping will also be recurrent activities as they are always highly useful to communicate with stakeholders despite their level of refinement. I plan to work on the project full-time 5 days a week, having no external parallel activities.

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Initials & Name I Gonzalez Gonzalez Student number 4938364

Title of Project Robot Code of Conduct in Automated Dairy Farming

Personal Project Brief - IDE Master Graduation

TU Delft

MOTIVATION AND PERSONAL AMBITIONS

Explain why you set up this project, what competences you want to prove and learn. For example: acquired competences from your MSc programme, the elective semester, extra-curricular activities (etc.) and point out the competences you have yet developed. Optionally, describe which personal learning ambitions you explicitly want to address in this project, on top of the learning objectives of the Graduation Project, such as: in depth knowledge a on specific subject, broadening your competences or experimenting with a specific tool and/or methodology, ... Stick to no more than five ambitions.

I got instantly interested in this assignment by Lely because I was actively looking for a project in which I could research future interactions or interactions resulting from the implementation and evolution of new technologies. I see vast potential in technology to improve people's lives, but I fully believe that to obtain that future outcome we need to make present changes, carefully steering the way we design and use technologies. After my graduation, I would love to continue working on multidisciplinary projects to fulfill this goal.

I am looking forward to improving the skills acquired during my Master on studying human behavior, carrying out exploratory prototyping, and user co-design and testing.
I am very excited to work with a global corporation like Lely. It is a great opportunity to research a real application and context, and to gain additional experience communicating with multidisciplinary stakeholders. This last point is super valuable to me as I believe it does not matter how good the design is if you cannot properly convey it.

Studying such a multi-layered topic will be a great challenge, but I expect to learn a lot about humans, robots and our mutual future. Some addition.al competencies I would like to develop are:
- Visual communication
- Learning to explore future contexts using methods like speculative design, how-to's and storytelling.
- See from, and applying the perspective of more than human design.
- Translating insights with different levels of abstraction into actionable directions and business opportunities.

References:
[1] T_HQ. (2020, Nov.16). How 2020 catalyzed the rise of the robots. [Online] Available: https://techhq.com/2020/11/how-2020-catalyzed-the-rise-of-robots/
[2] E. Philips, K.E. Schaefer, D.R. Billings, F. Jentsch, and P.A. Hancock, Human-Animal Teams as an Analog for Future Human-Robot Teams: Influencing Design and Fostering Trust, Journal of Human-Robot Interaction, Vol. 5, No. 1, 2016, Pages 100-125, DOI 10.5898/JHRI.5.1
[3] C. Bartneck, T. Belpaeime, F. Eyssel, T. Kanda, M. Keijsers, and S. Sabanovic, Human-Robot Interaction, Cambridge University, 2019
[4] T.B. Sheridan, Human-Robot Interaction: Status and Challenges, The Journal of the Human Factors and Ergonomics Society 58(4), 2016, DOI:10.1177/0018720816644364
[5] P.M. Erwin, Corporate Codes of Conduct: The Effects of Code Content and Quality on Ethical Performance, Journal of Business Ethics, 99, 2011
[6] KS. Welfare, M.R. Hallowell, J.A. Shah, and L.D. Riek, Consider the Human Work Experience when Integrating Robotics in the Workplace, 978-1-5386-8555-6/19/, 2019 IEEE

FINAL COMMENTS

In case your project brief needs final comments, please add any information you think is relevant.

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Initials & Name: I Gonzalez Gonzalez 5250 — Student number: 4938364

Title of Project: Robot Code of Conduct in Automated Dairy Farming

APPENDIX B

Topic interviews

Questions (Note: they will be tailored to the expert refering to a concrete robot or set of robots and role)

Draft agenda

1. How are you?
2. Present myself
3. Role of the other in Lely and time working here
4. Intro thesis
5. First thoughts and familiarity with robot(s)
6. Particular pre-planned questions (open discussion)
7. Gratitude
8. Interest in future discussion later on the process? Interest future workshop?
9. Permission to anonymously use insights for thesis

Functionalities and technical aspects

1. How do you implement actualization to the robots? Do you go farm by farm? Do you wait and implement several **updates** in a new version? Does it depend if the update is physical (e.g. sensor) or digital (e.g. software update)?
2. What steps do you normally follow when **installing** a robot in a farm?
3. How do the robots adapt to the **weather conditions**?
4. Do the robots have concrete **schedules**?
5. Do they have an **emergency mode** (e.g. to disconnect or evacuate in case of fire....)? Which are those mechanisms?
6. How do the necklaces get charged? Are they like a communication hub? Do they ever break down by collision or get stucked?

Others

1. Which do you think is the biggest **competitor**?
2. How would you improve that robot? Do you think it is **easy to communicate** with? **easy to understand**? **efficient**?
3. How do you think this hypothesized code of conduct would **affect your work**?
4. How do you **envision this code** of conduct?
5. What **value** do you think it will create to have robots designed to follow concrete and revisable **behavioural codes**? For the farmers? For the developers? For the end-clients?

Next steps and future technologies

1. Is the goal to make the **robots connect and collaborate** creating like a shared system within the farm?
2. What do you think will be the **role of AI** in the future farm? And the ideal one? Which would be the biggest challenges in their adoption?
3. What **other technologies** do you foresee being implemented? AR/VR?

Codes of conduct, ethics and the Lely identity

1. Do you think current robots share any behavioural trait?
2. What **behaviours** do you think the robots should have and not have? Does it depend per robot? Which ones will make your job easier?
3. How familiar are you with the **employee code of conduct**? Does it have a direct effect in your actions? And the Red rules or brandbooklet?

User interactions, communication and trust

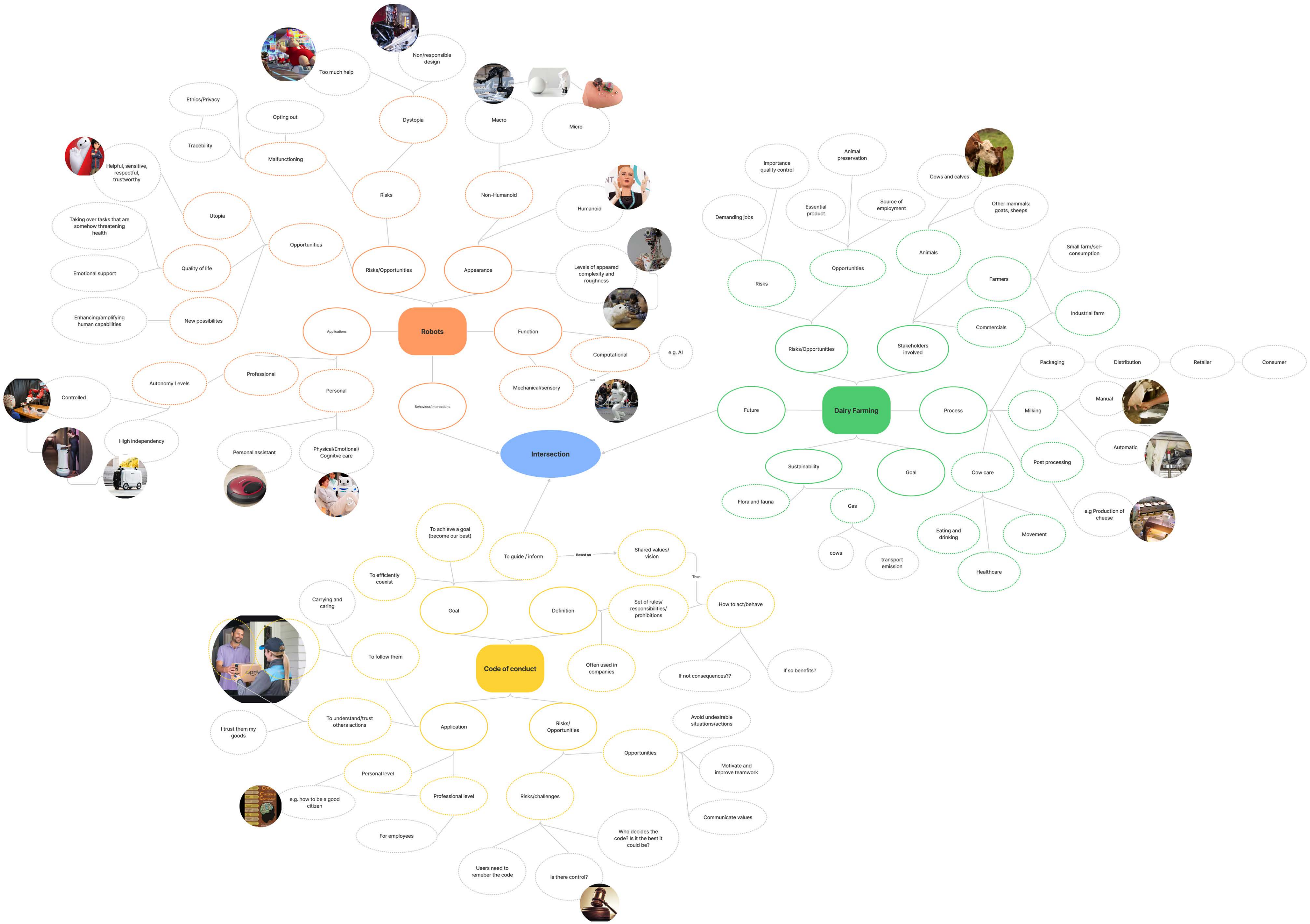
1. Do think farmers **trust** the robots? Maybe some more than others? What aspects influence trust?
2. What do the farmers **expect from the robots**? How do they succeed in providing it? How does it differ to have the farmers **expect from human employees**?
3. What **onboarding** do the robots have in the farm? How does it differ to welcoming a new employee/team member?
4. Which are the **touchpoints** of the robots with the farmers? And with the cows? And with other elements in the environment (e.g. insects, pets, visitors, farm resources...)?
5. How do users **treat the robots**? Does it depend per user and type of robot?

Future of farming, sustainability

1. How would a Lely farm look like in **2050**? How do you think we should balance artificial assistance and human control and agency?
2. What **future regulations** do you foresee? (environment, AI ethics...) How do you think it will impact Lely's products and developments?
3. How would the **perfect robotic employee** be?
4. What is the optimal **balance between** having **control and** having **assistance**?

APPENDIX C

Mind map



APPENDIX D

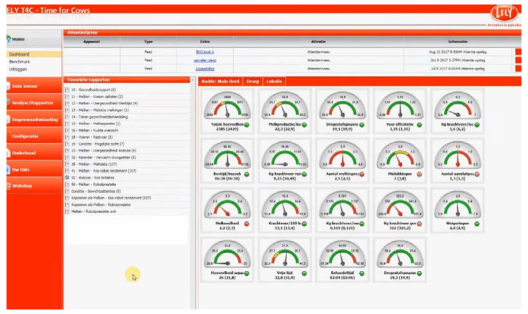
Lely current robot system

(Some of them)

Lely Discovery Collector
https://www.youtube.com/watch?v=yCJx-N_3nnEc

Lely Juno
https://www.youtube.com/watch?v=u0_hEjUViMw

Lely Astronaut A5
https://www.youtube.com/watch?v=5cWiE-p10ruA



Lely T4C system
https://www.youtube.com/watch?v=e_fZME2zHiI

PRODUCTS

Current	Future
1 Milking & Cooling	Milk factory
2 Feeding	Harvesting/Feeding
3 Manure and urine	Manure filtering
4 Cow care	Ultra XL
5 Energy & Lighting	Management 3.0
6 Free traffic	
7 Management Systems	
Dairy XL	

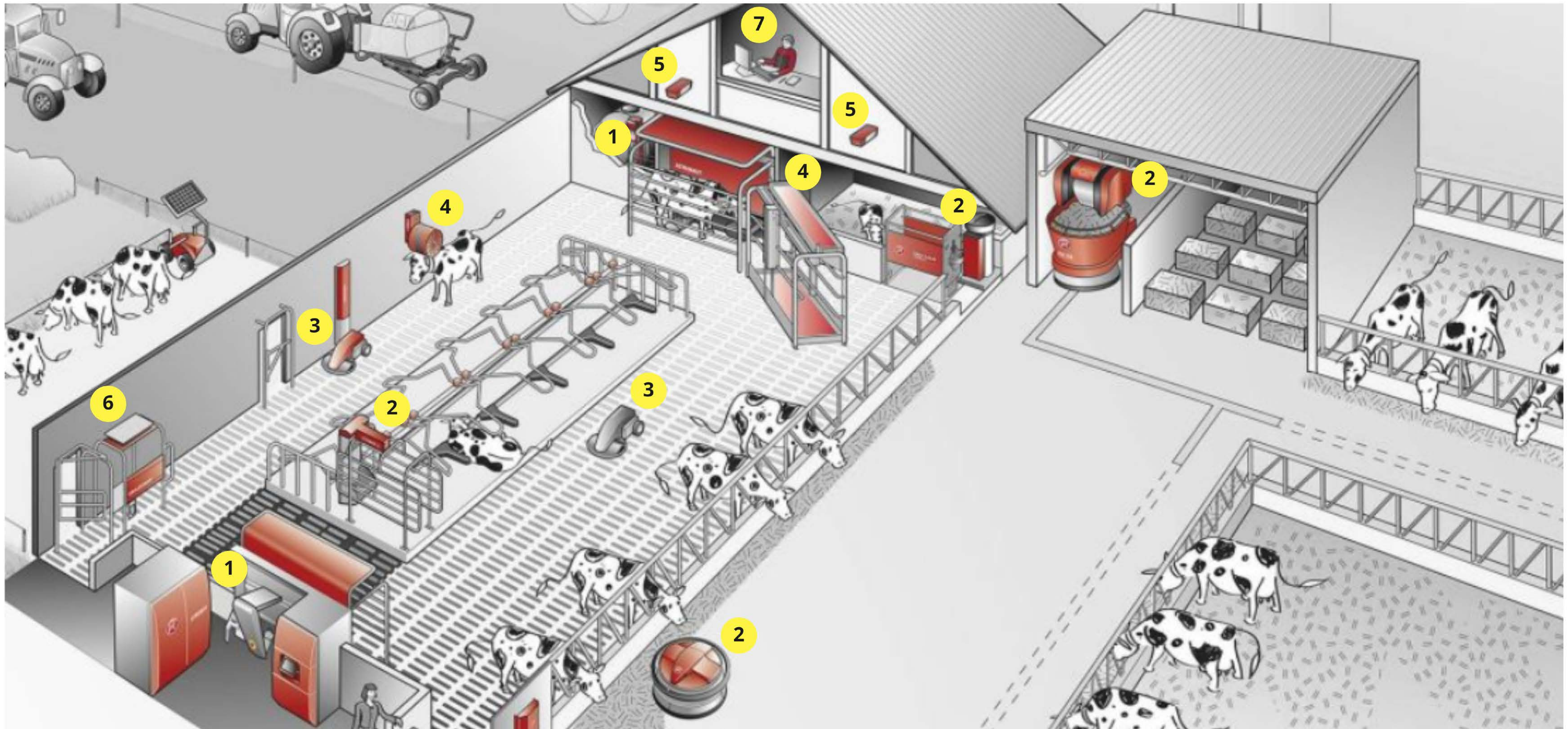
SERVICES

Farm Management Support

24/7 Technical Service Support

Original Spare Parts

Consumables



Lely Vector system: MFR (Left) and Feed grabber (Left)
https://www.youtube.com/watch?v=yhwsonTehh4

Lely Luna
https://www.youtube.com/watch?v=vq-1j4ImZxcw&ab_channel=Lely

Lely Cosmix
https://www.youtube.com/watch?v=i07GslRFjW-g&ab_channel=Lely

Lely current robot system - third parties

(Some of them)

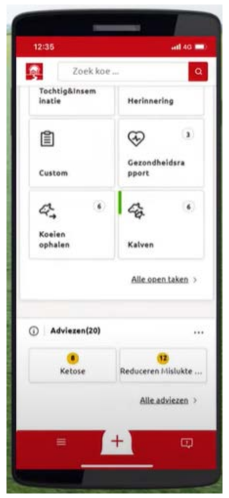
Lely Walkaway
https://www.youtube.com/watch?v=h-9vqjjaHR6s

Lely Calm
https://www.youtube.com/watch?v=OpSjfCBycNM

Lely Qwes
https://www.lely.com/solutions/milking/qwes/

Lely T4L lights
https://www.youtube.com/watch?v=yMj3mL-4h72w

Lely coming robot system
(Some of them)



Lely Horizon
https://www.youtube.com/watch?v=hkYFyDA-9cy4&ab_channel=Lely

Lely Exos
https://www.youtube.com/watch?v=R2Lx9t2EzeM

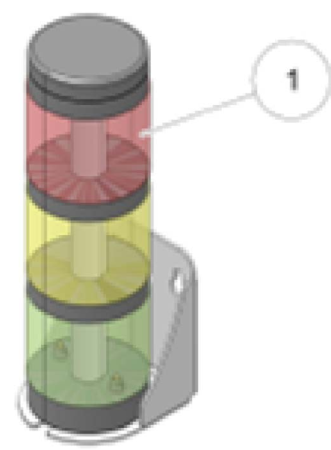
Lely Sphere
https://www.youtube.com/watch?v=xB3lyW8f-DhQ

Lely Orbiter
https://www.youtube.com/watch?v=f7kiaZw9n-Ow

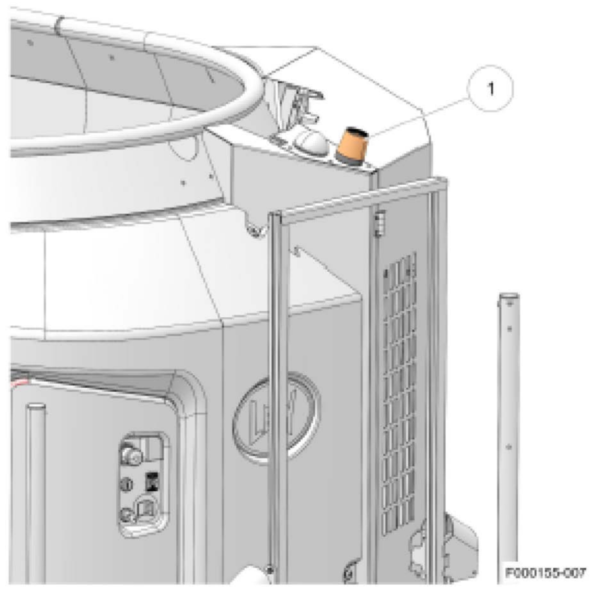
APPENDIX E

Frictions communication
(Lights)

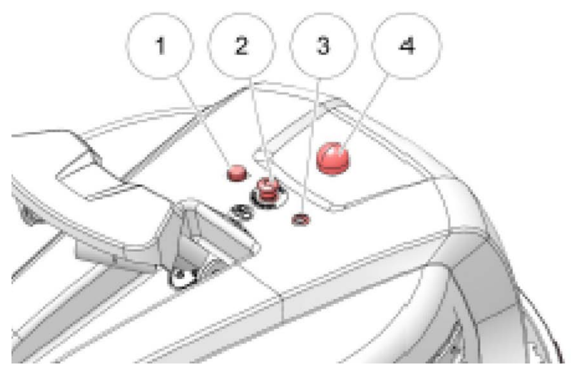
Traffic light long list of message options



Traffic light Vector system



Light Vector



Light Juno

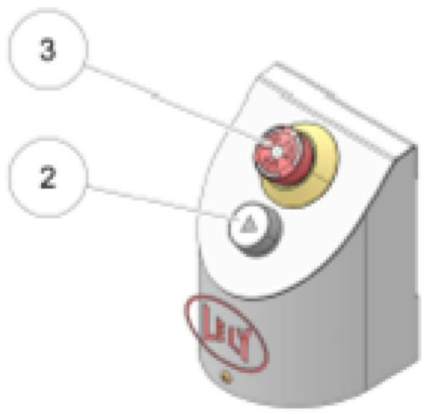
Lely current expressions

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
	How do ... robots/systems that...	Clean manure (only barn)	Distribute food	Prepare food (portion/type)	Push food	Get charged	Track cows	Milk cows	Allow/controll cow circulation	Clean cows	Control milk quality	Milk processing	Harvest grass	Reduce manure emissions
1	...does it show that is currently working?	SOUND MOV	SOUND DEVICE calm DEVICE LIGHT narrow alley LIGHT signal light MOV MFR T4C	LIGHT signal light DEVICE calm DEVICE T4C LIGHT sensor light MOV	SOUND you can chage beep DEVICE CO+ LIGHT MOV	LIGHT CO+ LIGHT LIGHT Juno	DEVICE T4C HOR	DEVICE DEVICE E-link HOR MOV	DEVICE T4C MOV	MOV	only shows if it stops working MOV + when opening door milk flow	MOV	MOV	MOV helix
2	... show something is wrong with the environment/ surroundings?	✕	MSG bumper/obstacle sensor DEVICE T4C	LIGHT open fence	MSG bumper DEVICE CO+	✕	✕	?	✕	✕	✕	?	?	✕
3	... show something is wrong with the robot?	SOUND non-critical alarm DEVICE CO+ SOUND non-critical alarm - route stop away from charger	MSG what failed?? MFR - FG - BC DEVICE T4C ✕ calm	MSG what failed?? DEVICE T4C DEVICE calm	MSG what failed?? DEVICE CO+ stop away from charger orange light SOUND	LIGHT LIGHT LIGHT no power morse code??	MSG no data cow (collar trapped?) DEVICE T4C HOR	SOUND DEVICE E-link LIGHT alarm LED MSG what failed?? DEVICE CALL emergency HOR	DEVICE T4C T4C no communication alarm if no communication in > 12 hours	MOV	DEVICE HOR DEVICE E-link MSG LIGHT alarm LED	✕	? DEVICE HOR	?
4	... show something is wrong with the cow?	✕	✕	✕	✕	✕	DEVICE T4C HOR	DEVICE E-link NOTI DEVICE HOR	DEVICE T4C HOR	✕	DEVICE HOR DEVICE E-link NOTI	✕	✕	✕
5	... ask for help?	MSG what failed?? DEVICE CO+ SOUND non-critical alarm - route no movement	MSG what failed?? DEVICE CALL emergency T4C no movement	LIGHT DEVICE T4C LIGHT LIGHT	MSG DEVICE CO+ SOUND non-critical alarm - route	✕	MSG DEVICE T4C HOR	SOUND DEVICE E-link LIGHT alarm LED MSG what failed?? DEVICE CALL emergency HOR	DEVICE T4C	✕	DEVICE HOR DEVICE E-link MSG LIGHT alarm LED	?	?	✕
6	... notify results? which results or info?	✕	Feed results DEVICE T4C	✕	✕	(through each robot) battery %93 Battery: 13506 9= Battery full	DEVICE cow biodata T4C HOR	DEVICE HOR milk • production • properties • cows milked	DEVICE time spent on pasture T4C	✕	DEVICE HOR El-link milk quality of cow or herd	? milk production/ profitability	? grass harvested	?
7	... prevent problems? preventive actions based of past events, in addition to safety measure and intructions on maintenance	✕	✕	✕	✕	✕	✕	✕ Strict maintenance points • To-Do list	✕	✕	✕	?	?	✕
8	... show next steps?	MOV DEVICE CO+	DEVICE ✕ calm/cosmix MOV T4C schedule scan times	MOV DEVICE T4C	MOV DEVICE CO+	✕	✕ Steps taken	MOV	MOV ✕ automatic circulation invisible	✕ Steps taken MOV	✕	?	?	✕
9	... show status in general? (how are you?)	DEVICE CO+	LIGHT DEVICE DEVICE calm T4C	LIGHT + MFR situation + Kitchen content	DEVICE CO+	LIGHT	✕	closed/open door product levels CSR	open/close	Position • Horizontal claw care - Vertical free traffic	Milk on the tank	? stock of raw parts	?	✕
10	... show why is doing something?	✕ dirty barn?	✕ empty alleys?	✕ empty alleys?	✕ spread food?	✕ robot needs energy?	✕ no visible info transfer		✕ Opening door for cow in one direction	✕ cow hygiene?	✕ quality control	?	✕ collect grass	✕ closing loop - cleaning air
11	... allow farmer intervention?	DEVICE CO+ manual drive	DEVICE CO+	DEVICE T4C DEVICE calm	DEVICE CO+	drive robot charger DEVICE CO+	✕	DEVICE HOR DEVICE E-link	Control through T4C DEVICE T4C	Control box DEVICE only Walkaway	DEVICE HOR DEVICE E-link	?	?	✕
12	... suggest actions?	✕	✕	✕	✕	%93 Battery: 13506 9= Battery full	DEVICE T4C HOR	✕	✕	✕	✕ next steps based on milk quality	? make adjustments to improve production	?	✕
13	... ask for/ acknowledge consent?	✕ assumes consent if not interrupted	✕ assumes consent if not interrupted	✕ assumes consent if not interrupted	✕ assumes consent if not interrupted	✕ assumes consent if not interrupted	✕ assumes consent if not interrupted	✕ assumes consent if not interrupted	✕ assumes consent if not interrupted	✕ assumes consent if not interrupted	✕	?	?	✕
14	... correct cow misbehavior?	✕	only Cosmix	✕		✕	✕		✕	✕	✕	✕	✕	✕
15	... praise cow good behavior?	✕	✕	✕	✕	✕	✕	treat food	✕	✕	✕	✕	✕	✕
16		✕	Communication: • Between MFRs ✕ not visible	Communication: • Feed Grabber - MFR ✕ not visible	✕	✕	Communication: • Collar - Gates • Collar - Astronaut only visible if system fails	Communication: • Collar + Gates	Connection with Astronaut to circulate milking cows?	✕	?	?	? closing loop? info • Sphere • Astronaut	✕
17	++ which is the next step for this task?	• Improved safety and running time by new contact charger • Update software previous version	• Implement a central command point for both user/tecnician to communicate with the system as a whole	• Same as on the left + improve teamwork with third parties (e.g. food advisors)	• Improve location and orientation to improve robot's safety	• Improved version of charger no connections exposed	• Working on locating cow • More data collected + improved teamwork with third parties (e.g. vets)	• More data points but less information weight for the farmer • Machine more independent • Show that it is working even if it is doing something else than milking • Recover itself and always work + self-diagnosis	?	?	• Perhaps still improve teamwork with third parties -> suggest next steps to achieve milk results adjusting other robots	?	?	?
18	++ some possible problems?	• Damage cows (laying, eating when Vector comes) • Lost/stuck - hititng walls or misisng corners • Manure collection error • Missing charger	• Bumper (MFR lost- obstructed - feed falling) • Strip lost • No ultrasonic signal • Error feeding cow Cosmix	• Lost communication • Problem feed grabber or crane time or performance	• Lost or orientation error + gyroscope problems, strips • Empty battery/charging problems • Obstacle detected	• No current • Not located by the robots	• Collars trapped in fences or turned	• Teatcups connection • Fail cow identificaiton • Milking error • Not empty milking tank • Lack of consumables	• Tied gate • Connection loss	• Nozzles do not spray • Buttons do not respond • Bath does not lowe • Brush does not start, stop or change direction	• No communication • No reagent • Stopped working	?	?	?

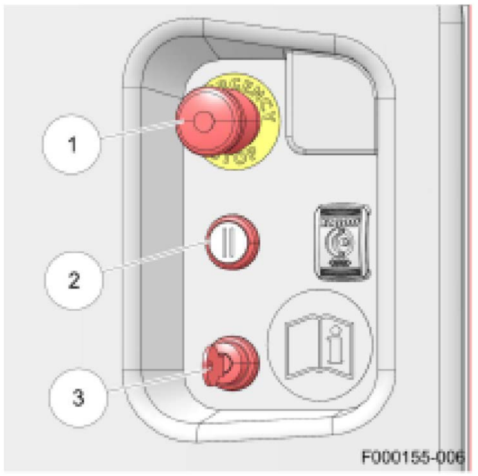
LEGEND - APPROACH

LIGHT	White light
LIGHT	Green light
LIGHT	Red light
LIGHT	Yellow/orange light
LIGHT	Traffic light
SOUND	Sound 1
SOUND	Sound 2
MOV	Movements same sequence
MOV	Movements that vary
MOV	Change of movement
	Continuous frequency
	Intermittent frequency
	Alternative frequency
DEVICE	Phone UI
DEVICE	Stationary UI
DEVICE	Phone + computer UI
DEVICE	Hand-stationary UI
HOR	Horizon
T4C	T4C platform
CO+	Control plus
MORE	Increasement
LESS	Decreasement
	Stop an action
	Start an action
PAUSE	Temporary pause
✕	Noting happens (yet)
✕	Not applicable
NOTI	Notification
MSG	Message
CALL	Call
	Pause button
	Emergency button
	Cow shock

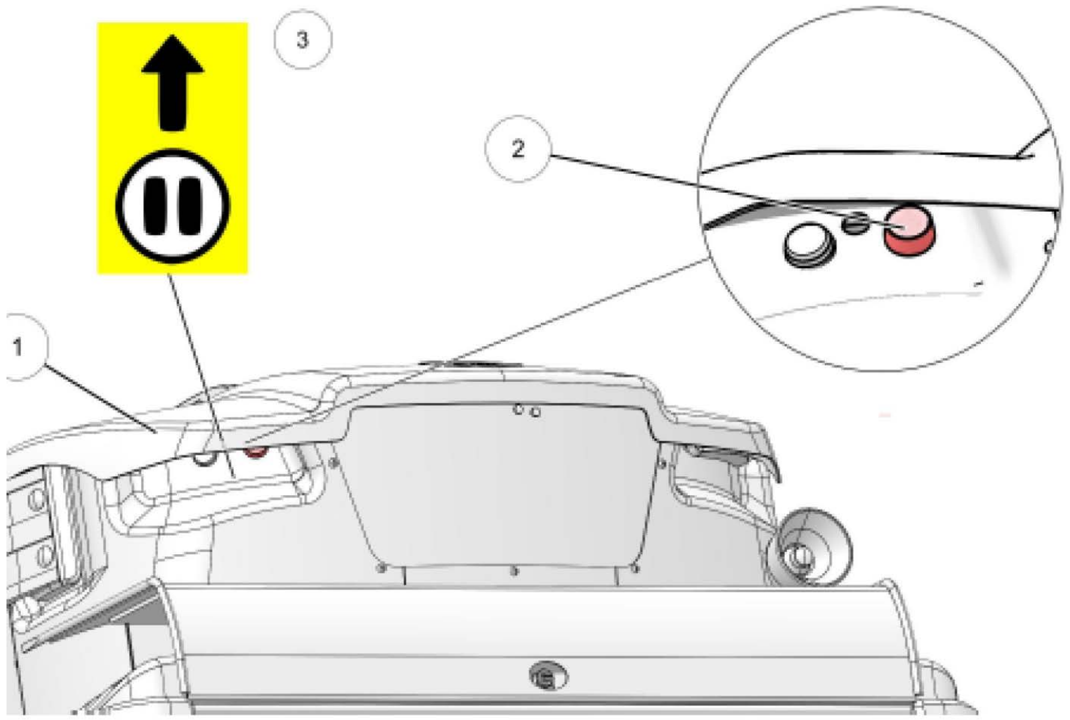
(Buttons)



Play button Vector



Buttons MFR Vector



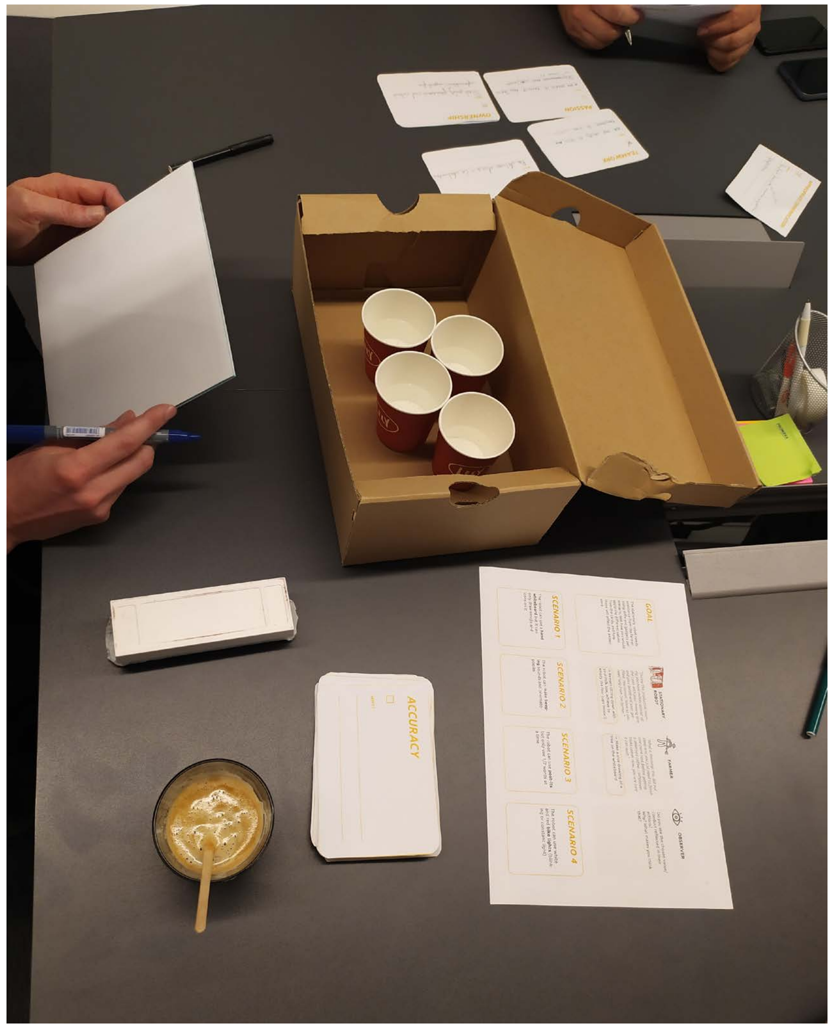
Hidden collector buttons

APPENDIX F

Workshop 1 - Set up

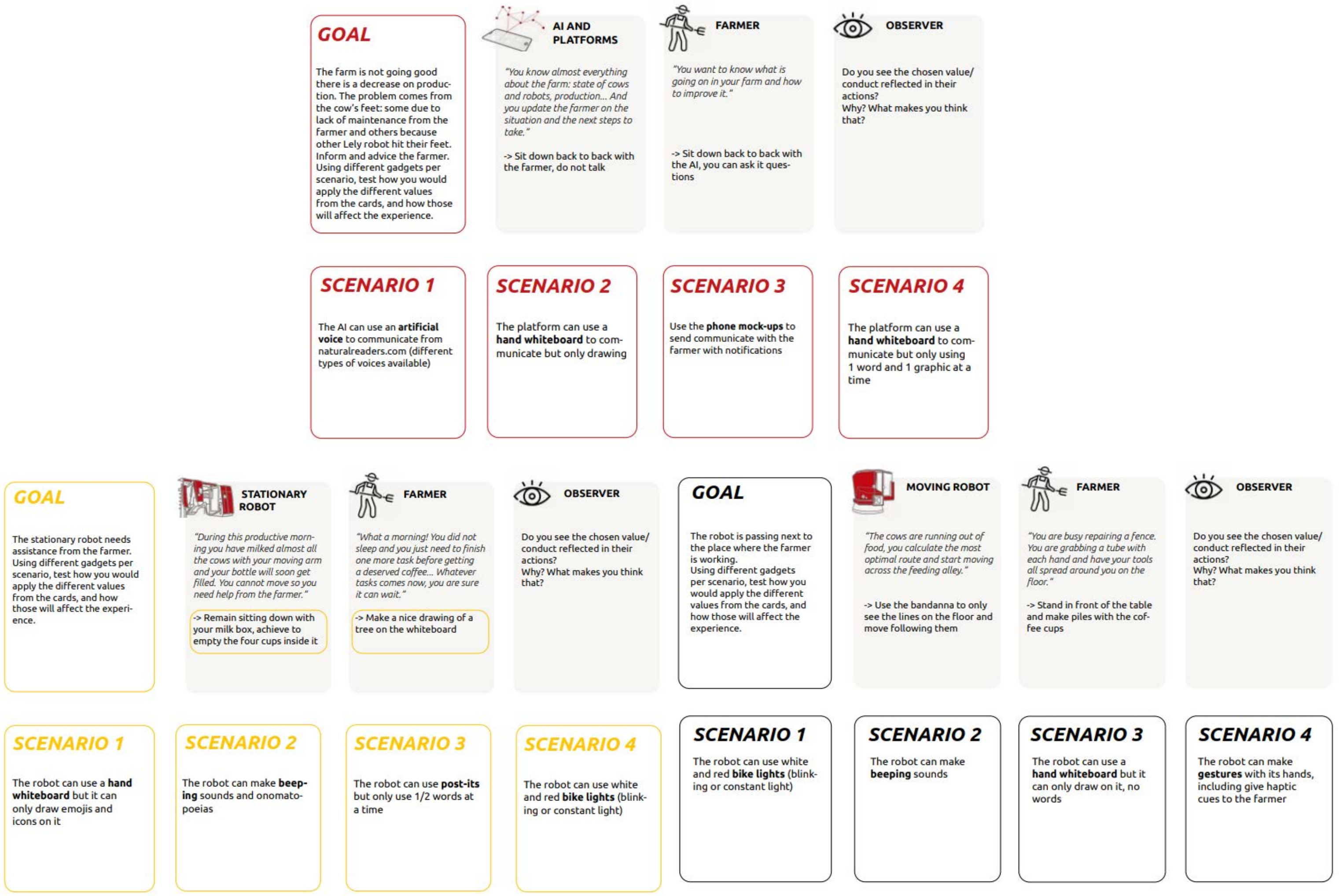
Roleplay

Participant name

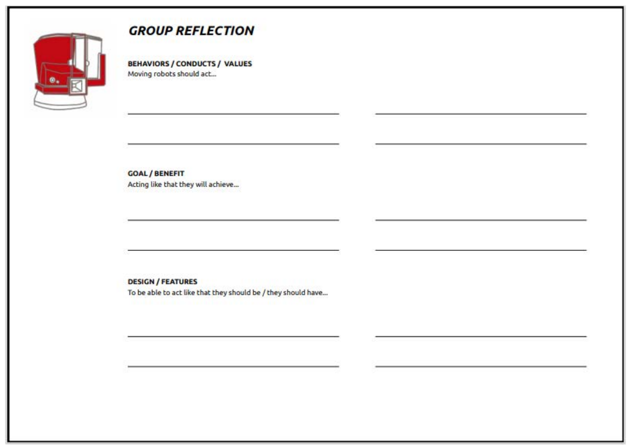


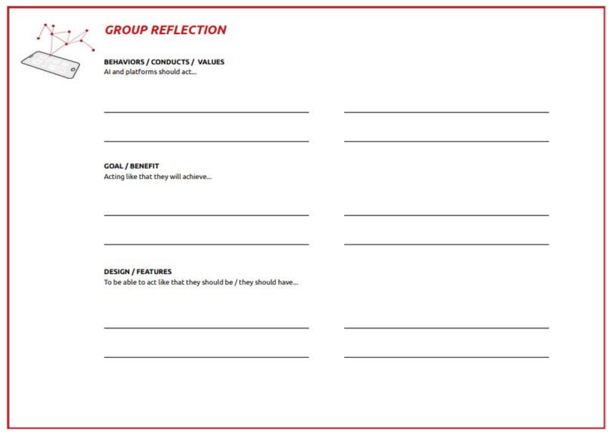
Group yellow enacting a tank filling

Value cards coloured per group



Scenario descriptions coloured by group





Final reflection canvases

Lely documents

Values from Lely documents

Workshop 1 - Analysis

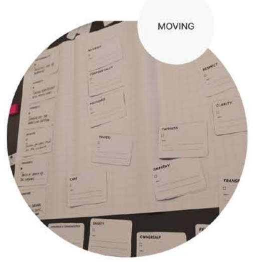
• MAP VALUES EMPLOYEE

General:
- most cards not filled (lack of time? not smooth discussion process?)

This pile was the first points they agreed Lely employees apply

Points to explore or that did not attract their attention

Points of improvement



They started clustering the values first per applicability.

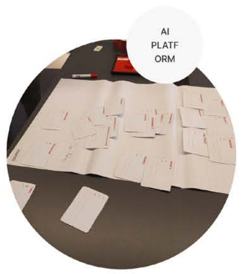
SUSTAINABILITY – Conscious use of resources
HONESTY – Meeting expectations with recruitment
CURIOSITY – Figuring out the underlying question
PASSION – Passion for your craft or the customer
TEAMWORK – Engagement between different teams and roles, getting the job done
PROGRESS – Notice of growth of the company

EMPATHY, FAIRNESS, TRANSPARENCY, RESPECT, TIDINESS, INNOVATION, POLITENESS, CARE, CLARITY, CONFIDENTIALITY, ACCURACY

RELIABILITY, APPROPRIATE COM, SAFETY, OWNERSHIP

Things left behind or yet to cluster

RESPECT – Lots of understanding of each other
HONESTY, EMPATHY, FAIRNESS, POLITENESS
CONFIDENTIALITY – Not talk about newst innovation outside Lely
TRANSPARENCY



They started clustering the values first per topic.

Core values and thrive: SUSTAINABILITY, INNOVATION, PASSION, CURIOSITY, PROGRESS

Measures: SAFETY, TIDINESS

Communication: CLARITY – Clear Vision/Goal; RELIABILITY; APPROPRIATE COM – Applied; ACCURACY

CARE – Care about colleagues
TEAMWORK – Applied
OWNERSHIP – Taking lead in project, taking on tasks

They went one by one, value by value.

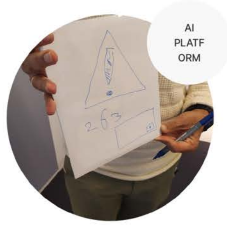
RESPECT – People grow if the feel values. Respecting people is important for personal value and growth
OWNERSHIP – Third party processes and contract implementation, support PM
EMPATHY, FAIRNESS
TRANSPARENCY – On what is possible within the processes
RELIABILITY – Trustworthy is a better value. Do I trust him/her/it in what it does? Combined with consistency and predictability, it makes a team
SUSTAINABILITY, HONESTY, CURIOSITY
PASSION – If you believe in it, follow it, keep trying. Show/communicate about what/where we should go
PROGRESS, ++
SAFETY, TIDINESS, POLITENESS, CARE, CLARITY
INNOVATION
TEAMWORK – Use the variety of skills and knowledge to make progress
CONFIDENTIALITY, ACCURACY, APPROPRIATE COM

Workshop 1 - Analysis - Activity 1

• ROBOT ROLEPLAY

CLARITY – Beeping: we know something is up, but what?; Whiteboard - clear message
APPROPRIATE COM – Beeping is efficient; Lights are not good enough, no alert; Whiteboard is easy to ignore
SAFETY – Whiteboard - what if the sensors are down? like the bumper detection?
POLITENESS – Beeping can be annoying

Lights – Soft cue
Beep – Annoying but efficient
Whiteboard – You need to look at it
Gestures

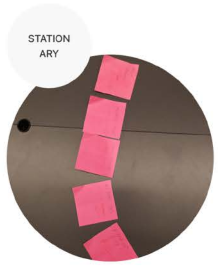


Impossible to understand by external observer

RELIABILITY – Say what we do, do what we say
ACCURACY – Doing things RIGHT (complete). Be accurate
SUSTAINABILITY – Applied
INNOVATION – Applied
PASSION – Live Life Lely - Proud Energy on what we are doing
CURIOSITY – Applied
PROGRESS – Applied

Artificial voice
Whiteboard
Postits
Whiteboard

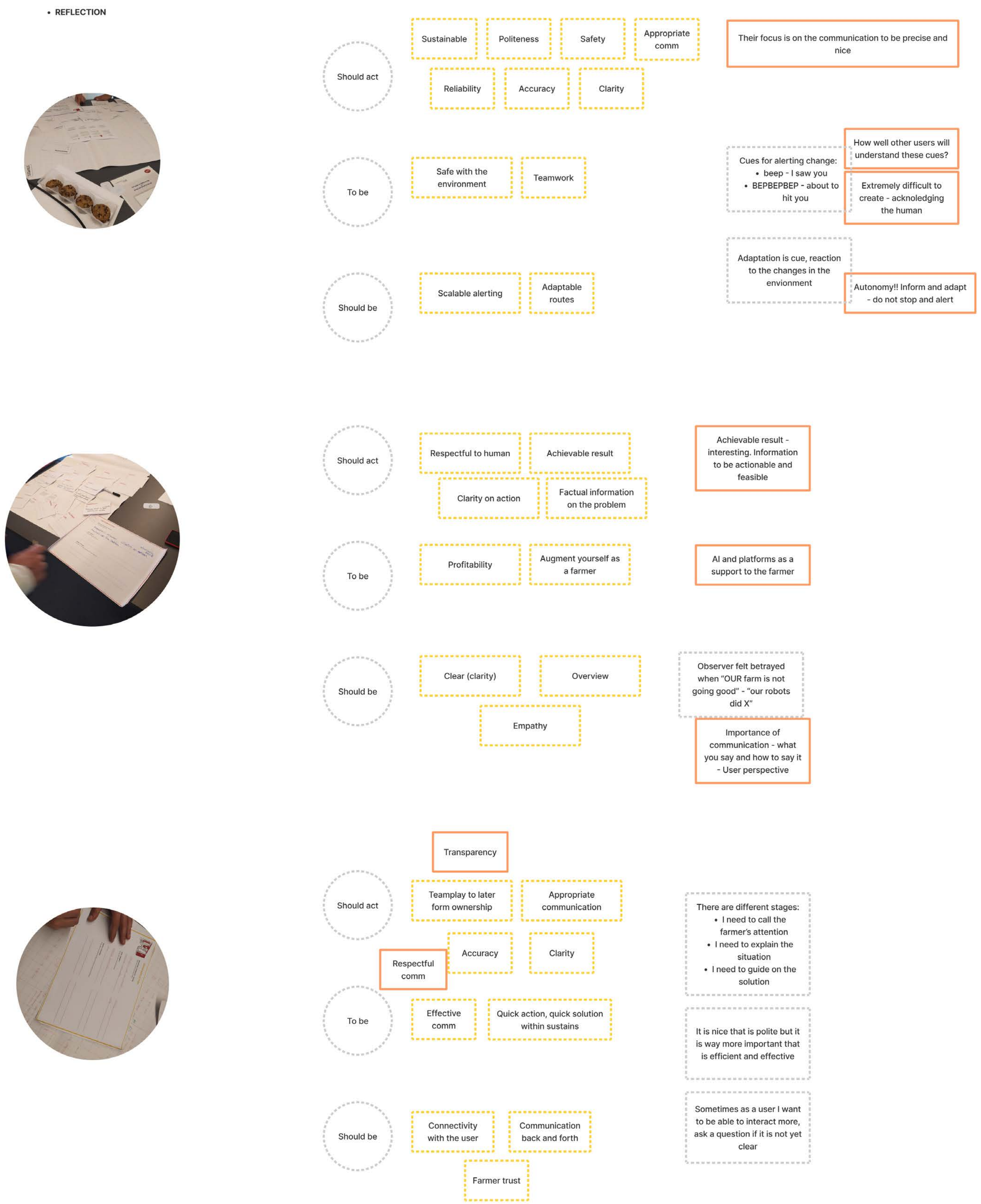
In all the activities, it was more about the message (incl. phrasing) than the channel



++ – Effective / Interactive
SAFETY – Pre-delivered documents + CE declarations
APPROPRIATE COM – Product (training?) information, manage expectations. Proposition
CURIOSITY – Robot communication "I am not working"

Whiteboard – The farmer saw the drawing but was not in the mood to respond... no even after adding "!"; It changed the drawing to a progress bar making it more transparent and accurate
Beep – I cannot say much with such a simple cue; Many noises in the barn; Lack of transparency; Do I act now or later?; Sounds like a metal detector; Good mosquito
Postits – 2 words is too few...; Long conversation; More confusion; Effectiveness top need
Lights – I cannot say much with such a simple cue; Only to point at the problem

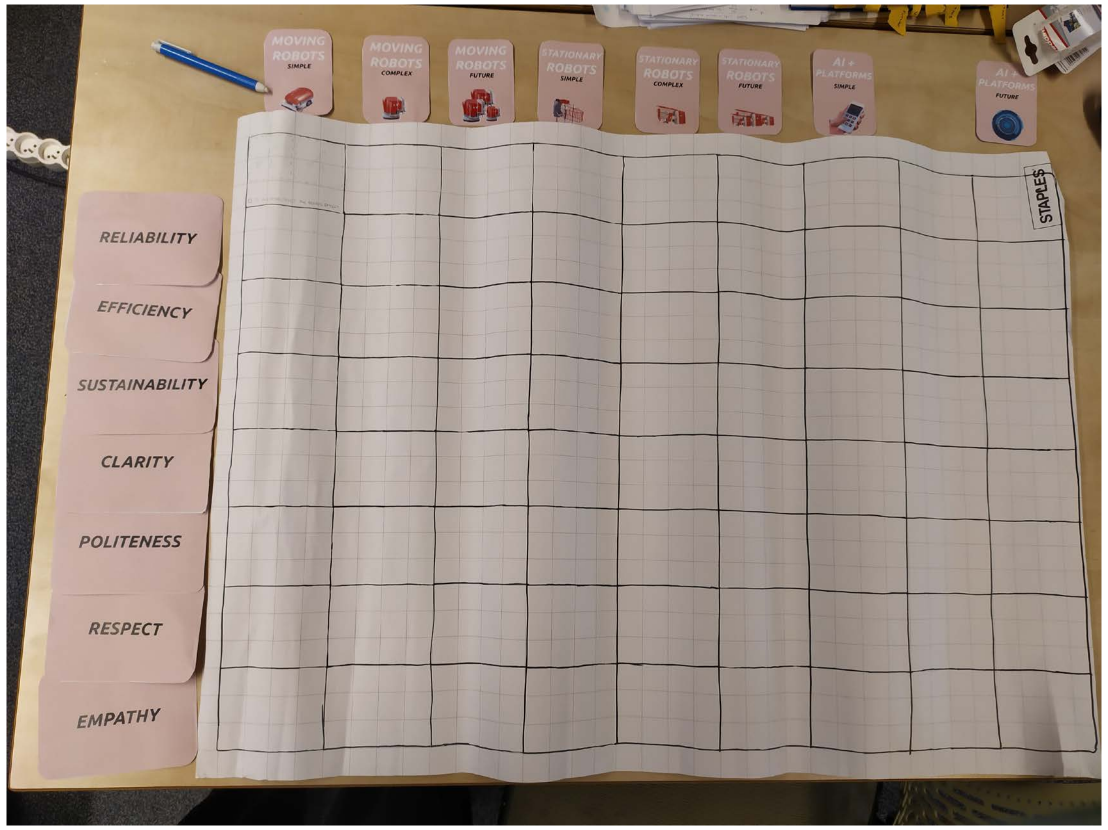
Workshop 1 - Analysis - Activity 2



Workshop 1 - Analysis - Activity 3

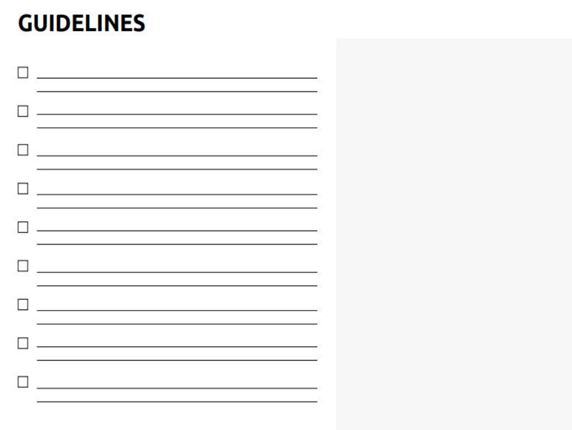
APPENDIX G

Workshop 2 - Set up



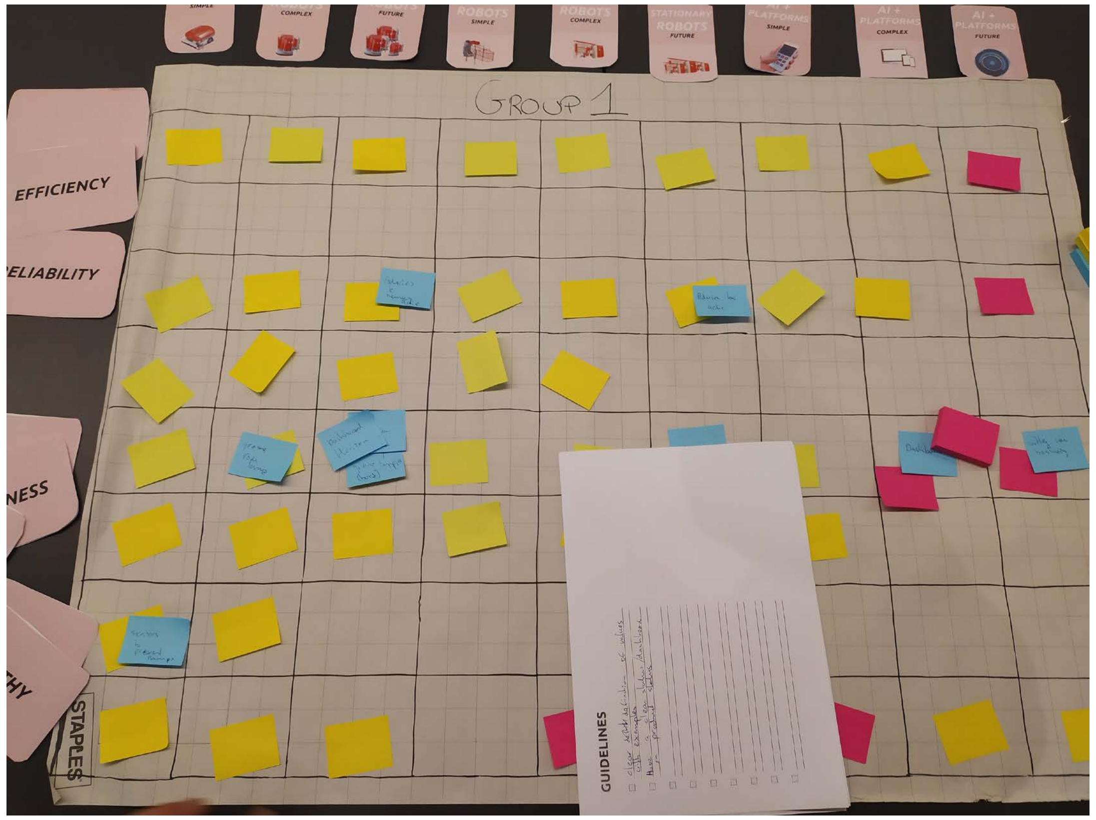
Workshop 2 table

Workshop 2 ideation canvas



Workshop 2 final reflection guidelines

Workshop 1 - Analysis



Workshop 2 table filled

Display written message

Signal what is going on
Green: milking
Yellow: open
Red: alarm

Positive feedback "I am working"

Focus on importance

MOVING

STATIONARY

PLATFORMS

We will convey the state of the farmer by...
quantitative information on what is going on and only notify if something "decide" form it

GUIDELINES

- Who is the target, farmer or engineer? Different approach is needed
- A device should function/ contribute to its core value
- Simple and structured way of information, don't overcomplicate it
- Robot have to respect the cows → less the user
- Farmer think simple → actionable

GUIDELINES

- Implement hierarchy when showing information
  - High-level (traffic lights) - then systems- then computer - then alarms/ indifcations
- Don't be afraid to leave the current road, step back and reiterate

GUIDELINES

- When designing a robot, decide which values the robot should have
- UI should have a role definition Farmer us Tech
- Avoid status indication on robots. Only green/red light to show status so that the user can be notifies to open UI
- Unify on how robots communicate, some exp. (expressions?) for all robots

Workshop 2- Table group 1

send user a message when robot stops doing its function

Tell users what he has to do to solve the alarm

Flash light to show where it is in the dark

Overview of status of all robots

MOVING

We will convey the state of the farmer by...
having an app to rule them all

STATIONARY

We will convey the state of the farmer by...
having one UI to rule them all

PLATFORMS

GUIDELINES

GUIDELINES

- Don't hurt human beings

GUIDELINES

- Robot-behavior-changes need to come in built-in release notes where purpose is clearly explained
- We could assume UI will not be good so how to add suficient feedback mechanisms in the same UI
- Getting an overview of the states of the robots in the farm
- Reliability may come along with un-pre-programmed movements (by farmer/technicians). So let the robot have more freedom to solve the problem by itself
  - But then the robot needs to be clearer in communicating these improvised movements

Workshop 2- Table group 2

sensors to prevent bumps

green red lamp

Alerts/advice to take actions

Dashboard Horizon

Big board on the wall

(more little green lamps?)

Advice to take action??

Protect or screen

Dashboard

Explanat ion of decision

MOVING

We will convey the state of the farmer by...
showing a green/red light and a dashboard on farm level

STATIONARY

We will convey the state of the farmer by...
showing a green/red light and a dashboard on farm level

PLATFORMS

We will convey the state of the farmer by...
showing the reasoning behind a decision

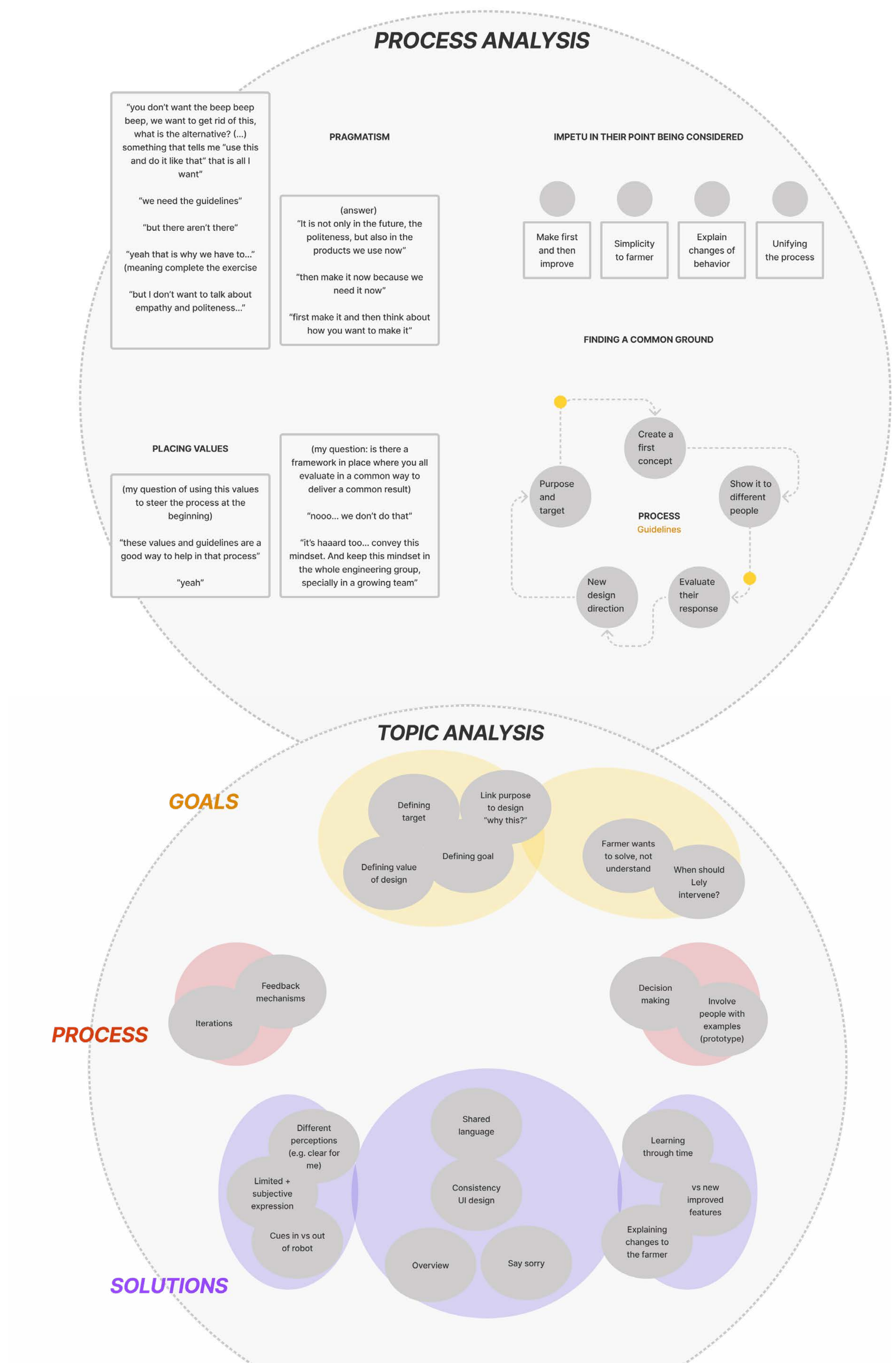
GUIDELINES

- Start with low hanging fruit
  - System UI look and feel
  - Sync communication means: light/sound

GUIDELINES

- Clear definition of values with examples
- Have a clean status/ dashboard on product status

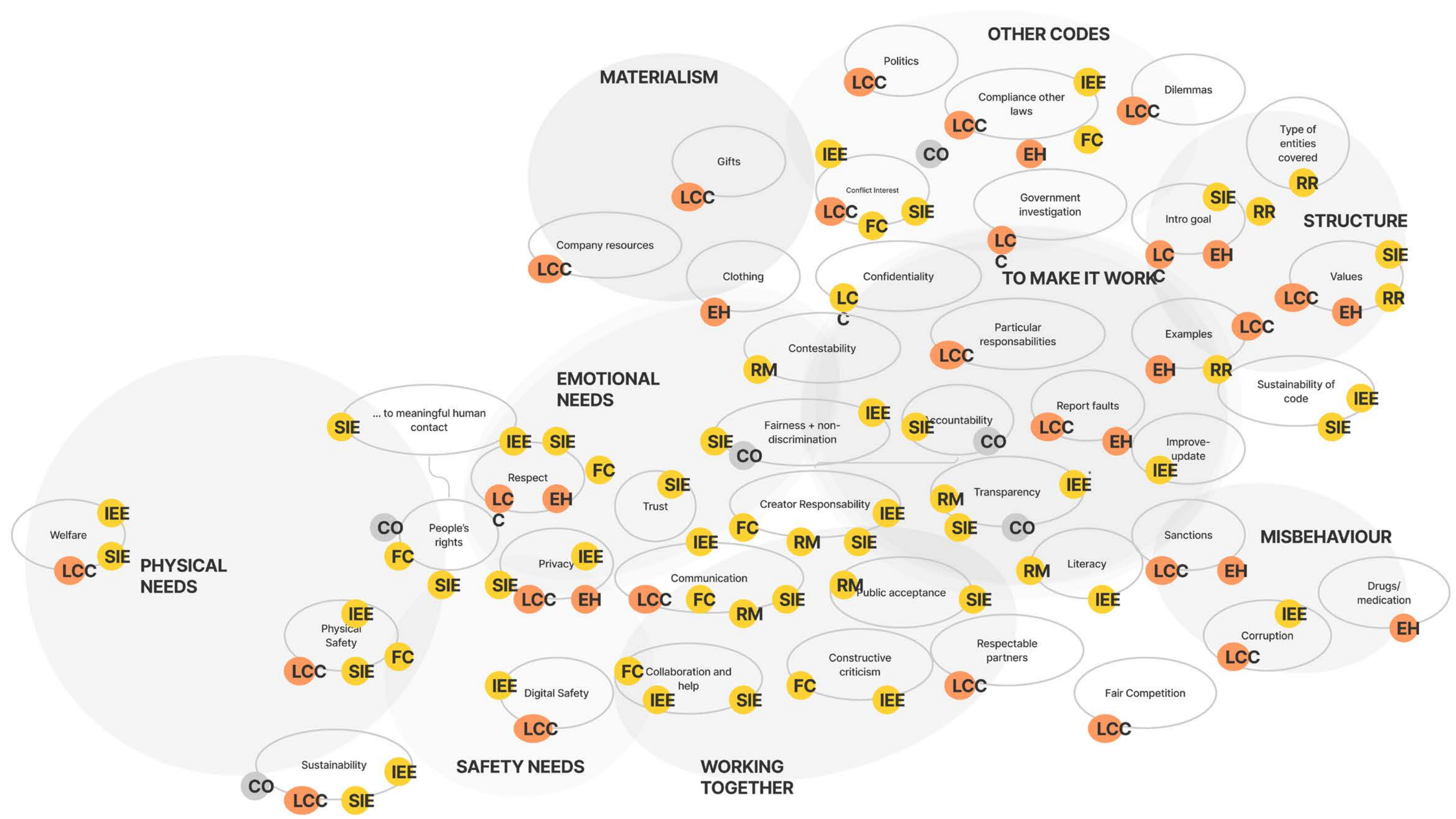
Workshop 2- Table group 3



Workshop 2- Final analysis

APPENDIX H

Codes of Coduct



RESPONSIBILITIES

Sustainability
Company resources
Gifts
Compliance other laws
Trust
Communication
Collaboration and help
Public acceptance
Respectable partners
Dilemmas

Constructive criticism
Creator Responsability
Government investigation
Clothing
Conflict Interest
Politics
Confidentiality
Legibility
Drugs/medication
Accountability
Report faults
Transparency
Corruption

RIGHTS TO PRESERVE

People's rights
... to meaningful human contact

Physical Safety
Welfare

Digital Safety
Privacy

Fairness + non-discrimination
Fair Competition
Respect

CODE FEATURES

Sustainability of code

Sanctions
Particular responsabilities
Type of entities covered
Intro goal

Values
Examples