Human-centered robotisation at KLM Engines

A co-design tool for FRAIM & KLM Engines to explore and evaluate the possibilities & limitations of robotising the workflow

Master Thesis by Tosca Horstink

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Master thesis

August 2022
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Executive summary

The demand for robots in the industry is increasing. Organisations acknowledge the need to innovate in order to keep up with the competition. When robots were first introduced, they took over human tasks if they could execute the task faster than humans. However, this often has a negative effect on the meaningfulness of work. That's why cobots were introduced, robots that could work together with humans in the same workplace. This provided the industry with many new opportunities. However, as with any new technology, research has to be done to find out how this technology can best be implemented. That's why FRAIM was founded. They are researching how cobots can be introduced without decreasing the meaningfulness of humans' work. FRAIM decided to join the Brightsky project, to take their research into practice. However, with the Brightsky project, FRAIM is facing other challenges. Not only does the technical feasibility have to be researched, but also the employees' needs and other stakeholder values have to be taken into account. A challenge that can be perfectly tackled with a human-centered design approach.

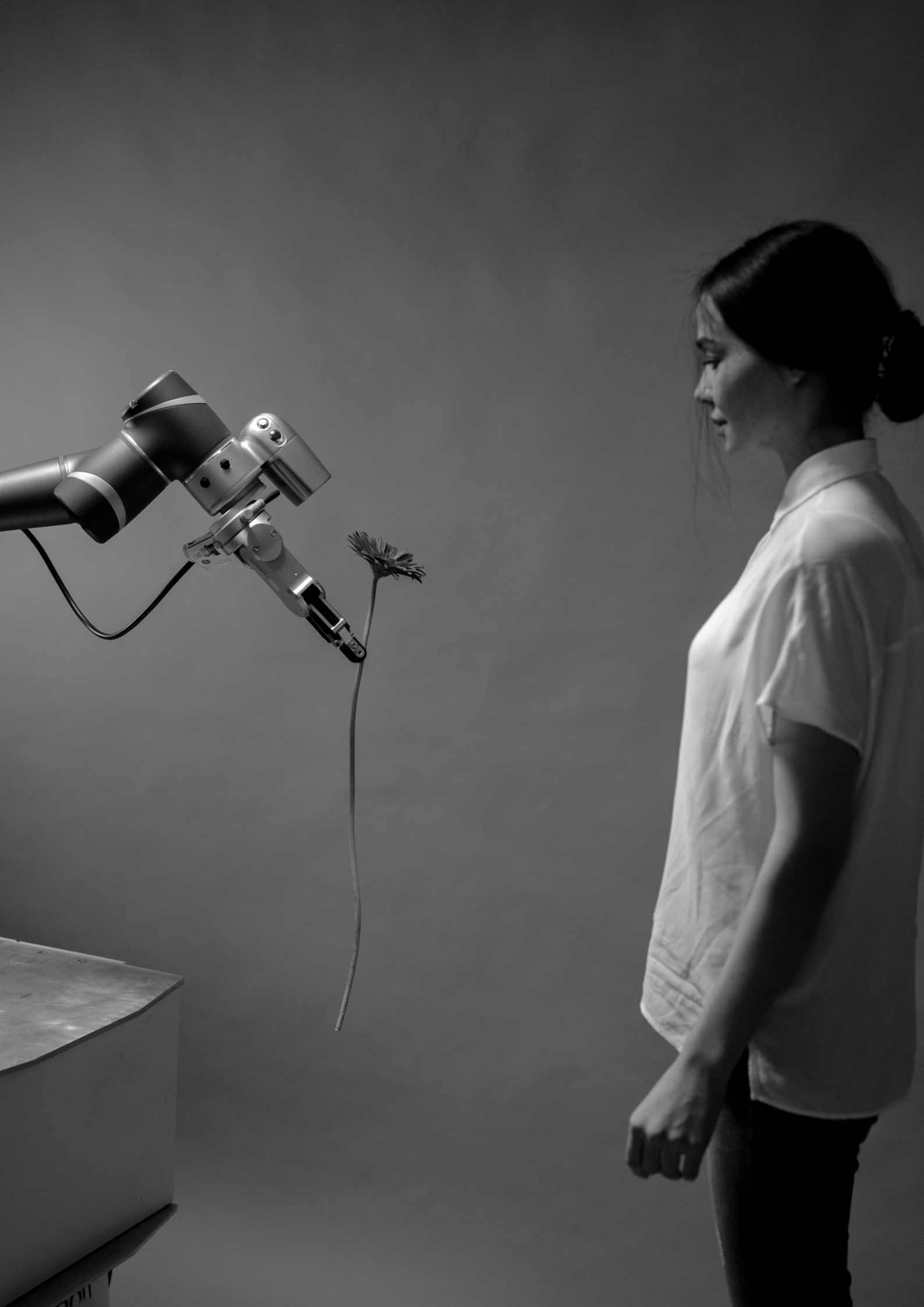
Firstly, through interviewing and stakeholder mapping, the essential stakeholders are identified. These stakeholders have high power or/and high interest in the company and thus contribute to the future of the organisation. Afterwards, the stakeholders are brought together for a co-creation session. In this session, the stakeholders discuss their individual needs and values to identify the contradictions and similarities. Next, a shared vision is created, representing the stakeholders' view on 'optimising' the workflow.

A stakeholder which is often negatively affected by the implementation of robots, is the employee, their needs are often neglected. That's why this project's focus is mostly on this stakeholder. During context mapping sessions, the themes of meaningful work are identified. These themes represent the conditions of meaningful work for the employees at KLM Engines.

During the research phase, it became clear that the stakeholders are unaware of the contradictions and similarities of their values. Furthermore, the knowledge and skills needed to understand the possibilities and limitations of implementing robots and their consequences on the stakeholders are lacking.
In the design phase, a co-design is created to tackle this challenge. Co-design is chosen, because it is well-known to be used for bringing together different expertise and for sharing knowledge and skills. Besides, the concept of game design is used. Game design helps to represent a real-life situation in a fun and engaging way and helps the participants to explore different scenarios. Using game design helps to visualise the consequences of robots on the workflow well.

The co-design is tested and evaluated to assess if the co-design meets the design requirements and to discover how the tool can be improved. A final iteration is done to improve the concept.

Lastly, the project is concluded and reflected on. The limitations of the project are discussed and future research and design recommendations are proposed.



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Introduct

Settig-up the project

This section is an introduction into the project and explains how it is set up. First the topic of robotics and the occuring problems are introduced. Secondly, FRAIM and the Brightsky project are explained. Lastly, the project and design approach are presented.

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Chapter 1
Introduction

In this chapter, the topic of this project is introduced. The problems of robotisation are explained. Afterwards, FRAIM and the problem they are facing are introduced. The design approach that is used to solve the challenge FRAIM is facing, is introduced. Lastly, the project set-up is presented.

1.1 The scope of the project

Since the industrial revolution, technology has rapidly improved. Technology can help organisations to work more efficiently. On the other hand, it pressures organisations to innovate in order to compete in the marketplace (Barbosa, Shiki, & Da Silva, 2020). One of these technologies is robotics. Robotics is described as the science of making and using robots (Cambridge Dictionary, 2022). A robot is a machine that can be programmed to automatically execute various movements to fulfil complex tasks. When robots were first introduced into organisations, they were taking over human tasks, based on execution time (Tsarouchi et. All, 2017). Figure 1, visualises how this works. First, it will be determined if the robot is capable of executing the task or not. If so, both the executing time by the robot and the human are measured and compared. If the robot can execute the task faster than the human, the task will be assigned to the robot. This way of task division causes some problems. What if all tasks, perceived as most interesting and challenging by the human, can be executed fastest by robots? A good example of what can happen, is the case of Amazon. Here, robots were implemented to execute those tasks that can be executed faster by robots than by humans. As a result, only the dullest tasks, such as moving boxes remain to be executed by humans (Guendelsberger, 2019). This makes the work boring and mentally exhausting (Lingmont & Alexiou, 2020).

Soon, people realised this caused jobs to change negatively or, even worse, disappear. That's why a more human-focused approach was introduced in which robots are used for automation by replacing humans to execute dangerous, unpleasant or expensive tasks (Rauankyzy,2020) or as Lin et al. state, robots take over the 3D's; dull, dangerous, or dirty tasks. Dull tasks include repetitive tasks, in which the employee has to repeat the same action repeatedly. Dangerous tasks, include tasks with a high-risk factor and have the potential to harm the employee. Dirty tasks, include tasks that are executed in an unpleasant context caused by an unpleasant smell or substances.

Nevertheless, this still caused jobs to change. On the one hand, work might become more challenging, because more knowledge and skills are needed to, for example, program robots. However, the opposite might happen as well, where a pauperisation of work takes place, in which human tasks are confined to compensate for robot limitations, for example, moving boxes from shelves to robots in warehouses, which can result in work dissatisfaction (Sainato, 2020). Dull, dangerous or dirty task can have a positive side. A dangerous task can, for example, also be seen as an exciting challenge. Letting robots take over such a task, means that the positive aspects disappear as well. Besides, focusing only on the division of tasks, leaves out other factors that

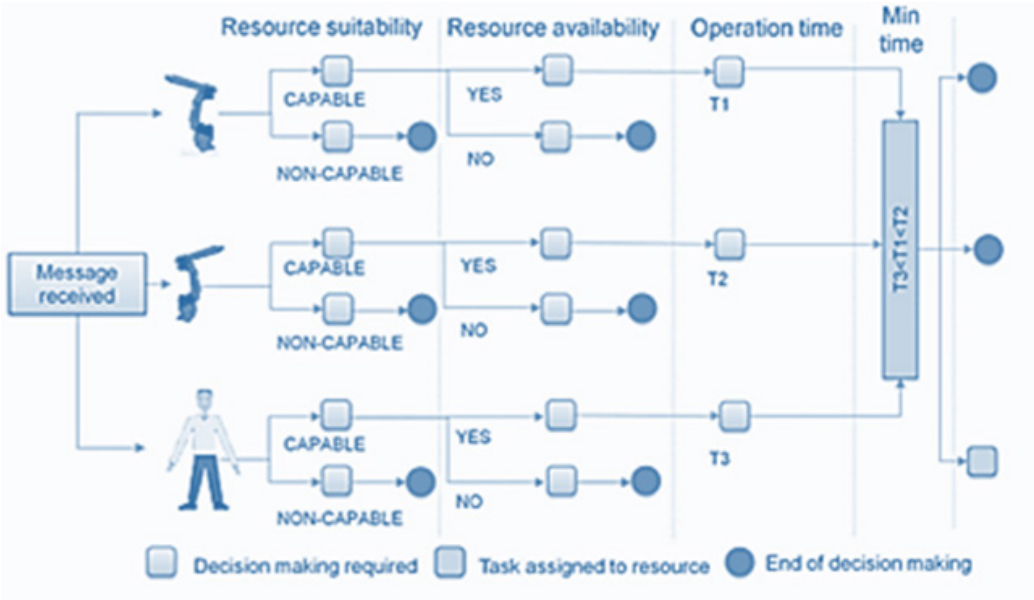


Figure 1: Task division based on executing time (Tsarouchi et. All, 2017).

are influenced by the implementation of robots, such as social interaction (Smids et al., 2019). The collaboration of a team including robots will differ from a traditional one and thus impacts the social aspects of the working environment. This also directly has an effect on management, not only because robotisation brings challenges in terms of work planning, but also because of its effect on employees' welfare, challenging the management to keep work at satisfactory levels.

As stated before, implementing robots into a workflow causes work to change. Nevertheless, implementing robots is getting more common, as they can optimise the workflow. As with many technologies, at the start, robots were expensive and thus could only be used in exceptional cases. However, through the innovation of robots, they are becoming more accessible to all organisations. Nevertheless, robots are not so far developed that they can take over entire jobs and thus, a combination of robots and humans should be used in the working environment. New technology also causes a lot of unknowns, thus raising a lot of questions; What can robots exactly do? Which tasks can they execute and which not? What happens to the employees who are currently executing the tasks? How can we best make use of the robot?

Research tries to answer these questions by looking at the characteristics of both robots and humans. Humans are, until today, still better at executing tasks that require cognitive skills, such as decision making, planning or the ability to adapt to a changing context. On the other hand, robots are better at executing tasks that require physical skills (Smids et al., 2019). Thus, another way to divide human and robot tasks, is by determining if a task requires cognitive or physical skills. However, as with the other approach, this one also causes some problems. For example, if a certain job consists of 90% physical work, there is not much work left for the employees and poses the threat of taking over employees' jobs. On the other hand, if 90% of the tasks require cognitive skills, the implementation of a robot may not be economically viable. Also, what happens to the tasks that require both physical and cognitive skills?

The value of human-robot collaboration

Conclusively, approaching the implementation of robots from a human-centric stance can still negatively impact the work of employees. The reason being that the human's work can become boring and mentally exhausting, as the human's task has been limited and streamlined.

Accordingly, the current view on a human-robot collaboration needs to be changed. The latest effective interpretation of a human-robot collaboration is that humans and robots ought to work together in the same workplace, rather than merely next to each other (see figure 2). To realise this collaboration, cobots are introduced into the market.

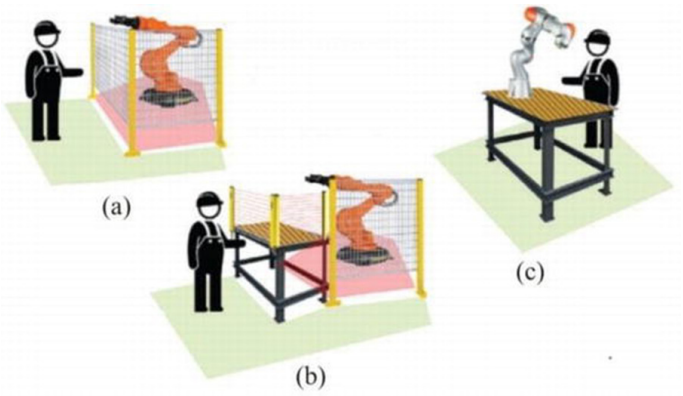


Figure 2: The changing human-robot collaboration (Vysocky & Novak, 2016).

A cobot is a collaborative robot, that responds to the presence of a human in the workspace. Besides, they can be controlled by a human hand instead of a computer. Using cobots, provides the industry with new opportunities. Instead of a robot taking over a task, they can now work together with humans in order to execute a task. However, the implementation of cobots comes with some challenges as well. The implementation of cobots brings cost with it, and thus it should contribute to the optimisation of the workflow (a faster process, decreasing cost, etc.), in order for the benefits to outweigh the costs. For example, if cobots are only implemented to make employees' work better, it does not automatically have a positive effect on the efficiency of the workflow. Besides, implementing cobots could still cause work to become boring or exhausting. For example, if the only task of the human is to control the cobot by hand, but all data is processed automatically, the human could still experience their work as boring or exhausting.

1.2 The foundation of FRAIM

As with many new innovations and technologies, there is not much known about how to implement and use them optimally. That's why there is a need to research the technology in the actual context of use. In this way, it can be determined what the problem is and what opportunities there are to solve this problem.
Robohouse is an organisation that researches robots and cobots in the work space, trying to create vibrant and attractive workspaces (RoboHouse, 2022). As they acknowledge the current problems of robotisation, a new subsidiary is founded called FRAIM. FRAIM focuses on the creation of a meaningful human-robot collaboration, by researching the technology of cobots in a practical context.

Brightsky

To research meaningful human-robot collaboration in a practical context, FRAIM joined the Brightsky project. This is a project initiated by the Dutch government, gathering organisations and financing them to execute research on automating the aviation industry, making it more sustainable. The focus lies on the maintenance, repair & overhaul, airport security and airport system (AmsterdamLogistics, 2021). Logically, this research is done for and at KLM Engineering and Maintenance, which is part of the largest Dutch airline company. Here, the biggest gains can be made. At this department, aircraft from internal and external clients are repaired and maintained. This project is a good opportunity for FRAIM to research meaningful human-robot collaboration in a practical context. However, the project also comes with its challenges. The Brightsky project shows that many stakeholders are involved in the creation of a human-robot collaboration. Robots should serve not only the employees' needs but also the needs of other stakeholders involved, such as the organisation and the government. Thus not only the feasibility of the technology should be taken into account, but also the other stakeholders' needs and values.

1.3 The design objective

The challenge that FRAIM faces is a complex one. That's why a design approach can help solve it. As this project involves different stakeholders, including the employees of KLM E&M, a human-centered design approach will be used. In human-centered design, technological possibilities are combined with human and business needs and resources (see figure 3) (Giacomin, 2014). This corresponds well with the challenge FRAIM is facing. In the context of automating the process of KLM Engineering and Maintenance, there is a need to combine both the organisation's interest, the possibilities of robots and cobots and the employees' need for meaningful work. If the final design takes all three into account, the design is desirable, because it meets the needs of the employees, feasible, because it is clear what robots can and need to do and viable, because the organisation has the resources and motivation to innovate.

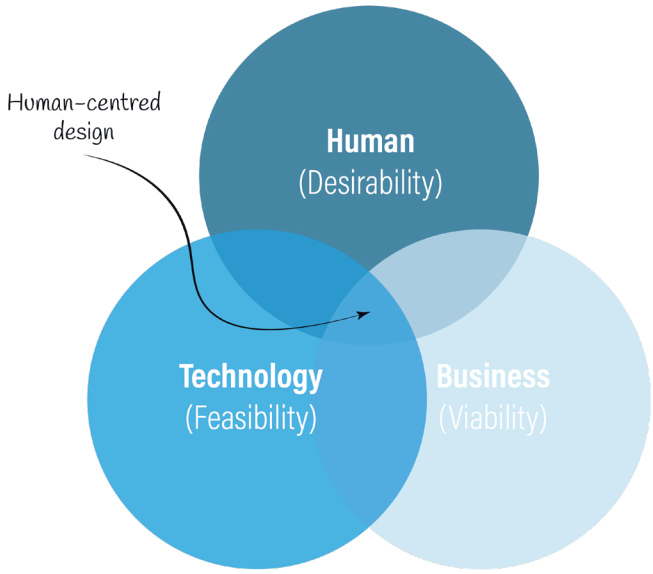


Figure 3: Factors of the human-centered design approach

Before the design can be created, The stakeholder's values are essential to take into consideration, as they are the conditions for effective implementation of robots.
With a human-centered design approach, the stakeholders are involved from the early stage.

At first, research can be done to get a good understanding of the stakeholders' needs to identify the right problem. In the design phase, stakeholders can be involved in solving the problem right.

1.4 Research questions

In order to solve the problems of robot and human collaboration in the workspace, one has to answer the relevant queries that present themselves
.
The main question to be solved is:

How can we help FRAIM & KLM Engines to implement robots within the parameters of the stakeholders' values?

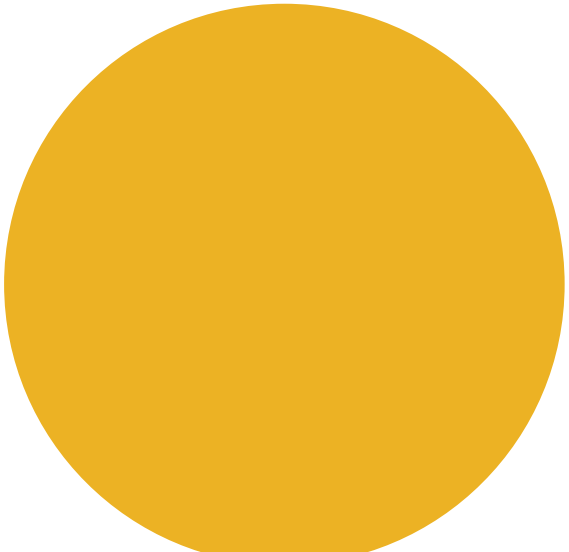
This research question is divided into several sub-questions. The sub-questions consist of both research and design questions.

Research

1. Who are the different stakeholders involved in the implementation of robots into the process of KLM Engines?
2. What are the stakeholders' intentions with the implementation of robots into the process of KLM Engines?
3. What is the shared vision of why to implement robots into the workflow?
4. What does the workflow of KLM Engines look like?
5. What makes the current work of KLM Engines' employees meaningful?

Design

6. How can a co-design tool help to explore the possible scenarios of how to robotize the workflow?
7. How can a co-design tool help to understand the consequences on the meaningfulness of work and the stakeholders' intentions?
8. How can a co-design tool help make a decision on which scenario fits best with KLM Engines?



1.5 Design process

This project follows the design process of human-centered design visualised in figure 4. The process consists of three phases.

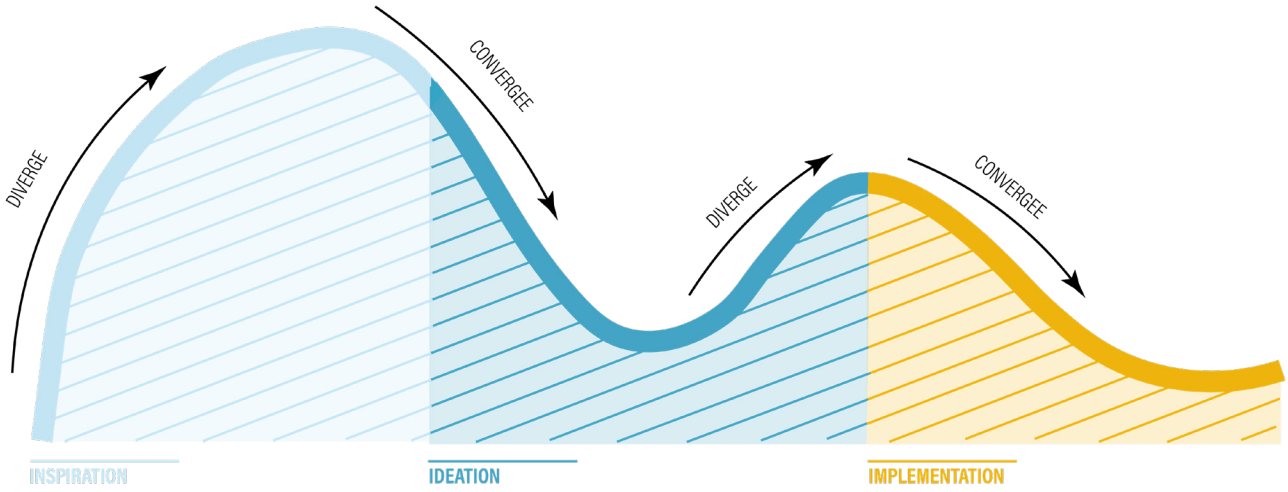


Figure 4: the design process of human-centered design.

Inspiration phase

The main focus of this project is on the fuzzy front end of the design project (see figure 5). At the beginning of the project, there were a lot of unknowns, which made it unclear what would happen in the design phase. In the inspiration phase, the stakeholders are identified and researched in order to discover the right problem to solve. In this phase, ethnographic research is used to immerse in the context of the stakeholders. Ethnographic research usually goes through certain phases (Sangasubana, 2014). Firstly, the natural context is observed and interviews are held to understand the knowledge and skills of different stakeholders. Afterwards, co-creation and context mapping is used to understand the stakeholders' needs and intentions. At the end of the inspiration phase, the problem is identified.

Ideation phase

After defining the problem, a design goal can be formulated. This describes the challenge of solving the problem right. In the ideation phase, the co-design tool is designed. This is done through several brainstorm sessions and iterations. In this phase, the design decisions are explained. At the end, a full concept of the co-design tool is presented.

Implementation phase

In the implementation phase, the co-design tool was tested in order to find out how the tool would be used in the actual context. Afterwards, an iteration was done on the tool to make sure the tool could be used in the intended context to reach the intended goal.

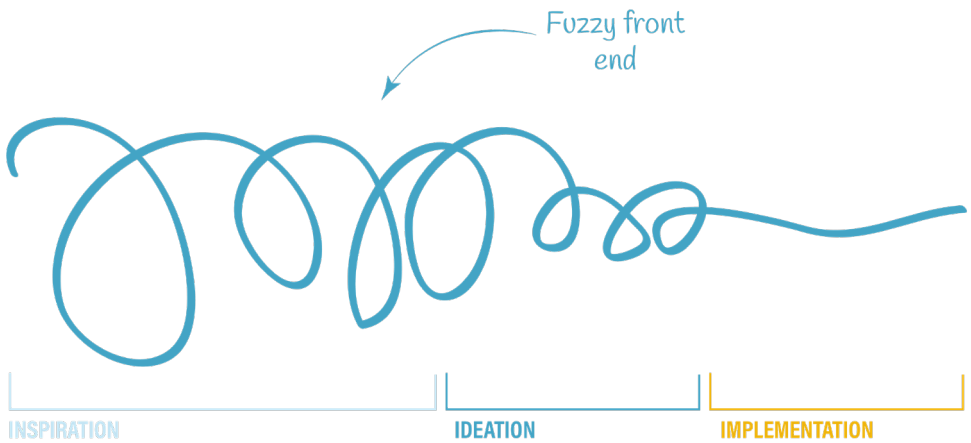


Figure 5: an illustration of the fuzzy-front end

1.6 Set-up of the project

Section 1: Ethnographic research to answer the sub-research questions.

In section 1, ethnographic research is used to answer the sub-research questions. In chapter 2, through literature research, observations and an interview, the stakeholders involved in KLM Engineering and Maintenance are identified. The most important stakeholders are gathered to discover the stakeholders' intentions and to co-create a shared vision. This is reported in chapter 3. In chapter 4, the concept of meaningful work is introduced. Afterwards, through context mapping, the themes making meaningful work at KLM Engines are identified. To be able to identify these themes, the workflow of KLM Engines inspection is mapped out.

Section 2: Defining the design goal

As stated before, this project has a fuzzy front end. The actual problem is discovered after research is conducted. In this section, all research insights are put together in order to formulate a design goal (chapter 5). This design goal is used as a base for the design phase.

Section 3: Creating the co-design tool

In this section, the co-design for KLM Engines is created. In chapter 6, the design requirements are set and a conclusion of the research is done. In chapter 7, the ideation towards the co-design is described. This is done by analysing existing co-design tools & games and brainstorming. Chapter 8, describes and explains the chosen concept.

Section 4: Performing the co-design tool

In this section, the co-design tool is tested with the most important stakeholders identified in chapter 2. This test is done to evaluate how the co-design will work in the actual context (chapter 9). The results of this test are used to make an iteration of the co-design tool (chapter 10).

Section 5: Evaluating the project

In the last section, the project is evaluated. In chapter 11, a conclusion of the project is given, evaluating if the research questions are answered and the design goal is achieved. In chapter 12, the project itself is evaluated and future research and design recommendations are explained. Chapter 13 contains a personal reflection, in which the learning objectives are discussed

Conclusion

This introduction discusses the evolution of robots in the industry and its inherent challenges. As robots are causing jobs to change in an often negative way for employees, a new kind of robot has been introduced, called cobots. As cobots can collaborate with humans in the same working space, they offer many new opportunities. However, as with every new technology, this raises many questions. To answer these questions, the focus should not only lie on the technology but also on the stakeholders involved in its implementation, including the employees using the robots. A human-centered design approach is an excellent way to tackle this challenge, as this combines technology (feasibility) with human (desirability) and business (viability) needs and capabilities. This approach is used in the research and design part of this project. Using the human-centered design approach facilitates the incorporation of the most crucial stakeholders' values.

Section 1

Ethnographic research

Through ethnographic research, the sub-research questions are answered. In chapter 2, the question *"who are the different stakeholders involved in the implementation of robots into the process of KLM Engines?"* is answered. Through an interview and stakeholder mapping, the essential stakeholders are identified. In chapter 3, a co-creation session is discussed, which answers the following research questions; *"what are the stakeholders' intentions with the implementation of robots into the process of KLM Engines?"* & *"What is the shared vision of why to implement robots into the workflow?"* In chapter 4, the context mapping sessions are discussed in order to answer the last two research questions; *"what does the workflow of KLM Engines look like?"* & *"what makes the current work of KLM Engines' employees meaningful?".*

Chapter 2
Stakeholder analysis

In this chapter, the stakeholders involved in the implementation of robots at KLM Engines are identified through an expert interview (see appendix A) and literature research. Afterwards, a stakeholder map is made to determine the essential stakeholders. The essential stakeholders have high power or/and interest in the implementation of robots and thus contribute to the success of the workflow development. The stakeholders are gathered to create a shared vision of what it means to 'optimise' the workflow (described in chapter 3). In this way, the essential stakeholders keep engaged and satisfied.

2.1 Identifying stakeholders

Through literature research and an expert interview with the continuous innovation lead of KLM Engines, the stakeholders involved in the implementation of robots are identified. In Figure 6, a overview of these stakeholders is visualised and their relationships are represented by the arrows.

The stakeholders can be divided into three groups:

- Stakeholders within K LM Engineering & Maintenance (KLM E&M),
- Stakeholders within KLM group (but outside the KLM Engineering & Maintenance) department)
- Stakeholders outside of KLM.

Stakeholders within KLM Engineering & Maintenance

To scope down this project, it has been chosen to focus on the Engines department of KLM E&M. As seen in figure 6, KLM Engines is part of the KLM E&M, together with two other departments KLM Components and KLM Airframe.

The employees of KLM Engines are also presented in the system map, as this project focuses on meaningful work of them. The employees are highly concerned about what happens to their work, but don't have much power over decisions made.

KLM E&M is on top of the three departments and involved in the decision-making process. The executive vice president of KLM E&M is the topman of KLM E&M and determines where money can be spent and thus has high power and interest.

Stakeholders within KLM group

KLM E&M is a part of KLM, which is a part of the KLM group. The KLM Group consists of KLM, Air France KLM (AF KLM) and Air France (AF).

These three are all independent organisations, but they keep each other informed. If one of the organisations has innovated successfully, the others can take over the innovation easily.

Besides, KLM Engines repairs KLM's own Engines. This does not necessarily make a profit. However, it decreases costs, as the repairs don't have to be outsourced. These internal clients are interested in the KLM's innovations, as this will hopefully improve or accelerate the repair.

Stakeholders outside of KLM

Besides, internal KLM Engines also has external clients. In contrary to the internal clients, they do pay money to KLM Engines to finish the order. This means that they also demand the Engine to be done in a certain time. The external clients thus have more power than the internal ones, as they can easily switch to another repair service.

As stated before the employees don't have much power in the decision making of KLM. That's why they are represented by the unions, to make sure the working conditions are met.

To innovate, KLM needs funding. The government helps them with this, however, they set conditions for the innovations. The government demands KLM to become more sustainable, because they want to make the Dutch aviation industry more sustainable (NOS, 2020).

Although KLM Engines tries to repair as many components as possible, it often happens a component is unrepairable. In this case, KLM Engines has to order new components from external suppliers. KLM Engines is currently highly dependent on these external suppliers, as there are strict rules amongst the Engines and only the actual brand can be used.

The Engines end up in the aircraft, which are used by the passengers to transport themselves from A to B. KLM is known to be a bit more expensive than its competitors, but therefore provides the user with excellent service. This means the user is also expecting this in the future, including a safe aircraft.

KLM E&M sees a need for innovation in order to keep up with its competitors in the future. That's why they involve external parties to come up with new ways to innovate. One of these parties

is FRAIM. As explained in the introduction, FRAIM is a subsidiary from Robohouse., which provideds FRAIM with an expertise in robotisation. FRAIM will analyse the current situation at KLM E&M and advice the department on how to implement robots into the current process. As FRAIM is the expert in robotisation, they have the knowledge on how and where to implement the robots.

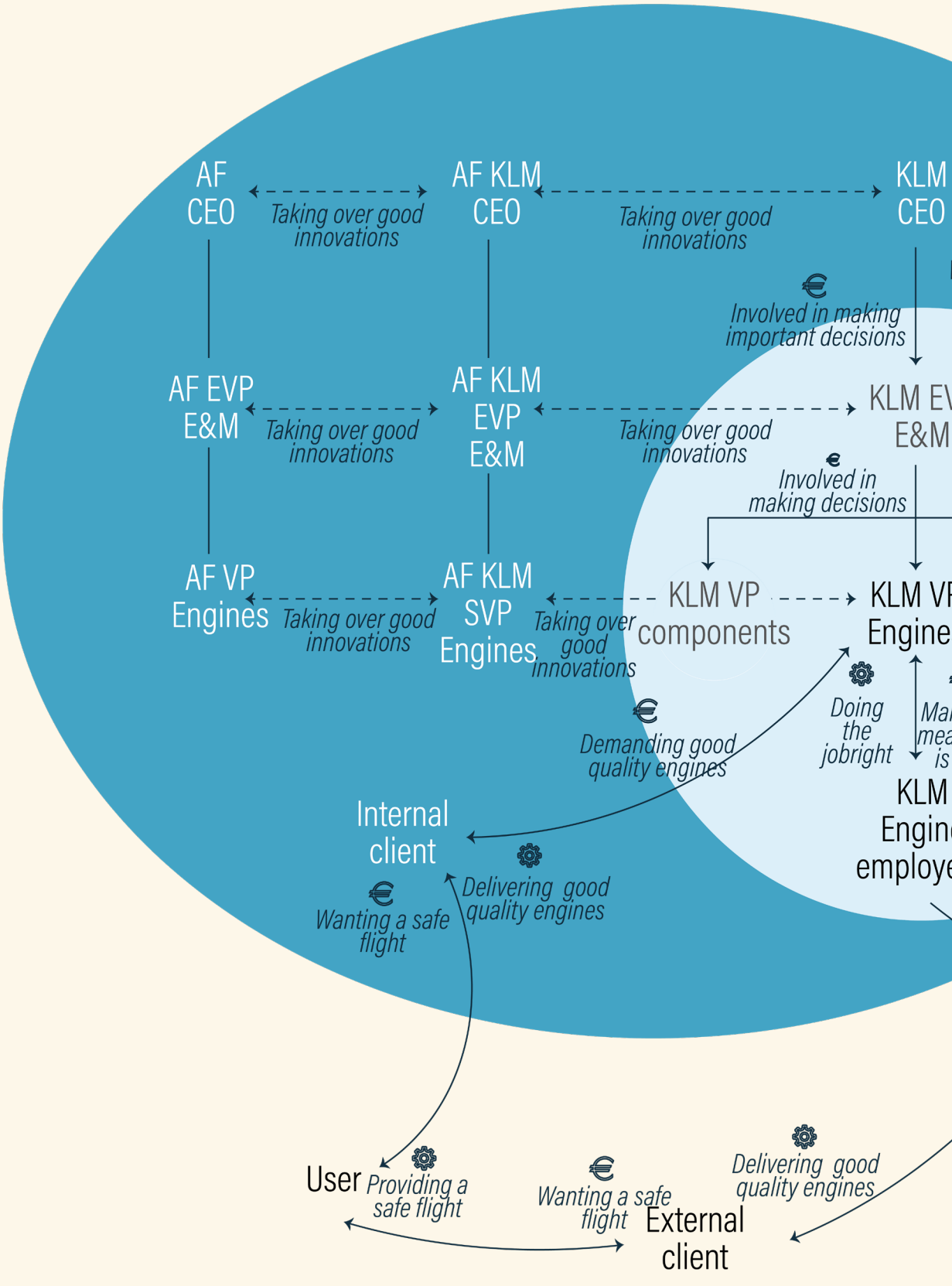
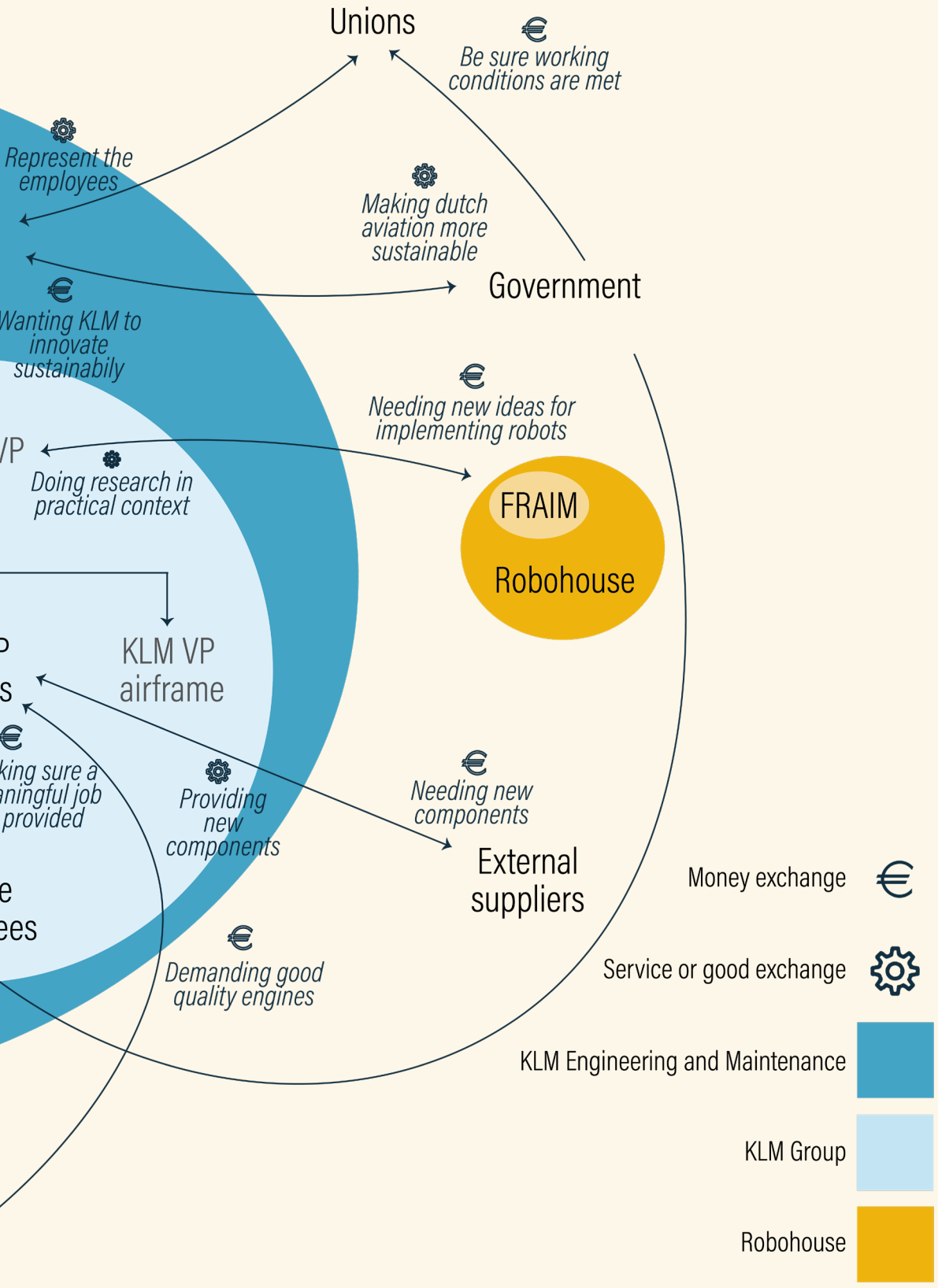


Figure 6: An overview of the stakeholders involved in robotising KLM Engines' workflow


Unions
Be sure working conditions are met
Represent the employees
Making dutch aviation more sustainable
Government
Wanting KLM to innovate sustainabily
Needing new ideas for implementing robots
VP
Doing research in practical context
FRAIM
Robohouse
KLM VP airframe
king sure a aningful job provided
Providing new components
Needing new components
External suppliers
ees
Demanding good quality engines
Money exchange
Service or good exchange
KLM Engineering and Maintenance
KLM Group
Robohouse

2.2 Stakeholder map

In order to determine which stakeholders are the most important in the implementation of robots, a stakeholder map can be used (Figure 7 (Newcombe, 2003)

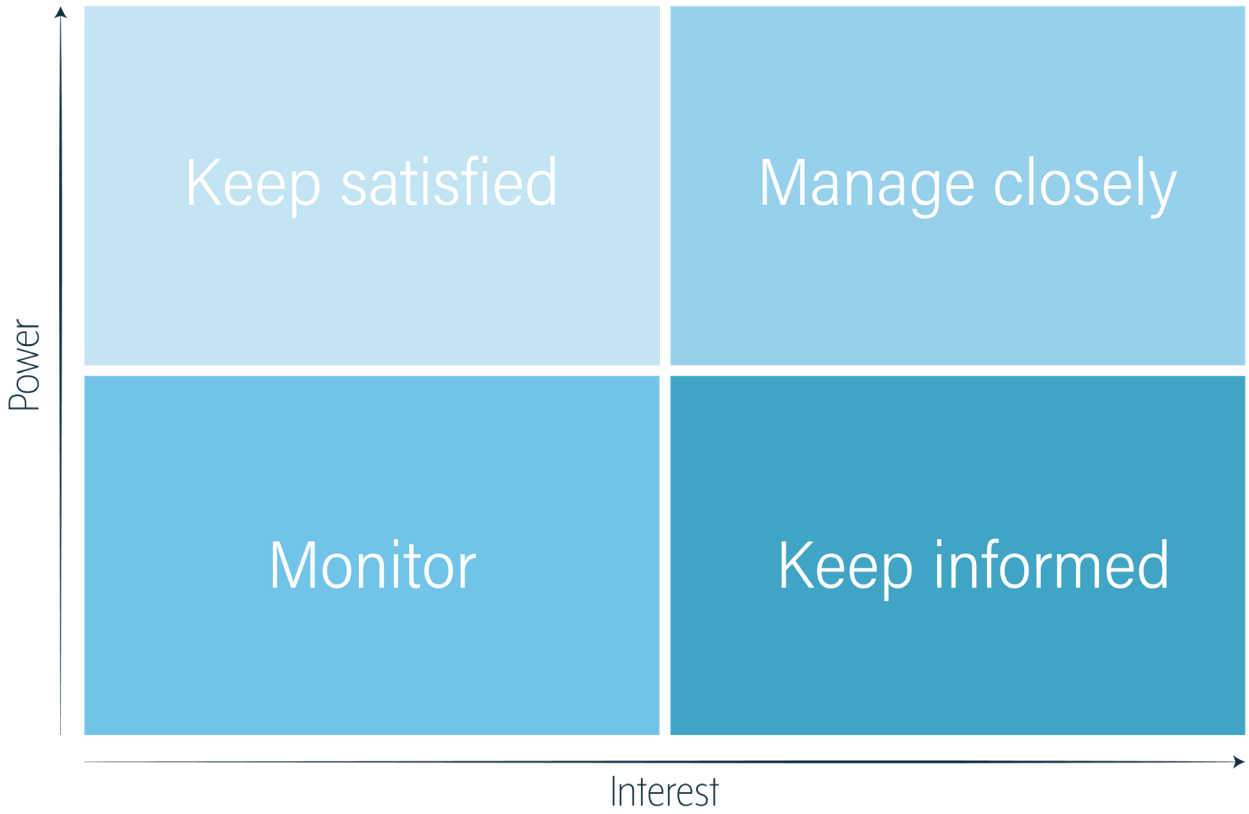


Figure 7: stakeholder map

Through a stakeholder map, stakeholders can be divided into 4 categories.

1. Stakeholders with low interest and low power only have to be monitored. These stakeholders are not in the position to make important decisions and are also not that concerned with the decisions made.
2. Stakeholders with high interest and low power have to be kept informed. These stakeholders don't have the power to make decisions but are highly concerned with the decision.
3. Stakeholders with low interest and high power have to be kept satisfied. These stakeholders have the power to make decisions. If the stakeholder does not agree with the decision made, they may use their power to make a change. However, they are not that concerned with the decision and will only act with important decisions or if they are strongly disagreeing.
4. The stakeholders with high interest and high power have to be managed closely. These stakeholders can be seen as the most important stakeholders. These stakeholders both have the power to make decisions and are concerned with the decisions made. It is wise to involve these stakeholders in making big decisions. In this project, it is important to involve stakeholders from the categories; keep satisfied, manage closely and keep informed.

Normally, the stakeholders to manage closely are automatically involved, but the stakeholders from the other categories are often forgotten. However, this can lead to dissatisfaction, distrust or the loss of support and resources.

Figure 8: Stakeholder map of the stakeholders involved in robotising KLM Engines' workflow

All internal and external stakeholders are placed on the stakeholder map (see figure 8). How the stakeholders from outside the KLM E&M department are placed on this map is explained in the previous section.

The essential stakeholders' interest

The stakeholders all have different reasons why they would like robots to be implemented into the process.

The government initiated the Brightsky project and finances the research on the implementation of robots into KLM overhaul & maintenance, is interested in making the national aviation organisation more sustainable. The European Union (EU) decided that each country has to set goals to become more sustainable. The government aims to become CO2 neutral in 2050, reduce the use of fossil fuels and reduce nitrogen emissions (Ministerie van Algemene Zaken, 2022). The government hopes the Brightsky project can help to contribute to reaching these goals. The focus will mainly lie in the repair and overhaul of aircraft. The government sees opportunities to repair more components; in this way, fewer components have to be made from raw materials and fewer components end up as scrap. Another opportunity that has been seen is finding new purposes for components that cannot be repaired anymore (but this is seen as less relevant in the implementation of robots (AmsterdamLogistics 2021).

The KLM group is most interested in keeping up with their competitors by making more profit or reducing costs. KLM Engines' biggest competitors are the Original equipment manufacturers (OEMs). They are the ones who make the original Engines and all their components and also determine the allowed margins. Next to that, the OEMs have a repair service themselves as well. These OEMs have high advanced machines and are usually the first ones who make use of new technologies. KLM Engines is currently highly dependent on the OEMs, because they need to meet the required margins and they have to order new components if the old ones turn out to be unrepairable. That's why KLM Engines sees a need to innovate its

process. Their first thought is that this can be done by repairing more components themselves by using better techniques. In this way, they are less dependent on the OEMs, because they need fewer new components. Next to that, the process will become faster, as the delivery time of new components always causes a delay in the entire workflow. As a result, more repairs can be done and the relationship with customers becomes better. As a side result, the process becomes more sustainable, which is good for the companies' image and prepares for the upcoming regulations the government will most definitely come up with in the future. KLM Engines also acknowledge that they need their employees. First of all, a strength of KLM Engines is the years of expertise they have not only in repair and maintenance but also in the general aviation industry. This expertise, knowledge and skills are mainly stored in employees' heads. Next to that, the process of KLM Engines is quite complex, with many different tasks for which a lot of different skills are needed and thus, a combination of humans and robots is needed to execute all tasks. KLM acknowledges that they should capture the expertise by providing their employees with satisfying work.

KLM Engines' Employees are mostly interested in keeping meaningful and satisfying work. What meaningful work is will be discussed in chapter 4. Their biggest concern is how robots are affecting their current work. Preferably, the robots will enable the same or even more meaningful work as their current work. They also want to make sure they keep a job and get paid.

The unions represent the employees and thus have the same interest as the employees. They are mainly interested in the working conditions. If a change in working conditions is made, the unions will represent the employees and make sure this is not happening without good arguments or communication.

Conclusion

Through this stakeholder analysis, three crucial stakeholders are identified. The first stakeholder is the KLM group at the management level, which is interested in staying relevant in the market by offering exemplary service, increasing profit, and decreasing costs. The second stakeholder is the government which is interested in making the Dutch aviation industry more sustainable. The third stakeholders are the employees, who are affected most by the implementation of robots and are interested in maintaining meaningful work. These stakeholders all have different interests in the implementation of robots. The similarities and contradictions in these intentions must be identified to create a shared vision. In this way, all stakeholders' values in 'optimising' the workflow are considered.

Chapter 3
Creating a shared vision

In this chapter, the essential stakeholders (identified in chapter 2) are gathered to discover their intentions for implementing robots. The intentions consist of some contradictions and similarities. They are combined into a shared vision during the co-creation session. This shared vision represents the stakeholders' values and is used in the design of the co-creation tool, to make sure these values are met.

3.1 Approach

In the previous chapter, it became clear that several stakeholders have interest and power in the implementation of robots. In order to determine why robots will be implemented in the workflow, a shared vision should be created. This ensures all important stakeholders are involved and satisfied.

This shared vision will be created through co-creation. Co-creation can be defined as the collaborative development of new value (Galvagno & Dalli, 2014). This means several people are working together to create new value in the form of concepts, solutions, services etc. In this case, the co-creation is done with several stakeholders of KLM E&M to create a shared vision for the implementation of robots. Co-creation can provide new perspectives and insights. The participants are all experts with their own experiences and intentions. In this way, assumptions are replaced by actual insights. Besides, co-creation involves the participants in the design process. As a result, the participants feel more engaged, because their ideas and feedback are used in the end design. Next to that, by involving several stakeholders, the end product or service will more likely be accepted by them (Galvagno & Dalli, 2014).

The co-creation session tries to answer the following research questions.

What are the different stakeholder intentions for the implementation of robots?

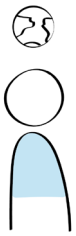
What is the shared vision for the implementation of robots?

Procedure

Participants

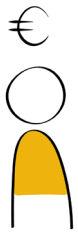
Four participants were asked to join the co-creation session. These participants were chosen carefully in order to represent the most important stakeholders, identified in chapter 2. Involving these stakeholders, ensures the stakeholders' values are taken into account.

The director of innovation is part of the Brightsky project and thus has a lot of knowledge about the different stakeholders involved and the requirements of the project. This participant can represent stakeholders that aren't participating in the session (for example, the government)



The Team Leader of Repair Development focuses on the improvement of the repairing process. For this participant, the focus lies on the optimalisation of the process in terms of efficiency and sustainability. The participants acknowledge that KLM has its responsibility to make the aviation industry more sustainable and their need to improve its position in the market.

The continuous Improvement Lead is mainly focused on representing the employees within KLM Engines and provide them with everything they need. He is the middleman between decision makers and employees.



The VP Engine Services is the topman of KLM Engines and is mainly focused on the improvement of the process to make more profit or reduce the costs. This participant KLM to keep a good market position in the future.

Method

The co-creation session has to be facilitated by a facilitator in order to reach the participants potential and motivate them to be creative. This is done with a creative facilitation method. With creative facilitation, the double diamond method can be used to guide the participant through the session (Cruickshank & Evans, 2012). As this session is done in the research phase of the project, only the first three steps of the double

diamond method are used; discover, define and develop. During these phases, the participants used different design techniques (see figure 9). These techniques are used to stimulate the participants to first think broadly and out of the box and secondly, choose a direction together in order to create a shared vision. Lastly, the participants have used brainstorming to come up with some first ideas on how to achieve this shared vision.

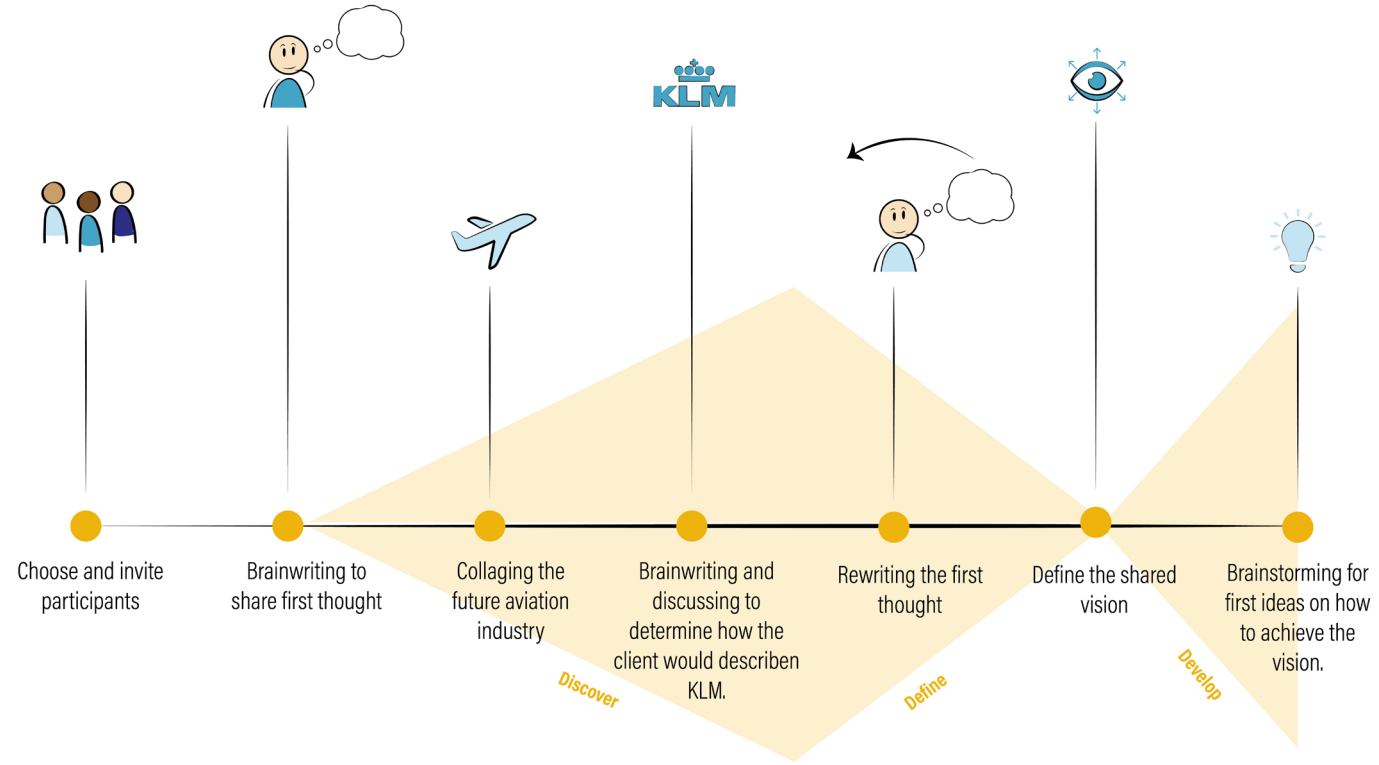


Figure 9: Research approach of context mapping session

3.2 Findings

Figure 10: The participants during the co-creation session

Different visions

The participants were asked to share their personal visions. After executing several exercises (Appendix C), the participants were asked to revise this vision and re-create it. These recreated visions are illustrated in figure 11.

In these visions, there are some similarities and some contradictions.

Similarities: all four participants recognized that the future process should be more sustainable. One participant, because they cared about the planet and thought there wasn't enough attention on this aspect. Another participant, because they assumed more and more regulations would be made by the government and that sustainability is going to be a must in the future. Next to that, all participants think technology and automation should play a role in the optimisation of the process.

Contradictions: Two out of four participants think that technology should be implemented as much as possible in order to optimise the process. On the other hand, for the other two, a careful

balance should be designed and the focus should not lie on quantity, but on quality.

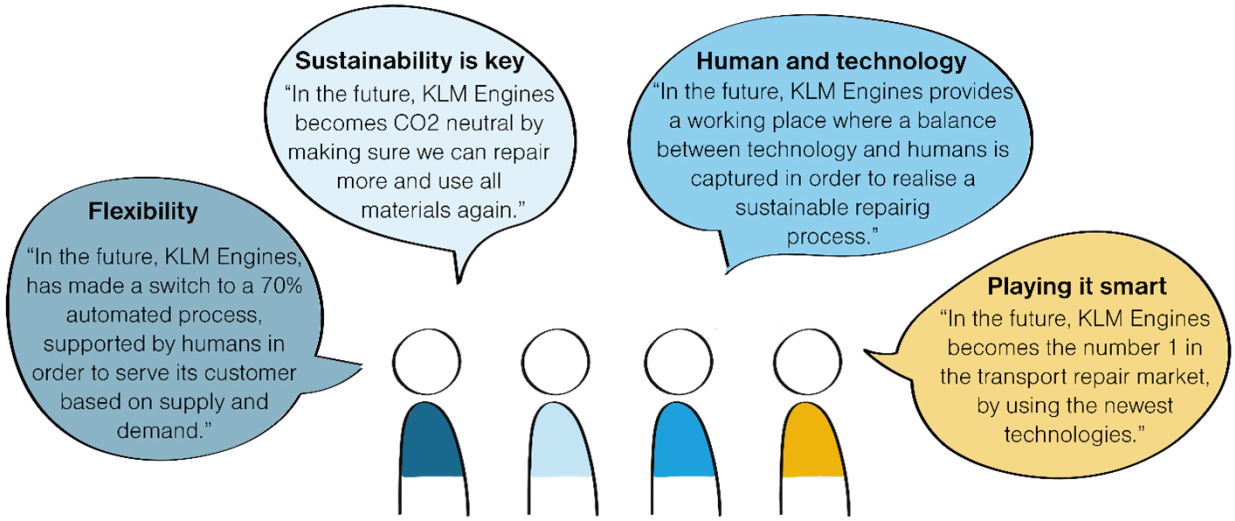


Figure 11: The participants' individual future visions

Shared vision

After sharing their own vision, the participants were asked to create a shared vision. The participants were asked to think about the future aviation industry and about the potential value customers would look for. In this way, the participants are able to immerse themselves in a future world. As a result, it is easier for the participants to discuss what KLM Engines should become to be relevant in this future world. By looking at the similarities and contradictions of the individual visions, the participants were able to discuss what should be included and excluded in the shared vision. The result is illustrated in figure 12.

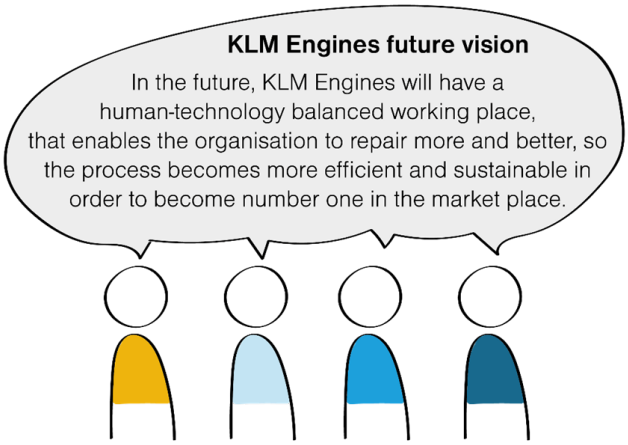


Figure 12: Shared vision as a result of the co-creation session

The shared vision created by the participant is:

"In the future, KLM Engines will have a human-technology balanced workplace that enables the organisation to repair more and better, so the process becomes more efficient and sustainable in order to become number one in the market place.'

The important factors that the participants wanted to be included in the vision are; a balance between technology & human skills & knowledge and the intention to repair more, so the process could both be more efficient (due to decreasing costs and execution time) and more sustainable (due to fewer components being thrown away and thus less raw materials have to be used).

Implementing robots

As stated before, the participants brainstormed to come up with first ideas on how robots could be implemented to achieve the shared vision. During this brainstorming, it became clear that there is a lack of knowledge on the possibilities and limitations of robots, let alone of cobots. The participants only are aware of the industrial robots (see appendix D for an overview of these robots), as they are currently used. These robots are static machines that can not be used in the same workplace as the employees. In the participants' view, implementing robots still means that either the robot or the employee executes the task.

Conclusion

The created shared vision shows an overview of the stakeholder's values. Achieving this vision ensures the crucial stakeholders will be satisfied with this way of 'optimising' the workflow. However, this co-creation session also shows that stakeholders are very focused on their own values and needs, unaware of others. This is partly caused by a lack of knowledge (not knowing why and which other stakeholders to involve) and partly a lack of skills (not knowing how to involve other stakeholders). That's why an organisation often chooses to 'optimise' the workflow by trying to accelerate it. Hereby only focussing on their own values and needs. As explained in the introduction, this comes with its challenges. Regarding robots, the participants are unaware of the new possibilities and limitations robots and cobots nowadays present. This prevents the participants from thinking beyond the well-known industrial robots, causing opportunities to be missed.

Chapter 4
Meaningful work at KLM Engines

In chapter 2, the stakeholders involved in the implementation of robots are identified. A stakeholder that is often not taken into account with implementing new technology is the employee. However, implementing robots mainly affects their work. It is thus essential to research this stakeholder's intention more thoroughly, as little is known about it. Literature and participatory research are done to discover what makes work meaningful for the employees of KLM Engines. Through literature research, a base is set for meaningful work. However, meaningful work depends on the context, the employee and the organisation. Thus, context mapping is used to determine what makes work meaningful at KLM Engines. The insights are translated into 9 themes. These themes are used in the design of the co-design tool.

4.1 Introduction into meaningful work

An organisation's goal is often to accelerate the workflow by implementing robots. As a robot is usually cheaper and faster than humans, it may seem to save a lot of time and costs. However, the implementation of robots is not just an engineering challenge. It also requires a human-centered approach to avoid encumbering additional intangible costs such as stress, frustrations and loss of talent (Welfare & all., 2019). Research has proven that meaningfulness of work and job satisfaction are important factors influencing the employee's well-being (Rothausen & Henderson, 2018). To adequately determine the impact of robotisation, it is crucial to understand what makes work worthwhile and meaningful and to consider how robots positively or negatively influence this.

The literature already describes what makes humans' work valuable and meaningful. As Bailey & Madden (2016) state, meaningfulness is, for employees, the most important factor in their work. If work is meaningful, it can motivate the employee and improve their commitment, performance and satisfaction. But what makes work meaningful?
There is much research about the aspects that influence the meaning of work. Here four aspects are described, which are related to the job crafting theory. As Wrzesnieuwski et al. (2013) state, job crafting refers to creating or initiating change to work. To understand what can be changed in work to make it more meaningful, they identified four categories of sources of meaningfulness.

The self

This factor includes personal values, beliefs and motivations (Baily & Madden, 2016) (Rosso et al., 2010). If tasks and interactions correspond with these personal values, beliefs and motivations, employees tend to find work more meaningful. Additionally, Smids et al.(2019) state that human beings need a purpose, which gives us direction in life. People seek activities (including work) that help fulfil this purpose. A purpose is very personal and thus will differ per employee.

The others

Another factor is the people surrounding the employee, including colleagues, family and friends (Rosso et al., 2010). (Wrzesnieuwski et al., 2013). The interaction with colleagues can give a sense of belongingness. People like to be part of a group or community with the same beliefs or values. Besides, recognition from outside parties plays an important role in the meaningfulness of work. If family, friends and society see that work actually adds value to society, it will also be seen as more meaningful by the employee him- or herself (Smids et al., 2019).

The context

The third factor is the context of work, including the organisational mission, the work-specific tasks and also financial and cultural circumstances (Wrzesnieuwski et al., 2013). Here, room for learning new skills and self-development is an important aspect. This often includes overcoming challenges. Besides, overcoming challenges contributes to increasing self-esteem (Rosso et al., 2010). An increased self-esteem will make the employee feel irreplaceable and valuable to the organisation. However, job-crafting itself is also an aspect that makes work more meaningful; this is often also called autonomy (Wrzesnieuwski et al., 2013). People who can be proactive and creative will feel more valuable (Amabile, 1997); accordingly is a desirable trait in the workplace.

The spirituality

The last factor is the search for a "greater good". This could be for example, a religion or god, but also the belief that doing good will make you a better person (Ashmos & Duchon, 2000). This often is related to someone's purpose.

4.2 Meaningful work at KLM Engines

Although literature gives a general overview of the meaningfulness of work, meaningfulness is highly dependent on the employees, the work and the organisation. That's why research is carried out to identify what makes work meaningful for KLM Engines' employees. This is done with the research method, context mapping.

Context mapping

Context mapping is a part of participatory design, a research method in which the user is involved (Spinuzzi, 2005). In context mapping, research is usually done, as the name says, on the context of the user, including the user, the (interactions with) others and the context. Context is referred to all the factors that influence the use of the product. In this way, the researcher gets a better understanding of how the product or service is used in the actual context. In this project, no product will be researched, rather an entire process or a so-called customer journey. Although this may differ from a product, the essence stays the same and the aim of the research is to get to know the context in which employees are operating. Research has been carried out to identify what aspects and how these aspects are influencing the employee within the process. This context is described in three ways in a particular order. First of all, the participant is asked to talk about the current situation, as it is easier to describe a specific situation. After this, the participant is asked to speak about their memories of the past. These memories can be compared to the current situation, which makes it easy for the participants to explain why they think the situation has improved or not and how they feel about this. Lastly, the participants are asked to discuss their future dreams (Visser et al., 2005). After analysing their feelings, it is easier for the participants to think about how they would like the future to be (see figure 14).

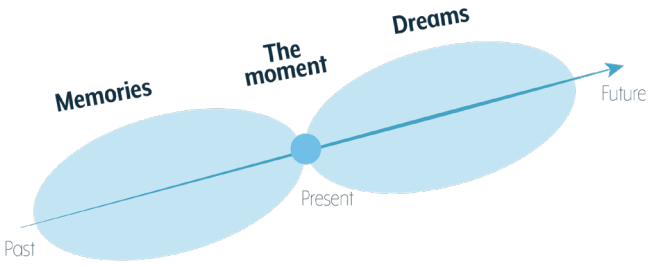


Figure 14: Conext Mapping Method: Connecting Past, Present and Future

Using the context mapping method helps to identify the latent needs, as it helps to dig deeper into people's knowledge. Figure 13 shows that generative tools (of which context mapping is one) concentrate on knowing, feeling and dreaming and, in this way, help the user to talk about latent needs.

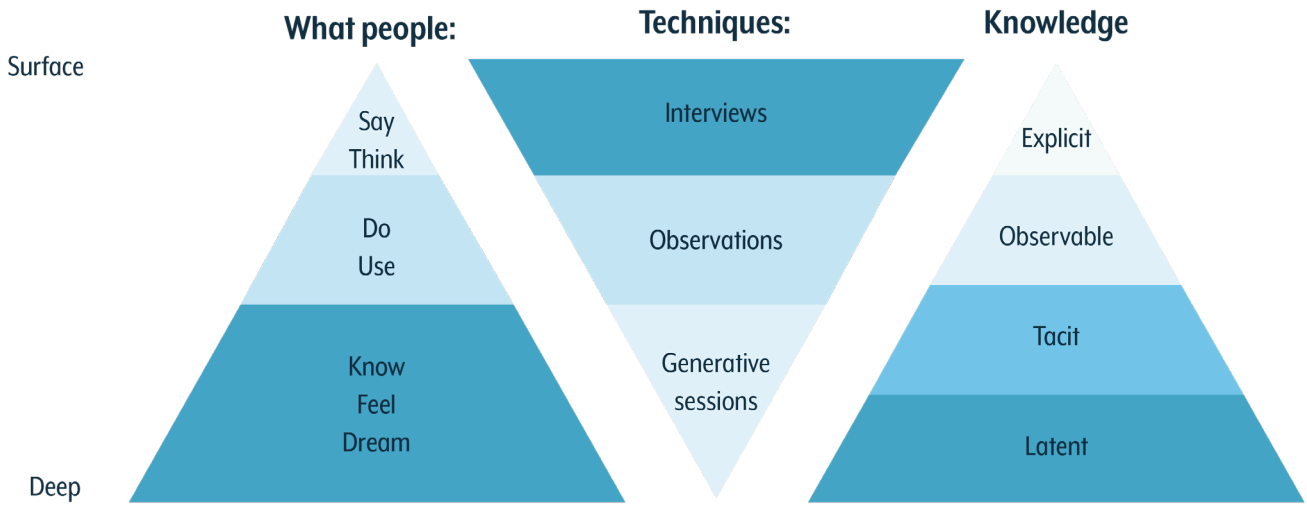


Figure 13: Context Mapping Method: Exploring Deeper Levels of Knowledge

The context mapping session tries to answer the following research questions:

What are the activities of the inspection workflow?

Why do the employees feel like this? What are the underlying motivations?

What emotions do the employees feel during the work day? Why?

What themes can be identified that contribute to the meaningfulness of work?

Procedure

Figure 15: The participants of context mapping session 1

The goal of this research part is to learn more about the employees' work, so the themes that influence the meaningfulness of work can be identified. By implementing robots, the entire workplace is changing, including employees' work. How it changes depends on the way a robot is implemented. To know how a robot should be implemented, an understanding of what aspects makes employees' work meaningful is needed. By looking at the different tasks, interactions and context-specific aspects, research can be done to identify the underlying values, beliefs and motivations. motivations.

Participants

Two context mapping sessions are done. The first session is done with a team of the inspection department, consisting of three employees. This session is done to determine the themes later on in this chapter. After the themes were identified, another session was held with a team from another department to assess if the themes also apply to other employees. This team also consists of three employees.

The session

The context mapping method consists of several steps (see figure 16). The preparing phase consists of all prior research that is needed to conduct the research. In this project, which includes a literature research and a context research, so the current process and stakeholders are identified.

In the second phase, the actual collection of the data is done. This regularly consists of the sensitizing the participants and executing the session itself. With the sensitizing, the participants already dive into the context, so it is easier to talk about it during the actual session. In this project, the sensitizing is done by already talking to the employees about the project in advance, during the first visit to KLM Engines. As the participants are not used at all to work with creative tools,

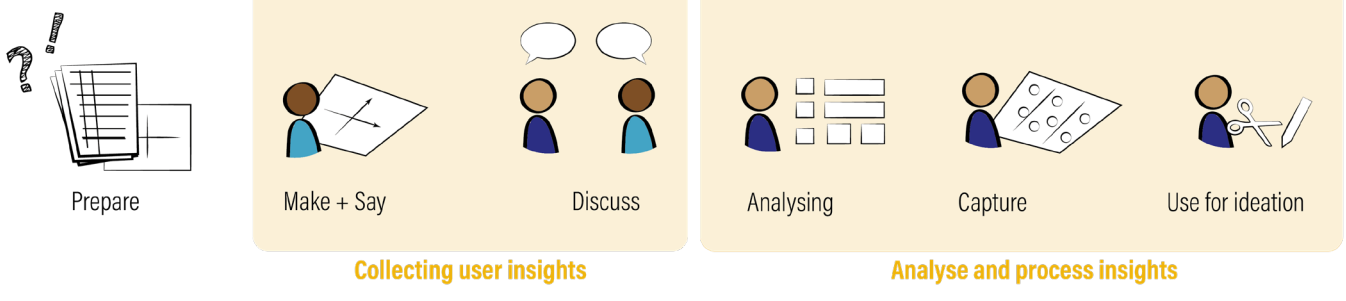


Figure 16: The context mapping session process

they are not asked to do another kind of sensitizing.
During the session, a template (see appendix C) that was filled in together with the participants. The last phase is done without the participants and consists of the analyse of the gathered data, which is reported later in this chapter. At the end, the insights are used for the ideation of solutions.

4.3 Mapping out the workflow

Together with the participants of the context mapping research, the workflow is mapped out in order to both identify which activities contribute to the meaningfulness of work for the employees of KLM Engines and to get a grip on where robots could be implemented (see appendix F for a complete overview). All insights used to create this workflow are gathered from several observations at KLM Engines and a follow-up interview with the continuous innovation lead (see appendix A & B).
If an order comes in, the Engine follows the steps of a predetermined workflow in a particular order. This means one step has to be finished before the Engine can go to the next department. At

Zooming in on the inspection

KLM Engines, each phase of the maintenance process includes a set of activities. A few fixed teams execute each phase. These activities are very different for each department and together form a massive set of activities. To scope down the project, the focus will, from now on, lie on the inspection department of KLM Engines.
The inspection consists of one main activity: measuring. The measuring is done with many different hand tools and the Coordinate-measuring machine (CMM) and is thus divided into "measuring by hand" and "using the CMM machine". The rest of the activities are divided into the "before measuring" stage and the "after measuring" stage. The before measuring stage consists of different preparation activities which need to be done before the measuring can be executed. The after-measuring stage consists of activities which prepare the component for repair. The activities and the order in which they are executed are visualised in figure 25.
Figures 17 & 18 show two examples of measuring activities. Figure 17 shows a hand measuring with a right-angle ruler on a compressor. The visual on the right shows a hand measurement at a fan blade. The employee can feel with the top of the finger if the crack in the component is too big or not. The cracks and margins can be very small and the measuring should be done very precisely.

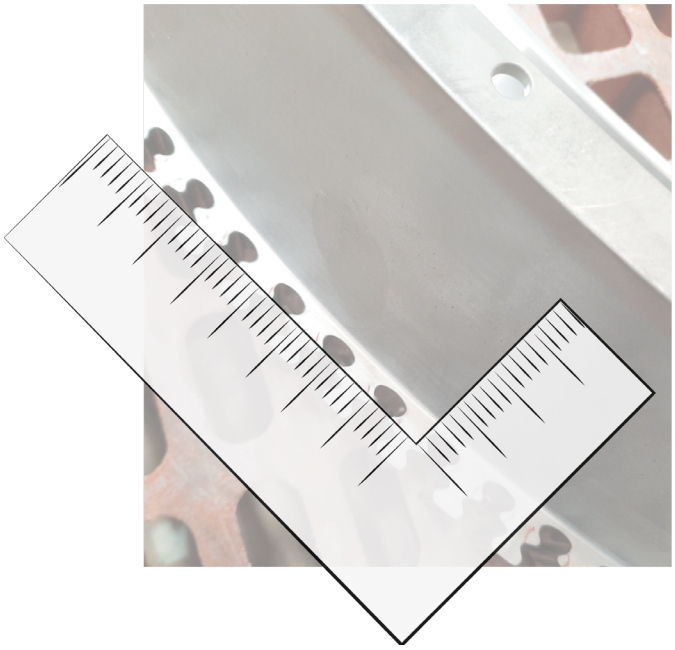


Figure 17: Measuring with a right-angle ruler on a compressor

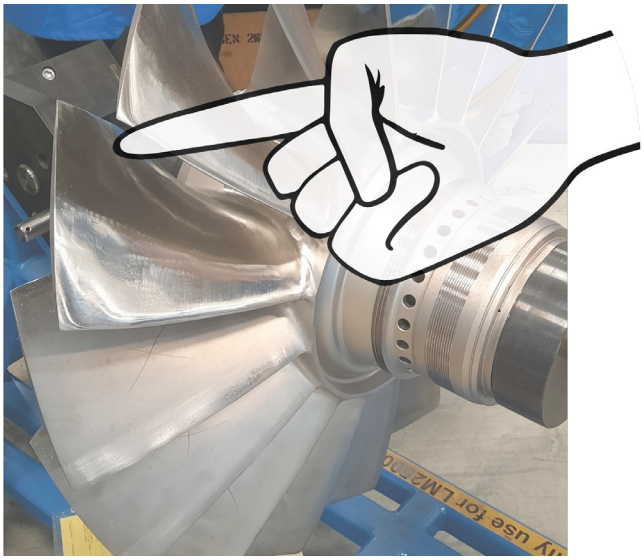


Figure 18: Measuring with the tip of the finger

4.4 Findings

Together with the participants, the activities are analysed to identify the emotions and underlying motivations of the inspection department's employees. The findings are described below and visualised in the "emotions" level of figure 25.

Choosing a component

The employees start each day, by choosing a component to be treated. Due to the number of components, the employees feel confused and frustrated, because they don't know where to start. The employees explain that in the past there was a planning, including day numbers. Then, the process needed to be accelerated and KLM Engines got rid of this planning. However, the effect was the opposite, because the components are now treated in a random order, causing the workflow to delay.

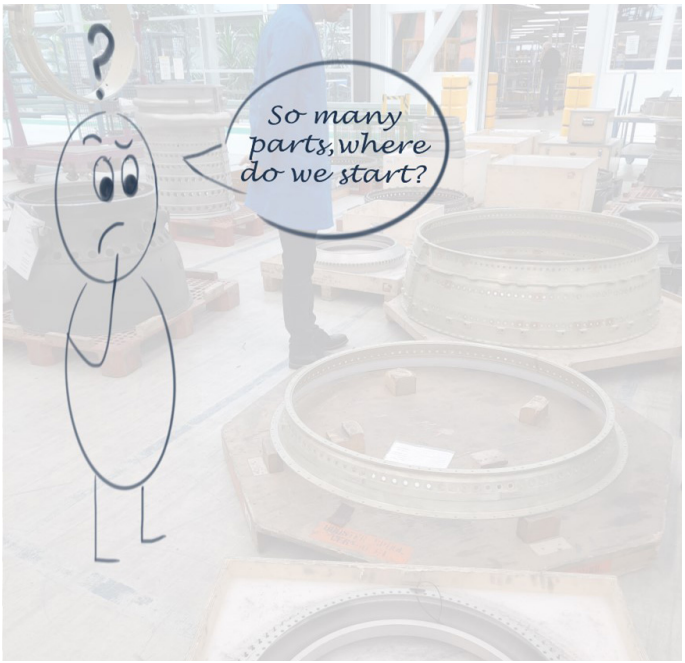


Figure 19: Choosing a component to treat

Reading the instructions

After, choosing a component, the employees have to read the instructions, that can be found on the component. The employees find this very pleasant, as they always know which instructions correspond with the component.

Choosing the right tool

After reading the instructions, the employees choose a tool to treat the component with. This can be a hand tool or a CMM machine. The average age of the employees working at inspection is around 50 years. These employees are already working at KLM Engines for many years. That is why they are very experienced but also used to the way of working. This causes them to have a difficult time adapting to using new technologies. Besides, the employees trust their own skills more than a machine, thus they choose to use hand tools more often. The employees explain that some cracks can only be identified by touching the component with the top of the finger. However, the employees acknowledge that the CMM tool should be used more often, to speed up the process. The employees explained, that one of them always programs the CMM, leaving no room for others. Although most employees prefer hand measurements, they are frustrated that their programming skills now get lost.

Searching the right tool

After the right tool is chosen, it has to be found. Sometimes, the tool lies at the other end of the workplace and the employees have to cross the workplace to get it. This is considered as a useless and time-consuming task. On the other hand, walking through the workplace provides a lot of opportunities to have a chat with colleagues.

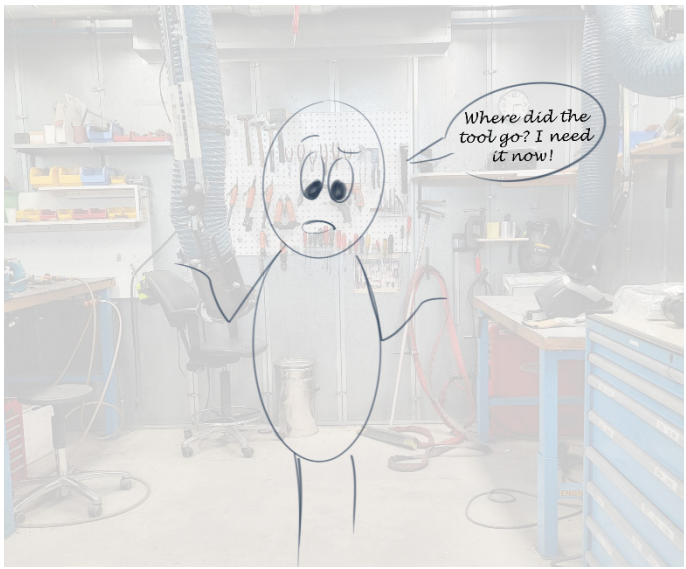


Figure 20: Searching for the right tool

Talking to colleagues

The employees explain that colleagues are the ones who make the work fun and pleasant. The employees find working in a nice team is important. This social interaction stays on

an informal level. The employees don't feel comfortable giving feedback on colleagues' work. This is a result of being afraid to take responsibility and not acknowledging that mistakes can be made

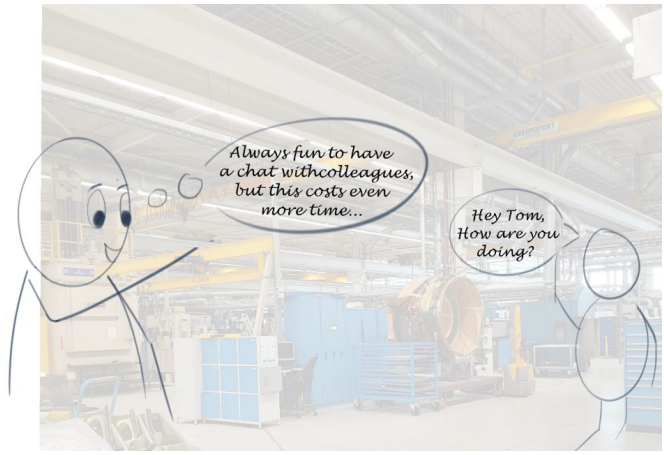


Figure 21: Talking to colleagues

Measuring tasks

The main activity at the inspection department is measuring. The employees take any measuring tool and measure how large the cracks are, so these can be compared to the allowed margins. The employees explained that the variation of measurements makes them like the work. Every part needs a different treatment and the employees never know how the day will look like. Due to the lack of planning, the employees never feel like they are reaching 'the end' of work.

Figure 22: Measuring by hand

Documenting measurements

After the measurements have been done, the results are documented into the computer. The employees are happy they can use the compute. This makes it much easier to compare the measurements with the margins. However, the documentation is not always done, which causes data to be missing.

Compare measurements with margins in manual

After, the measurements are documented, they are compared to the margins in the manual. The employees determine if a repair is possible. The employees find it very convenient the manuals can be find on the computer (all data being in one place). The employees feel responsible to execute this step well, as this decision affects the rest of the process.

Repair or not?

If the decision made to not repair the component, it costs the organisation quite some money. This gives the employees a lot of responsibility. However, the employees explain they don't feel appreciated for this.

It often happens, a component cannot be repaired. If this happens, the component goes to scrap and isn't used anymore.

If a repair is possible, a repair plan is made. Sometimes, the employees don't know for sure if the component can be repaired or not. Then, the component gets checked a second time. The employees feel, they are experienced enough to make the right decision. Thus, they don't like it when the component has to be checked again. This gives them the feeling of neet being appreciated or trusted.

Bringing the component to the next station

After the repair plan is made, the component is brought to next station. The employees feel this is, again, a useless activity.

Intermediate measurements

Sometimes, an intermediate measurement is needed at one of the other departments. The employees of the inspection department then go to the other department to check what needs to be done. Unfortunately, this is done much less than in the past, because the younger employees don't feel connected to the older generation and thus don't ask for help that often. The employees explain, some failed repairs, could be avoided by intermediate measurements.

Finish the day

After working, it's time for the employees to finish the day. The employees explain, everyone is leaving early. This is a result from a lack of management. There is no consequence for leaving early. The employees use the phrase "If they go early, we go early" to justify their behaviour. The employees explain they are willing

to just finish their shift if everyone else does it as well it.

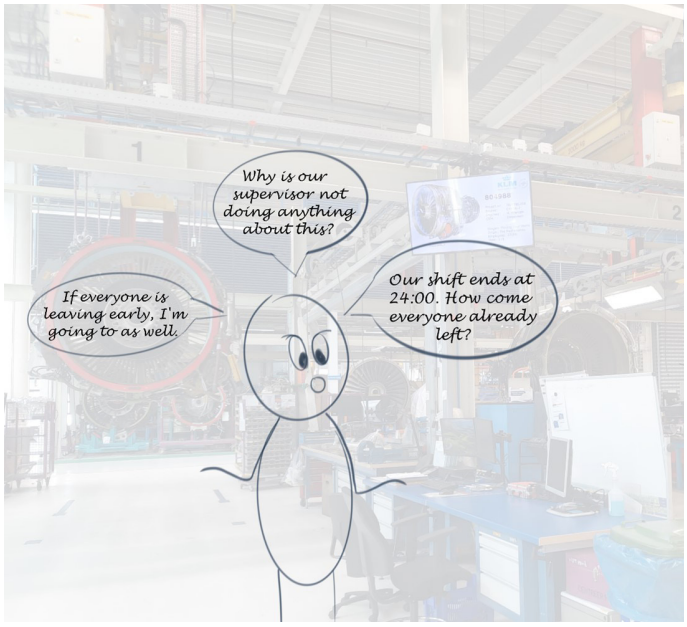


Figure 23: Finishing the day

Giving Feedback

Finally, the employees mentioned feedback on heir work is missing. This can be divided in two parts.
Firstly, the employees explain they often give feedback to management about defaults in the work process or workplace. However, they never get any response. They feel like they are not being taken seriously.

Secondly, because the components are going to the next department after inspection, the employees never know the end-result. "Was the repair successful?" "Was it done in time?".

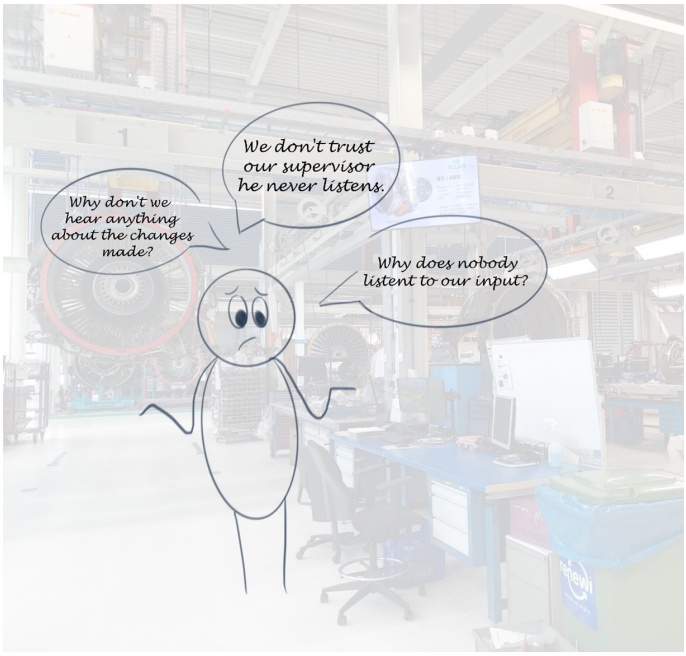


Figure 24: Giving and receiving feedback

4.5 Inspection's workflow

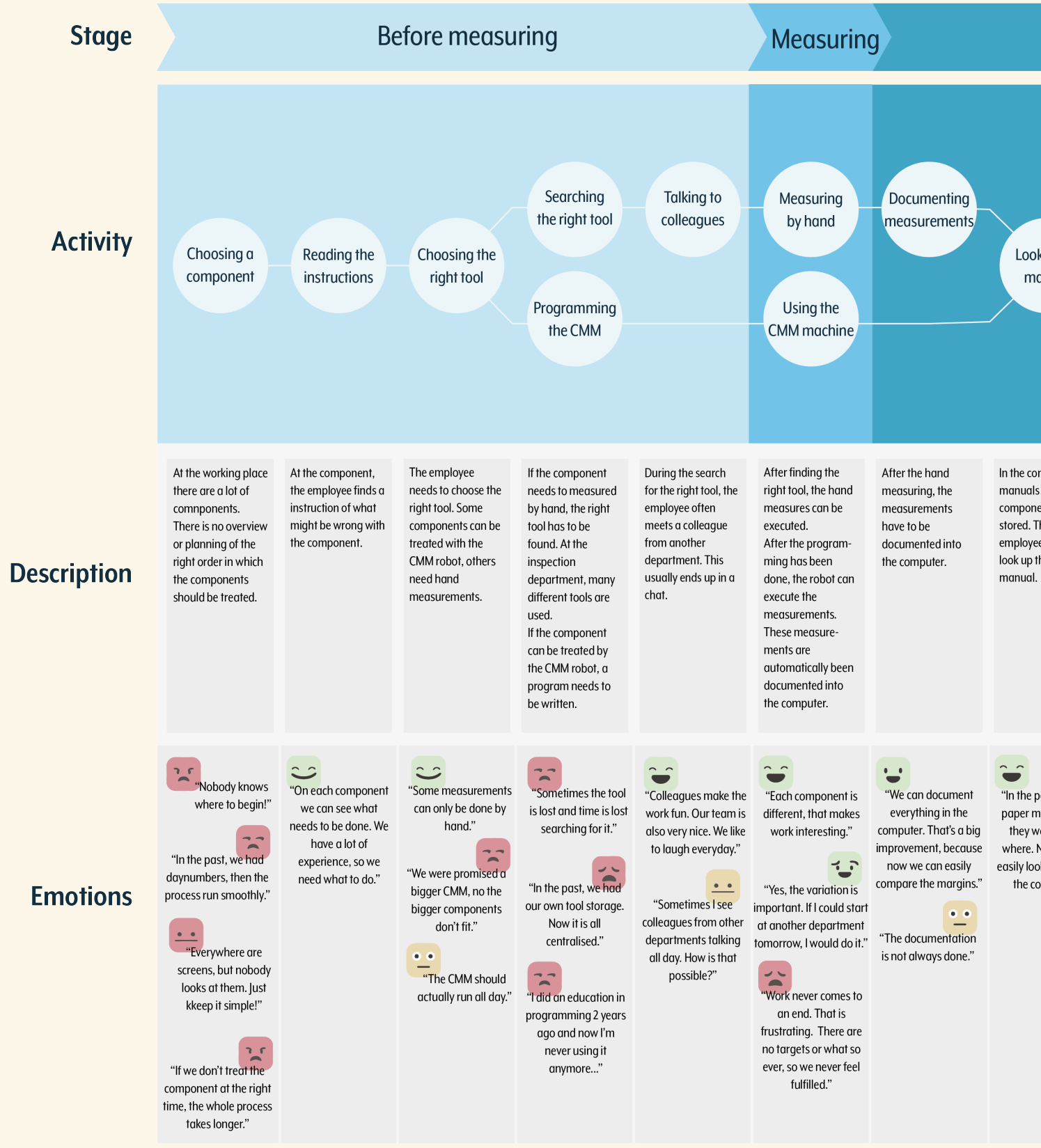
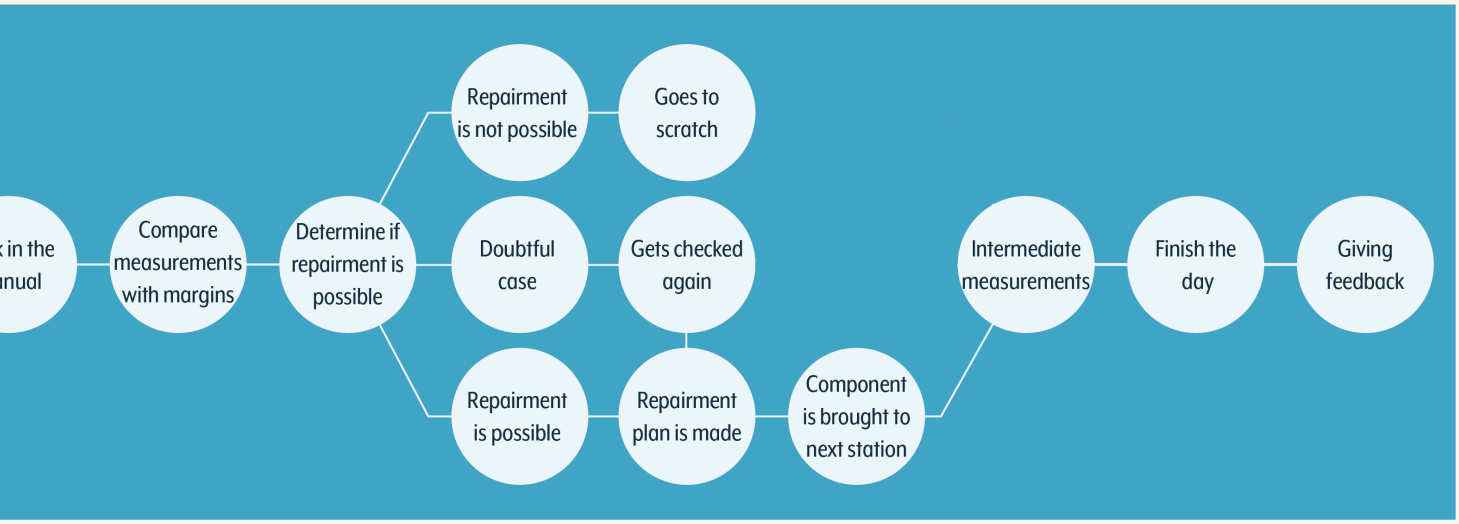


Figure 25: Mapped out workflow of KLM Engines' inspection department, including an emotion level.

After measuring



mputer, the of all nts are he e has to he right	The data documented has to be compared with the margins given by the manual.	When comparing the measurements with the margins, the employee has to determine if a repairment of any kind would be possible. There are three possible outcomes.	Outcome 1: the component can not meet the margins anymore. Repairment is not possible. Outcome 2: the employee isn't sure what to do. Outcome 3: the component can meet the margins and the employee knows what to do.	If the component can't be repaired, it goes to scratch and nothing is done with it. If the employee isn't sure what can be done, the PD team comes to check if the component can still be repaired. If the component can be repaired, a plan for repairment is made.	After the repairment plan is made, the employee brings the component to the next station. Here they start the repair.	After and sometimes during the repairs, colleagues come back to inspection to do a intermediate measuring. The employee can check if the margins are still correct.	The employee leaves. However the employees all have the same end time of their shift, employees leave way earlier.	Employees give feedback to their managers and innovation leaders if the process doesn't run smoothly
ast, we had anuals and ere every- low we can k them up in mputer."	"Both the measurements and margins are in the computer, so we can easily compare them."	"Everything depends on our decisions made. That's a big responisibility. Not all colleagues want this responsibility." "At this department you have the most responsibility, but don't get paid that much."	"A lot of the times, the component can not be repaired anymore, they just go to scratch."	"PD takes forever to check again. Why do they need so much time?" "Sometimes, the manual doesn't tell you what to do. Then you need to think yourself. We got the experience, so we know what to do."	"Annoying we have to bring the component ourselves. This time could be spend on tasks of our own expertise. In the past, we had someone for this."	"In the past, colleagues came to inspection more often for an intermediate check. Now we sometimes find out after 2 week the component is not repaired well and it has to be thrown away."	"Some colleagues are leaving at 8PM, while are shift ends at 12PM. How is this possible? There are just no consequences." "Now we leave early as well. I do want to stay, but then everyone has to." "There is just no management at all."	"We do give feedback, but nobody is listening or doing anything with it." "Our manager doesn't even know our names, I don't trust him anymore." "In the past we could hand in ideas and we got rewarded. We want to think alog, but we want some recognition." "In the past we had a way better relationship with the managers."

4.6 Identifying themes

The insights from the research with the employees can be clustered. These clusters (see appendix G iterations) are the underlying themes of what makes work meaningful for the employees of KLM Engines. The clusters are divided into the categories of meaningful work from literature (figure 26). In each category, several themes can be placed. This means, there is more than one way to fulfil all categories.

Figure 26: The themes of meaningful work at KLM Engines divided through the literature theory of meaningful work.

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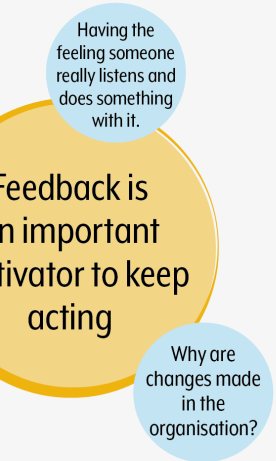
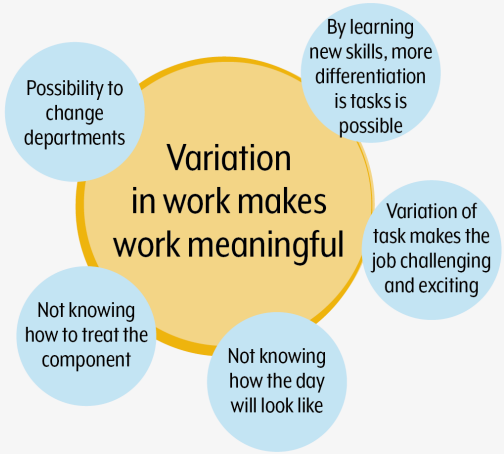


The context



The self

Having a goal gives leads to fulfilment

The employees explained that it is very demotivating that the amount of work seems endless and there is no daily goal or target. As a result, there is no feeling of fulfilment and also no need to work harder or faster. Due to a lack of planning, the process doesn't run as smoothly as it could, because the employees don't know what components to treat first. Next to that, the employees explained they find it frustrating that they don't know what happens to the component after it leaves the department. Was the repair successful? Did the component end up in the aircraft or at scrap? If the employees know where the components end up, they can also feel fulfilment and be proud of the work they have done. In this way, they feel motivated to keep doing their work. This can be explained by the feedback loop (see figure 27) (Van der Bijl-Brouwer & Watson, 2015). Drive and a sense of achievement come from the feedback after an act. In the case of the employees, they don't get feedback on the work done. If they received feedback on it, they would feel more appreciated. As a result, they would be motivated to keep working and not leave their shifts early.

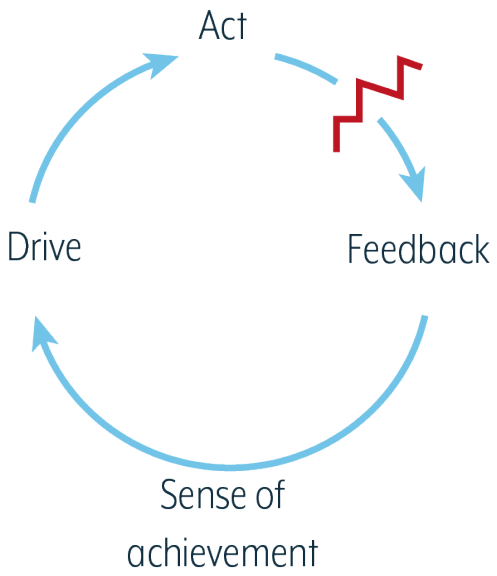


Figure 27: The feedback loop (Van der Bijl-Brouwer & Watson, 2015)

Feeling undervalued when executing activities that don't meet the skills

Employees described some tasks as "useless", for example, spending time searching or picking up tools or bringing components to the next stations. However, these activities are still crucial to making the workflow run smoothly. What the employees actually mean is that they feel their skills are way too high for those activities and they think their time can be spent more wisely. The employees think these activities could also be executed by someone who doesn't have their skills. This can be explained by the flow theory of Nakamura & Csikszentmihalyi (2014) (see figure 28). This theory depicts that employees come in the so-called "flow" state when the level of challenge corresponds with their level of skills. When bringing components to the next station or searching/picking up tools, the employee's skills are way higher than the challenge, which results in boredom.

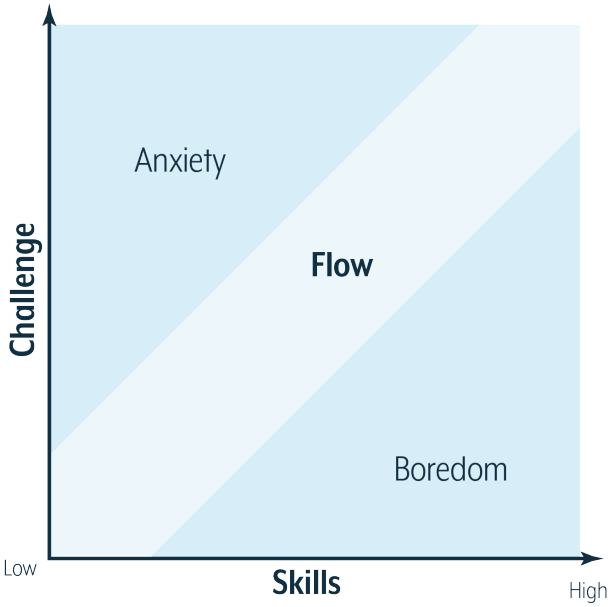


Figure 28: The flow theory of Nakamura and Csikszentmihalyi (2014).

Too much responsibility leads to anxiety

Although the employees feel undervalued when the activities are inferior to their skills, they also feel anxiety when too much is asked of them. Most employees don't want full responsibility for the work done. Although KLM Engines intends to create a working space where mistakes can be made, most employees are afraid to make them and admit them. They rather give responsibility to others. This can also be explained by the flow theory. Taking responsibility is seen as a big challenge for most of the employees and doesn't meet their lacking leadership skills and thus results in anxiety.

The others

Feedback is an important motivator to keep acting

The employees explained they are missing feedback from their colleagues on their work. They said it is difficult to improve your work if no one gives feedback on how you did your previous

work. Next to that, the employees also miss feedback from higher up. They explained that they often give feedback to the management about what goes well or not, but they never hear what is done with this feedback. Also, when changes are made in the workflow, it is often not explained where this is coming from or why this would improve the process. Looking at the feedback loop, this can be explained. The employees don't receive feedback on their given feedback on optimising the working place and as a result, they get demotivated in trying to make it better.

Acknowledgement is an important motivator

The employees express their pride in the work they are doing. They feel their work is significant in making the workflow successful and also want this to be recognised by others. They want the acknowledgement of others that they have certain skills, knowledge and experience. The employees feel frustrated when colleagues or people from the management don't trust their judgement about a component and have the need to check it themselves. The employees then feel like their skills are not acknowledged.

Social interaction with colleagues is an important motivator

Next to a pleasant work environment, KLM Engines gives a lot of opportunities for social interaction with colleagues. The employees stated that the colleagues and the teamwork aspect make them like their work and stay at the company. "A day without laughing isn't a good day", one of the employees said. Wherever you go, there is always someone to have a chat with. Although the employees do see this as something that contributes to pleasant work, they also think it sometimes takes more time than expected. The employees, therefore, sometimes do less work, which decreases their feeling of achievement.

Being treated equally is desired

In addition to the previous theme, the employees explained that they want every employee to be treated equally. There is an attitude of "If he can, I can as well". This results in some envy towards each other and is mostly caused by a lack of management. No one really understands what is happening on the working floor and makes sure everyone gets the same treatment. However, the employees have a strong need to be, together with all colleagues, part of the organisation. They also explained they want to know what is happening within the organisation so they know why certain decisions are made.

The others

Possibility for development & growth gives a purpose in work

The employees said they like the possibilities for development within KLM. All employees started at different positions and then worked in several other departments. Even if they stay in the same department for a while, there are possibilities to develop themselves and obtain more skills or responsibility. The employees at inspection stated they were disappointed that this department doesn't give many possibilities for development anymore. This can also be explained by the flow theory; as the employees are getting used to the task, the challenge decreases while the skills stay the same, which again results in boredom.

Variation in work makes work meaningful

Related to the previous theme, the employees explained they are looking for variation in their work. They explained the fun part about working in the inspection department was the unpredictability of the task. As every component is different, they never know how the workday will look and what kind of tasks they must execute. Besides, they stated they would immediately change departments for a while if possible so that they could have a change of activities and context again. The flow theory explains that employees seek another challenge or a new skill to learn, so they return to the flow state.

Conclusion

The context mapping sessions show that meaningful work depends on more than just the work actions. In the case of the inspection department, the main action is measuring. However, the employees don't feel the measuring activities make work meaningful. The most important themes that can be identified are the 'variation in work' and 'social interaction'. It is essential to acknowledge that the themes may consist of some contradictions. These contradictions are prone to occur when one theme is fulfilled;

then another theme may not be realised. For example, when the employees find bringing the component to the next step in the workflow to be a task requiring little skill, it has little meaning and value. When implementing robots, this task can be cut out, which positively affects the meaningfulness of work. However, at the same time negatively impacts social interactions in the workplace. Regarding robots, the context mapping sessions showed that the employees are unaware of the possibilities and limitations of robots. They think of robots as machines that take over their favourite tasks and as machines demanding extra unknown skills.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Section 2

Defining the design goal

This section connects all the insights from the previous section and concludes with the design goal used in the next section.

Chapter 5
Defining the design goal

In this chapter, the insights gathered are summarized and used to answer the research questions. Afterwards, the actual problem can be identified. This problem is formulated into a challenge, which is the base for the design goal.

5.1 Answering the sub-questions

This chapter concludes the research part and connects all the insight to identify the problem that the design phase will try to solve. The chapter ends with the definition of the design goal.
Section 1 of this project has answered the following sub-questions:

Who are the different stakeholders involved in the implementation of robots into the process of KLM Engines? What are the stakeholders' intentions with the implementation of robots into the process of KLM Engines?
The stakeholder analysis showed that many stakeholders are involved in the implementation of robots into KLM Engines. These stakeholders have all their intentions for robotising the workflow, however they are unaware of how to this. Three essential stakeholders were identified. Firstly, the KLM Group, including the stakeholders within KLM Airfrance, Airfrance and KLM, as there are intentions are very similar. They are primarily interested in keeping up with competitors by making more profit or decreasing costs. They want to implement robots to accelerate the workflow so that more repairs can be done simultaneously. Secondly, the government, which initiated the Brightsky project to make the aviation industry more sustainable, mostly wants to implement robots to make KLM Egines'workflow more sustainable. Lastly, the employee; a stakeholder often forgotten when implementing a new technology, but will mostly be affected by the implementation of robots. For each stakeholder, 'optimising' the process means something else.

What is the shared vision of why to implement robots into the workflow?
A shared vision helps the organisation implement robots to 'optimise' the workflow according to the crucial stakeholders' values. The shared vision that was eventually created includes these values and is formulated as follows: 'In the future, KLM Engines will have a human-technology balanced workplace, that enables the organisation to repair more and better, so the process becomes more efficient and sustainable in order to become number one in the market place'. As the shared vision was co-created, it became clear that the stakeholders are unaware of each other's values and only focused on their own. This individual focus probably results from a lack of knowledge and of understanding of the consequences of including them.

What does the workflow of KLM Engines look like?
After mapping out the workflow of KLM Engines, it became clear that it consists of a huge amount of activities divided over several departments. The components follow the departments in a particular order. If a delay occurs in one department, it delays the whole process. To further scope the project, the focus is on the inspection department. During the context mapping session, the activities of an average work day are identified. The most significant activity of the inspection department is measuring, which is divided into hand measuring and measuring with the CMM machine. However, the other activities are certainly as important and are divided into 'before measuring' and 'after measuring'. It's important to know the activities, to understand where robots can be implemented and what effect this has on the rest of the activities. Implementing robots with one activity might affect other activities as well.

What makes the current work of KLM Engines' employees meaningful?
During the context mapping sessions, it became clear the specific work actions (in the case of the inspection department the main activity is measuring) do not impact the meaningfulness of work most significantly. However, nine other themes are identified. Some essential ones are 'variation in work', 'being treated equally to others' and 'social interaction'. These themes fit with the existing literature about meaningful work, but are dependent on the work, the context of work and the individual. It is important to acknowledge that implementing robots can positively affect one theme, while negatively affecting the other one.

5.2 Defining the design goal

From the research phase two things can be concluded. Firstly, figure 29, illustrates one of the challenges that has occurred in section 1.

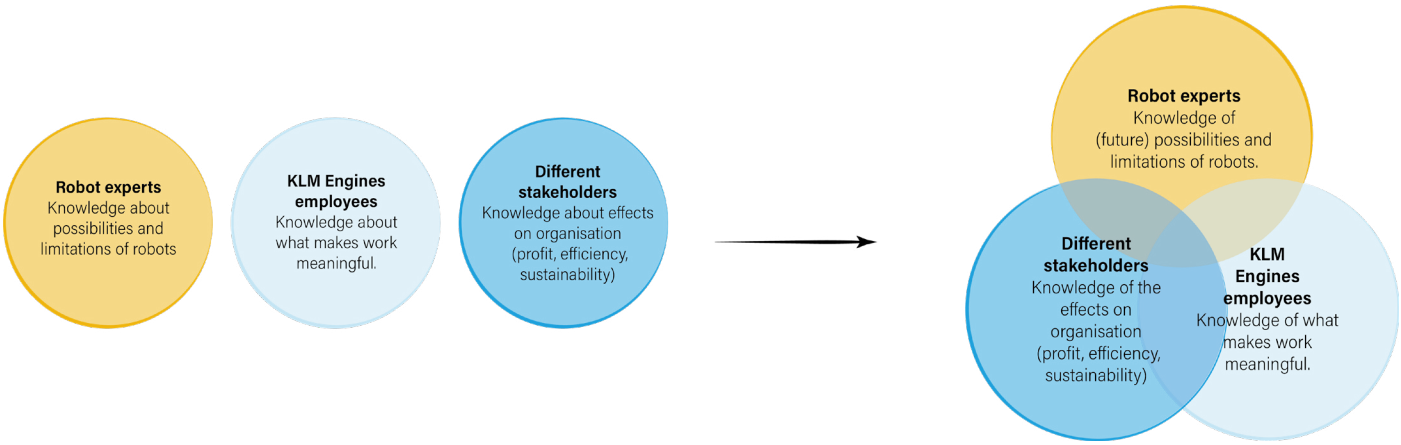


Figure 29: Combining stakeholders' knowledge, values and skills.

Through research, knowledge has been gathered about the different stakeholders' intentions and the themes that make work meaningful for the employees from KLM Engines. Here can be seen that stakeholders have different needs and values. The different stakeholders' intentions for the implementation of robots have both similarities and contradictions (explained earlier in this chapter). The stakeholders are primarily focused on their individual needs, mostly because there is a lack of knowledge about others. However, the required knowledge for implementing robots while maintaining employees' meaningful work is divided among the stakeholders.

The employees know what is needed for their job to be meaningful. The different stakeholders understand what is needed to optimise the workflow of KLM Engines. However, as these stakeholders' knowledge about robots is outdated, there is also a need for expertise on robots. The researchers from FRAIM are in possession of this expertise and know everything about the possibilities and limitations of robots. The problem is that this knowledge remains divided.

Secondly, as explained in the introduction, implementing robots can, at the same time, have a negative effect and a positive effect on the stakeholders. For example, if robots accelerate the workflow to 'optimise' the process according to KLM's values, it can negatively impact the meaningfulness of work. Even within meaningful work, implementing robots can positively impact one theme while negatively impacting another.

The challenge is for the stakeholders to share needs and values in order to understand what the different intentions are and how these can be achieved. This is best explored by creating scenarios. In this project, a scenario means a possibility of robotising KLM Engines' workflow. As a result, the scenarios will increase the comprehension of the impact of robotisation on the different stakeholders. When the stakeholders are brought together, they can explore different scenarios to gather new insights on where robots could be implemented in the workflow and share knowledge to understand the impact on each stakeholder.
If the consequences are understood by the stakeholders, a discussion can arise on which consequences are important for the organisation to take into account for further development of robotising their workflow, and which are not or less important.

Co-design

As this challenge occurred after an iterative design and research process, the choice is made to tackle the challenge with co-design. Here, the choice for a co-design is explained.. Co-design is based on the thought that everyone can be creative, if handed the right tool (Vaajakallio &

Mattelmäki, 2014). Co-design is not only about using stakeholders' insights from an early stage to create a solution. It also engages the stakeholders through the design process so they understand the consequences of their actions. Co-design involves the stakeholders to learn from their own and each other's experiences and designing new solutions together with them (Burkett, 2017). It is a good method to connect different stakeholders, learn from each other's knowledge, skills and/or resources, and create new ideas that could not have been created by the individual alone(Zamenopoulos & Alexiou, 2018).
The challenge described can be transformed into a design goal, which is formulated as follows:

"The goal is to design a co-design tool which enables the essential stakeholders involved in robotising KLM Engines' workflow to exchange expertise in order to explore the possibilities and limitations of robots and understand their consequences on the stakeholders' values."

Section 3

Creating a co-design tool for FRAIM & KLM Engines

This section explains how the co-design tool is created in order to reach the design goal. In chapter 6, several design requirements are set up. In chapter 7, the concept of the design tool is discussed.

Chapter 6
The design requirements

In chapter 5, the design goal was formulated and the choice for a co-design tool is explained. In this chapter, the design requirements are set in order to achieve this design goal. The design requirements are based on the research phase.

From the research phase, a couple of design requirements can be created. Privitera & Pancioli (2015) describe design requirements as "the functional attributes that enable the team to convert ideas into design features". In this project, the design requirements are used as a base for the ideation of the co-design tool. The chosen concept has to meet the design requirements in order to reach the design goal.

In order to make a design that reaches the design goal, a number of design requirements are set up. The following section will explain how these requirements are met.

FRAIM and KLM Engines can use the tool tool...

1. ...bring together and involve different stakeholders in a fun and engaging way.
   To involve different stakeholders, it is crucial to bring them together. Accordingly, the stakeholders need to invest time and effort. To ensure the stakeholders are willing to do so, they need to see the tool's value. Besides, to keep stakeholders involved, the tool should be engaging and fun.

2. ...get an understanding of the criteria for providing meaningful work for the employees of KLM Engines.
   As stated in the previous section, the conditions for the shared vision and meaningful work (the themes), identified in the research phase, can be used as evaluation criteria for the scenarios. The themes of meaningful work are personal and abstract and can be interpreted differently by any individual. That's why it is vital for the stakeholders to first immerse into these themes to get an understanding of the created criteria before using them for the evaluation.

3. ...get an understanding of the criteria on how to reach the shared vision of the stakeholders involved in the implementation of robots.
   The conditions for reaching the shared vision are more straightforward than the ones on how to achieve meaningful work. Still, they should also be understood before they are used during the evaluation of scenarios.

4. ...get an understanding of the activities of KLM Engines inspection's workflow.
   The stakeholders outside KLM don't know what the current workflow looks like. What are the particular actions and activities? An understanding of this workflow is needed in order to determine which activities can be automated.

5. ...together explore the different possibilities of robotising the organisations' workflow.
   As stated in the previous section, the stakeholders outside FRAIM lack knowledge about the possibilities and limitations of robots. However, there are still many possibilities of implementingn robots into KLM Engines' workflow. Thus, the tool should provide the stakeholders with a method to explore these different scenarios.

6. ...get an understanding of the possibilities and limitations of robots.
   In section 1 it became clear that knowledge from different stakeholders (from different disciplines) is needed to understand both the possibilities and limitations of robots and the consequences of implementing them in the workflow and their impact on the employees. That's why the tool should provide the stakeholders with a way to learn from each others' knowledge & skills.

7. ...evaluating the scenarios to understand the consequences on the activities of the workflow.
   The introduction explained that robots impact the workflow and the stakeholders. The organisations need to understand what this impact is. That's why the created scenarios should be evaluated. In this way, the consequences of robots on the workflow and its activities can be understood.

8. ...evaluating the scenarios to understand the consequences on the stakeholders.
   In the introduction is explained that robots have an impact on the workflow and the stakeholders' values. The organisations need to understand what this impact is. That's why the created scenarios should be evaluated. In this way, the impact on stakeholders' can be understood. In this project, the focus lies on the employees (with providing meaningful

work) and other essential stakeholders interested in implementing robots (see chapter 2).

9. ...make a well-considered decision for one of the possibilities
   After evaluating the different scenarios, the stakeholders can discuss which of the scenarios fits best with their organisation. This should be achieved together with the stakeholders, so they are all well represented in the decision-making process.

Chapter 7
Creating the co-design tool

In this chapter, it is explained which design steps are taken to come up with the concept of the co-design tool. These steps consist of an analysis of co-design tools, after which three promising design directions occurred. As game design is determined to be the best choice, this concept is further explored. The game dynamics are created through brainstorming and game analysis, which are explained in chapter 8.

7.1 Approach

The co-design tool has been created through different design steps.
First of all, the concept of co-design has been explored. Through literature, several features of the co-design have been identified.

Afterwards, an analysis of existing co-design tools was completed and three promising directions were identified. As the concept of game design fits best with the purpose of the co-design, this concept has been explored further.

7.2 Co-design

What is a co-design tool?

Co-design tools are there in many forms and can not be defined in one way. However, some features can be determined for the co-design tool in order to be successful (Burkett, 2017) (Evans & Terrey, 2016). These features can be used in the creation of the co-design tool.

1. The co-design tool should involve several perspectives and disciplines. Co-design is used to build upon the real-life organisational context. In this context, several stakeholders with different perspectives and from different disciplines are often involved and thus should be involved in the co-design process.
2. The co-design tool is person-centered. The co-design should help the participants of the co-design process to understand the experiences of different stakeholders in order to understand the consequences of their design actions.
3. The co-design tool is used to reach a predetermined goal. Why is this co-design tool used? What are the intended outcomes? However, this goal should not be elaborated on in detail. There ought to be room to face problems and even realise there are more or other issues than anticipated.
4. The co-design tool should help the participants to explore real-life solutions. New possible solutions should seek a balance between being feasible, viable and desirable. In this way, the participants of the co-design process are not only encouraged to be open-minded and think out of the box, but also to think about the consequences when actually being implemented.
5. The co-design tool should help make solutions become tangible and visible. As a result, the participants of the co-design process are able to express their thoughts and get a mutual understanding of the solutions. As stakeholders from different disciplines carry out the co-design, the knowledge spill-over is essential for the stakeholders to understand each other's expertise.

Exploring co-design tools

In the previous chapter, it was decided that the deliverable of this project will be a co-design tool, because this is an excellent method to bring together different stakeholders and share knowledge and skills. However, co-design tools exist in many forms, serving many different purposes. An exploration of existing co-design tools was done (IDEO, MUZUS, co-design. tools). These tools could be clustered, and three promising directions were identified.

Direction 1: Building tools

Figure 30: LEGO as co-design tool

Many co-design tools exist around building and

prototyping different scenarios. This is achieved, for example, by using LEGO (see figure 30). The advantage of these tools is that it becomes easy to remove and add different building blocks, so new scenarios can be created easily. Besides, the scenarios become very visual as they can be built in three dimensions. In this project, building tools could be used to build different workflow scenarios and adapt them when robots are implemented.

Figure 31: LEGO as co-design tool

Direction 2 Roleplaying

Next to building tools, many co-design tools are based on role-playing (see figure 31), because this enables the participants to immerse themselves in other stakeholders. The participants can play out a scenario to test how a certain concept works in practice. Besides, it helps to explore how the context changes after a certain action is taken. Roleplaying is a good way to help the participants understand others and make a scenario more realistic. In this project, role-playing could be used to exchange knowledge and skills and play out scenarios in which robots are involved in the activities.

Figure 32: LEGO as co-design tool

Direction 3 Game design

The last direction is game design (see figure 32). In many co-design tools, gamification is used to make the tool more engaging and fun. Game design comes in many forms, which makes the opportunities endless. In this project, a game design tool can help the participants create and visualise scenarios and communicate knowledge and skills. Game design helps the participants to both create realistic scenarios and be creative.

7.3 Game design

The concept of game design has been chosen for the co-design tool, because with game design, knowledge and skills can be exchanged, different scenarios can be built, and these scenarios' impact can be visualised. The combination of these factors cover the design requirements well. Game design has often been used in participatory design tools, because it enables participants to grasp the stakeholders' thoughts, knowledge and skills in a fun and engaging way. For example, at Muzus, a service design company, a game has been designed to help employees of the Dutch 'Uitvoeringsinstituut Werknemersverzekeringen' (UWV) to understand people, who receive unemployment benefits, better.

Vaajakallio (2012) describes a design game as: "a tool for co-design that purposefully emphasise play qualities." It is not a well-defined method, but rather an expression highlighting exploratory, imaginative, dialogical and empathic aspects of codesign". Through game design, a particular situation can be staged. The situation can be a reflection of real life, but also a dream world. The game design approach has the advantage of being both concrete and flexible. This flexibility enables the participants to create different scenarios, while the concreteness enables the participants to evaluate them. This makes it easier for the players to reflect on the current situation and imagine desired future ones (Brandt & Messeter, 2004). Game design is used for several purposes. Vaajakallio & Mattelmäki (2014) identified four, of which one is: engaging multiple stakeholders. This corresponds with the paramount goal of the tool in this project.

According to Vaajakallio & Mattelmäki, (2014), game design can help stakeholders engage in the design process. A game design can help conceptualise ideas, explore different perspectives, understand the work context and practice or create different user scenarios. The tool developed for FRAIM and KLM Engines strives to achieve all of the mentioned.

MDA model

To use game design in the development of the co-design tool, the features of game design have to be identified. Hunicke, LeBlanc & Zubek (2004) developed the MDA model, introducing the components of game design. The model explains a game design consists of Mechanics, Dynamics and Aesthetics.

Aesthetics

Aesthetics describe the desired emotions the game design evokes when interacting with the players. The dynamics of the game designed are there to provoke these emotions. The aesthetics are often seen as what makes the design game "fun". Creating game dynamics that achieve one or several aesthetics make the game fun and engaging, which is one of the design requirements. Hunicke et all. (2004) describe 8 different aesthetics:

1. Sensation (Game as a sense-pleasure)
2. Fantasy (Game as a make-believe)
3. Narrative (Game as a drama)
4. Challenge (Game as an obstacle course)
5. Fellowship (Game as a social framework)
6. Discovery (Game as uncharted territory)
7. Expression (Game as self-discovery)
8. Submission (Game as a pastime

Mechanics

Mechanics are designed interactions with the components. These interactions are often described as rules. For example: at Yahtzee you can roll the dice a maximum of three times. Mechanics come in many forms, such as levels, teammates, and leader boards (Sailer et al., 2017).

Dynamics

Dynamics are the parts of the mechanics that are visible to the players. It describes the output, which is a result of the players' input. For example, if a player moves three steps on a game board, he can draw a card. Game dynamics can have many forms. These game actions are created to achieve the desired aesthetics.

Gamification

Game design makes use of gamification. Gamification means that only certain elements of games are used. This distinguishes game design from serious games, in which a fully developed game is used. In game design, gamification connects real-world context with game elements (Sailer et al., 2017). In the co-design tool, gamification can be recognized as not all steps of the process are gamified. In this way, the tool is engaging and fun, but also doesn't distract the participants from reaching the desired goal.

Design direction

As the co-design tool is made to connect stakeholders, 'fellowship' is a logical desired aesthetic. This aesthetic can be achieved by encouraging the players to share information. Alongside that, as the co-design is meant to let the stakeholders share their expertise, the aesthetics 'expression' is chosen. This can be achieved by, for example, distinguishing different characters that represent the expertise (Hunicke et all., 2004). Lastly, the aesthetic 'discovery' fits with the design goal. 'Discovery' can be achieved by encouraging the players to explore different scenarios. The game dynamics explained in the next chapter are designed to achieve these three aesthetics.

Chapter 8

The co-design tool

In this chapter, the elements of the co-design tool are explained. First, a co-design process is created in order to achieve the design goal. Then, the choice for the different game dynamics is discussed, which helps the co-design tool to meet all the design requirements of chapter 6.

8.1 The process of the co-design tool

As stated before, a co-design tool is designed to reach a predetermined goal. The goal of this co-design tool is for FRAIM and KLM Engines to enable the essential stakeholders involved in robotising KLM Engines' workflow to exchange expertise in order to explore the possibilities and limitations of robots and understand their consequences on the stakeholders' values.

Before the actual game elements are made, a process that the co-design should go through has been created (see figure 33). The steps are based on the requirements stated in chapter 6 and are created to divide the design goal in smaller steps.

Afterwards, brainstorming sessions were used to create the game elements for each of these steps. The choice of the elements is explained further in this chapter and based on the information gathered in the previous chapter.

The created co-design process represents the steps KLM Engines and FRAIM should go through in order to reach the design goal.

Step 1: The first step of the process is based on the requirement 'bring together and involve different stakeholders'. In this step, the team members of the project team are carefully chosen.

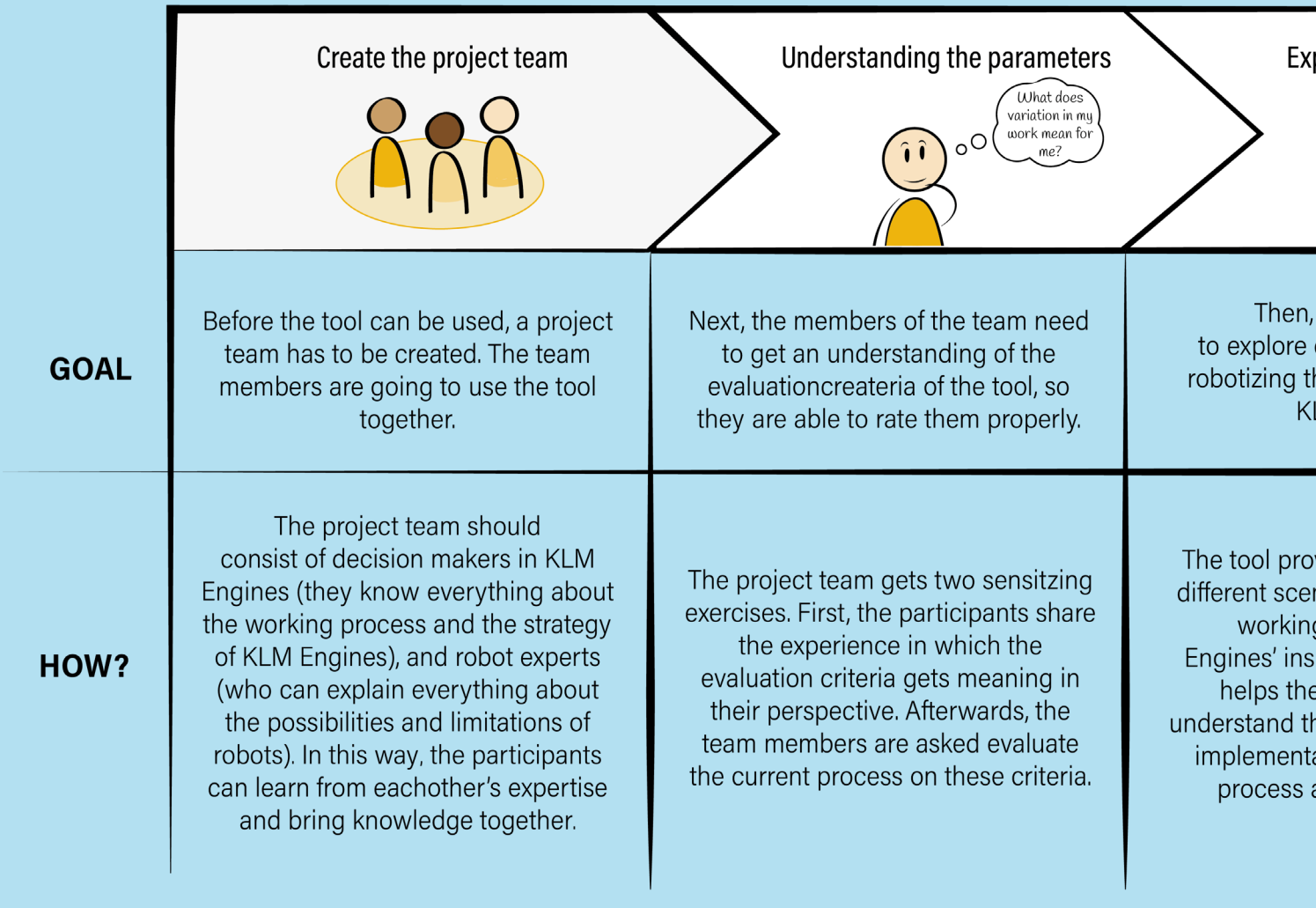
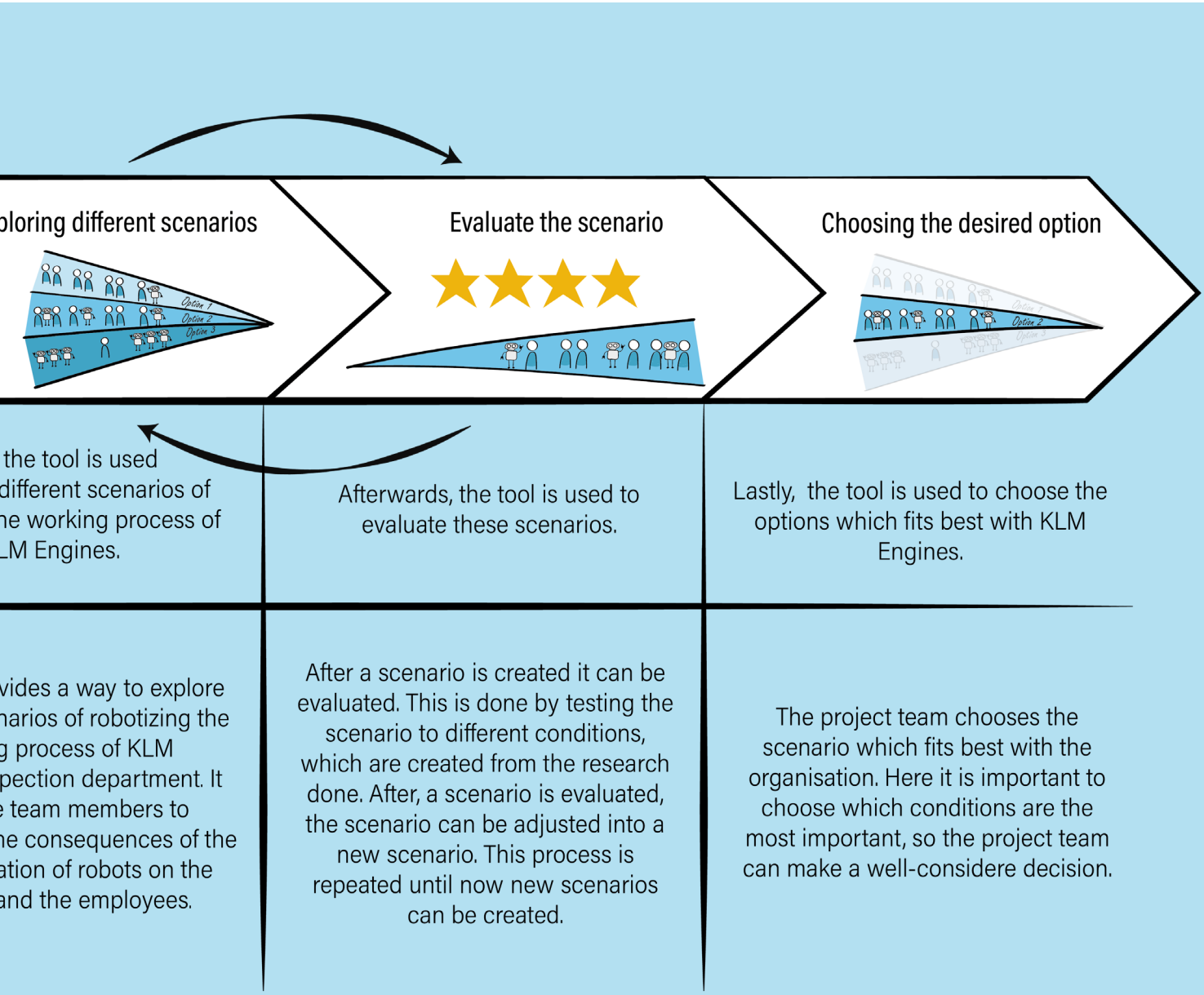


Figure 33: The process of the co-design tool

To what extent the other design requirements are reached is based on the knowledge and skills of the chosen team members. Thus, it is important that different disciplines are represented.

Step 2: The second step of the process is based on the requirements 'get an understanding of the criteria for providing meaningful work for the employees of KLM Engines.' and 'get an understanding of the criteria on how to reach the shared vision of the stakeholders involved in the implementation of robots'. Before scenarios can be created and evaluated, an understanding is needed of what the stakeholders want to achieve with the implementation of robots. In order to clarify the 'why', research has identified the different stakeholders' intentions. These have been translated into themes of meaningful work for KLM Engines' employees and a shared vision of other relevant stakeholders. These themes and shared vision are conditions on how to achieve the stakeholders' values. They should be understood by the team members of the project team, so they can evaluate the scenarios to these parameters.

Step 3: The third step is based on the design requirements 'together explore the different possibilities of robotising the organisations' workflow', 'get an understanding of the activities of KLM Engines inspection's workflow' and 'get an understanding of the possibilities and limitations of robots'. During this phase, the different disciplines exchange knowledge to provide all stakeholders with enough information to be able to explore the possibilities of robotising the workflow. First of all, the robot experts from Robohouse need to get a good understanding



of the workflow and the activities therein. In this way, they can give details on where robots could be implemented and where not. On the other hand, the other stakeholders need to get a better understanding of the limitations and possibilities of robots, to understand where robots could be implemented and where not. If the stakeholders all have access to this knowledge, they can together discuss the different scenarios of implementing robots.

Step 4: The fourth step is based on the requirements 'evaluating the scenarios to understand the consequences on the activities of the workflow' and 'evaluating the scenarios to understand the consequences on the stakeholders'. In this step, it's time to evaluate the scenarios in order to understand the consequences of implementing robots both on the activities of the workflow (how are the activities changing?) and on the stakeholders (to what extent is the work meaningful? As well as to what extent is the shared vision reached?

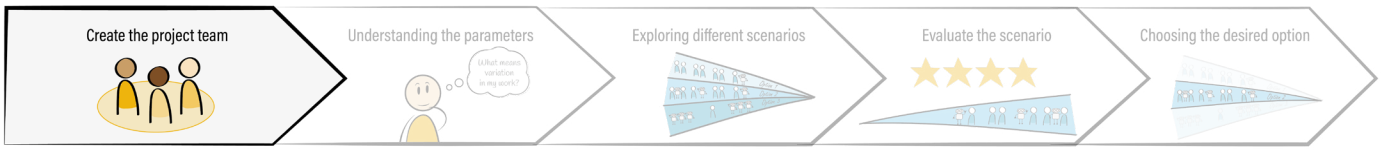
Step 5: The fifth step of the process is based on the design requirement 'make a well-considered decision for one of the possibilities'. In this step, the team members should be able to make a well-considered decision for one of the options by discussing which evaluation criteria they find most important and which they find less or not important.

8.2 Creating the game dynamics

Ideation

The steps of the co-design process have been clarified. In the next section, the steps are explained further and the game dynamics of the co-design tool are discussed. In other words, how do these game dynamics help to reach the goal step by step?
The game dynamics are created in several brainstorming sessions (see appendix H & J) . Herefore, inspiration came from existing games and co-design tools. During the brainstorm sessions, discussions with peers and the supervisory teams are held in order to create a complete toolkit.

Step 1: Creating the project team



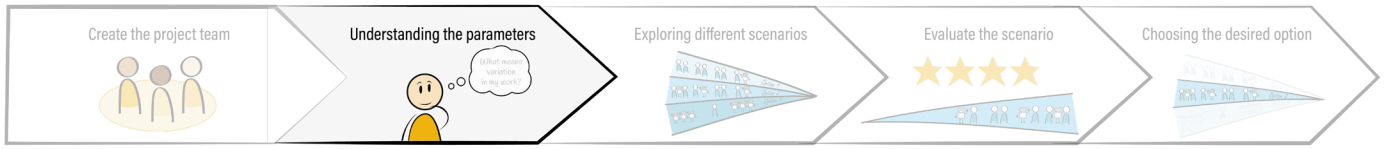
I In this step, the project team is created. The team members should provide the team with all the needed knowledge. Due to this project, relationships with several stakeholders are already there. These relationships are used to create the project team in advance and consist of the following team members:

- **Two researchers from Robohouse** are working with robots and cobots for many years. They know in detail what the exact possibilities and limitations of cobots and robots are. Their knowledge is needed to understand where robots can be implemented and what their consequences on the activities are.
- **The continuous innovation lead** works every day with the employees of KLM Engines. He is focused on improving the workflow and workplace, following a bottom-down approach. The continuous innovation lead knows all the ins and outs of the activities of the workflow and what the pain points of the employees are. This team member is needed to understand the activities of the workflow and the consequences robots have on the meaningfulness of work.
- **The Vice President of Engine Services** is working on the strategy of the KLM Engines and thus knows where KLM

Engines wants to go in the future and what is needed for this. This team member is needed to understand the consequences of implementing robots on KLM Engines (one of the stakeholders involved in the shared vision creation).

- **The director of innovation** works at the Brightsky project and knows which interests are important to take into account. From the shared vision co-creation session, it became clear this team member is mostly focused on sustainability and thus will help the team understand the consequences of implementing robots on the sustainability of the workflow.
- **The Team Leader Repair Development** knows the workflow from a more technical perspective and identifies the bottlenecks of the process. This team member will help the team to understand the consequences of implementing robots on the efficiency of the workflow.

Step 2: Getting familiar with the evaluation criteria



Now the project team is created, it is time to get an understanding of the evaluation criteria. These criteria are created from the research insights.

Turning insights into evaluation criteria

The research done at KLM Engines can be used as evaluation criteria for co-design the tool. These are the evaluation criteria for evaluating the different scenarios. In this way, it is easy to assess the scenario to both meet KLM Engines' vision and provide the employees with meaningful work.

Turning the vision into evaluation criteria

First of all, the shared vision created in chapter 3, is used to create parameters for the evaluation tool.

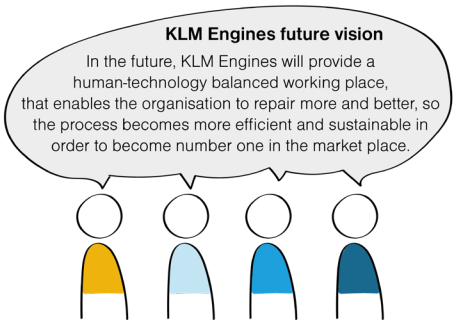


Figure 33: The shared vision created in chapter 3

The shared vision (Figure 33) contains several factors which can be used to create parameters. The overall goals are making the workflow more efficient, making the workflow more sustainable and creating a human-technology balanced working place.

The parameters which enable a more efficient and sustainable workflow used for the design concept are:

1. Has the possible number of repairs increased?
2. Has the capacity of the components treated increased?
3. Do the benefits outweigh the costs incurred?

Turning meaningful work themes into evaluation criteria

The other part of the human-technology balanced working place is the human factor. Focussing on the human can help provide them with more meaningful and satisfying work. As a result, the productivity of the employees increases (Pratt, et.all., 2013). In chapter 4, the themes of meaningful work were identified.

The self

1. Feeling undervalued when executing activities that don't meet the skills.
2. Too much responsibility leads to anxiety.
3. Having a goal gives the possibility of fulfilment.

The others

1. Acknowledgement is an important motivator.
2. Feedback is an important motivator to keep acting.
3. A sense of belongingness is wanted.
4. Social interaction with colleagues is an important motivator.

The context

1. Variation is work makes work meaningful.
2. Possibility for development & growth gives a purpose to work.

To transform the themes into evaluation criteria, they must be formulated in a way that can be rated. This resulted in the following evaluation criteria:

1. Do the employees' skills meet the challenge of the activities?
2. Does the employee feel there is a balanced responsibility?
3. Does the employee have a goal to reach?
4. Does the employee feel acknowledged by others?
5. Does the employee get feedback on their work?
6. Does the employee feel equal to others?
7. Does the employee have social interaction?
8. Does the overall work, provide the employee with enough variation?
9. Does the employee have enough possibilities for development & growth?

Together with the 'shared vision' evaluation criteria, there is a total of twelve evaluation criteria.

Game element 1: draw out your own experience

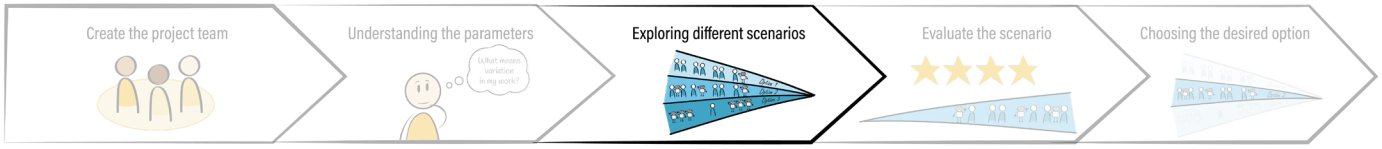
The evaluation criteria for meaningful work are quite abstract and personal. This means the criteria can mean something different for one person than for the other. Although the criteria are a conclusion from research done with the employees, it is valuable to let the team members think and discuss their interpretation of these evaluation criteria. This game dynamic will contribute to the aesthetic of expression. As a result, it will be easier to value the created scenarios to these criteria, while using the co-design tool.

This process step is executed on the experience sheet (see appendix K), where the participants are asked to draw and describe their work experience. For example, the participant chooses the evaluation criteria: 'Does the employee have a goal to reach?'. The participant thinks of one of their work experiences, which they think gives meaning to this criteria. For example, the participant draws and describes the experience in which the participant and its colleagues set weekly goals in the Monday morning meeting. This helps the participant to identify the actions that need to be done in order to reach this goal and to have a feeling of achievement when the goal is reached.

Game element 2: evaluate the current scenario

As stated before, a co-design tool tries to represent real-life situations. The participants are thus asked to use the evaluation criteria to evaluate the current workflow. This is done with a special evaluation sheet (appendix K). The evaluation sheet consists of a circle diagram, which is divided into twelve parts representing the twelve evaluation criteria. The participants are discussing to what extent the workflow meets the evaluation criteria. For example, for the evaluation criteria 'Does the employee have a goal to reach?', the participants discuss if the goal for the employees is clear and if they can have a feeling of accomplishment. After the participants have done this for all criteria, the evaluation sheet provides the team with an overview of what criteria are rated low and thus leaves room for improvement and which are high and thus should be retained. As this game dynamic is conducted with the whole team, it contributes to the aesthetic 'fellowship'.

Step 3: Exploring different scenarios



The goal of this phase is to explore all the possibilities and limitations of robots and cobots in the workflow. It is thus important that all stakeholders understand what the process looks like, what kind of robots there are and what their possibilities and limitations are.

Game element 3:the workflow game board

As stated before, a co-design uses real-life and visualized tools to help the participants get a better understanding of the context. First of all, all participants need to get an understanding of the workflow. Looking at existing games (see appendix J), this can be done in several ways. For this co-design tool, a board game is chosen to represent the workflow, because a board is a convenient way to present the activities in a particular order. The activities are illustrated, so the participants who are not familiar with the workflow can also visualize the activities. The participants who are familiar with the workflow can provide the other participants with more details on the particular actions.

Game element 4: the small and large robot cards

The participants should also understand the possibilities and limitations of robots. To create a game dynamic, the robots are visualized in two types of robot cards. The large robot cards give an overview of both the most common industrial robots (see appendix D for an overview of these robots) and the cobots used at Robohouse. This contributes to the aesthetics of discovery and expression, as the participants express and lean from robot expertise. The participants from Robohouse are there to provide the other team members with more detailed information or to give alternative options. Next to that, the participants are also provided with small robots cards, which correspond with the larger ones. These small robots cards can be moved around the game board. The small cards make the game more dynamic because the cards can easily be added and removed. In this way, the participants can together discuss where and why a cobot or robot should be implemented and what the consequences of the activities are. For example: with the activity 'bringing the component to the next station', the participants discuss what kind of robot or cobot could be implemented. A robot could take over the entire activity, but what effect does this have on other activities, such as talking to colleagues? For each activity, the participants can explore different options and discuss the consequences of the workflow. To encourage the participants to explore different possibilities, they are provided with 'dream cards' on which they can draw and describe their dream robots. This helps the team to expand boundaries and helps the participants of Robohouse to understand what features of robots are wanted by the organisation.

The possibilities and limitations of cobots

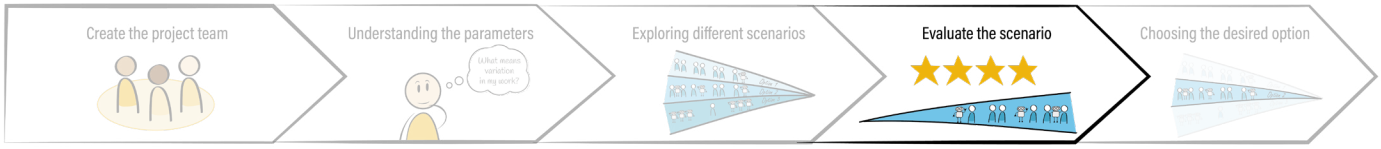
Cobots is a quite new concept and is thus quickly introduced. Cobots are designed to work together with humans in the same workspace. Instead of taking over a complete activity, they are designed to support the human to perform the activity better. The activity could be performed faster or more accurately, but it could also make the activity less physically demanding. This

provides organisations with more possibilities for robotising their workflow.
At Robohouse, the design lab FRAIM works at; they are currently researching three different kinds of cobots (see appendix I for pictures). These cobots are all designed so they can safely be used by or in the same working space as humans. The cobots are all light-weighted and thus are easily and safely manageable. Due to the many joints, the cobot moves very smoothly and feels and looks like a human arm. The UR5e and the FRANKA cobot can both take a maximum weight of 5 kg, while the KUKA can take a weight of max. 14 kg. With the UR5e and KUKA cobot, different kinds of tools can be attached to the tail. In this way, they can be used for a wide variety of activities. The FRANKA cobot has a grab system, which makes it ideal for any kind of picking and moving activity. However, the FRANKA cobot can not handle different kinds of tools and thus can be used for a fewer number of activities.

These cobots provide a new perspective on what can be done with robots. Currently, at KLM Engines, robots are seen as machines that take over an entire activity. They choose an activity for which the executing time could be optimised and research how the robot could take over this activity. However, with cobots, new opportunities occur. It is no longer needed for the cobot to take over the entire activity, rather with a cobot, the human can still be involved.

Figure 34: The cobots being researched at Robohouse

Step 4: Evaluate the scenario



After a scenario is created, it should be evaluated according to the evaluation criteria. In this way, the team can test to what extent the scenario meets the shared vision and to what extent the scenario provides meaningfulness in work. This gives a clear overview of the consequences of the scenarios.

Game element 5: the work process game board

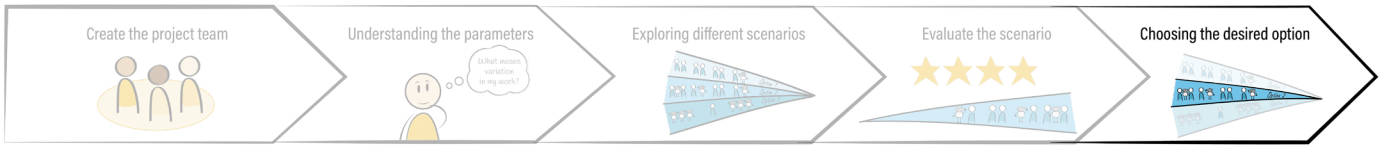
The participants discuss for each evaluation criteria, how and to what extent the created scenario has influenced this. For example, the participants created a scenario where robots

take over as many activities as possible. This will probably have a positive effect on the evaluation criteria created from the shared vision, but will have a negative effect on the criteria 'Does the overall work, provides the employee with enough variation?',

After evaluating the scenario, the team can make a new scenario. This can be done by

1. Looking at the evaluation sheet and choosing one or several criteria to focus on
2. Removing all robot cards and start over, to start with a clean sheet.
3. Creating "what if" scenarios, to think more out of the box. ("What if we put in as many robots as possible?" "What if we only focus on the meaningfulness of work?"

Step 5: Choosing the desired option



The third and final step of the process is choosing a desired option. Although, the scenarios are rated on each of the design criteria, it is not yet determined whether the criteria are important for the organisation or not.

The participants look at the evaluations of the different scenarios and discuss which evaluation criteria they find important and which they find less or not important. Afterwards, they can choose a scenario that fits best to these criteria.

Section 4

Performing the co-design tool with FRAIM & KLM Engines

In this section, the results of performing the co-design tool are discussed. Are the design requirements met and is the design goal reached? How can the tool be improved?

Chapter 9
Evaluating the co-design tool

In this chapter, the results of testing the co-design tool will be discussed. This chapter describes how the test was set-up. The test was executed in order to assess if the co-design meets the design requirements. Furthermore, the insights are used to make an iteration of the co-design tool.

9.1 Set-up of the co-design session

Prototyping

In order to test the co-design tool it has to be prototyped. The prototype must contain all the information about the workflow & robots. Besides, the exercise sheets must be able to be completed. The created game dynamics should be visible. However, as the goal of the test is to determine how the co-design can be improved, the materials of the prototype don't matter. That's why most of the tool is made from paper and cardboard.

Planning

The session was planned for 1,5 hours, including a short introduction of the research insights and an explanation of the co-design tool. During the session, it became clear that 1,5 hours is not enough to go through each step of the co-design process.

Goal of the session

As in every design process, the tool should go through several iterations to create the best version. During the conceptualization of the tool, some iterations are made. However, this test is carried out to see how the tool works in the actual context and how it can be improved to meet the design requirements.

My role in the co-design session

Initially, the game was meant to be played without a game leader. This means no facilitator is used to guide the participants through the co-design session. The participants were handed a manual to guide them through the game (see appendix K). However, during the session, I acted more as a facilitator than intended. This was mainly due to a lack of time. Therefore, my assistance was necessary to aid the project team in going through the game more quickly. Reading the manual took too much time, so a combination of reading the manual and being instructed orally was used. Besides a lack of time, some of the exercises needed some extra explanation. Thus, I realized it is advisable to add a facilitator to the session.

My role in the co-design session

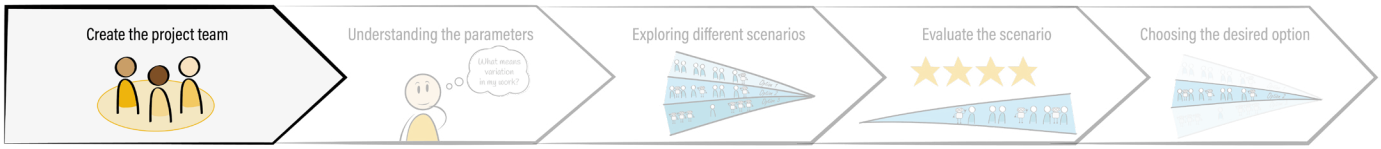
The final project team of the co-design session only consisted of the following participants.

Team member:	Expertise:
1. Researcher from Robohouse (PhD student at Delft University of Technology)	Possibilities and limitations of robots.
2. Continuous innovation lead at KLM Engines	The thoughts, feelings and needs of the employee of KLM Engines. & Details of the KLM Engines inspections' workflow.
3. Team Leader repair & development	Strengths and weaknesses of the workflow of KLM Engines.

Figure 35: The participants of the test

9.2 Evaluating the co-design tool

Step 1: Create the project team



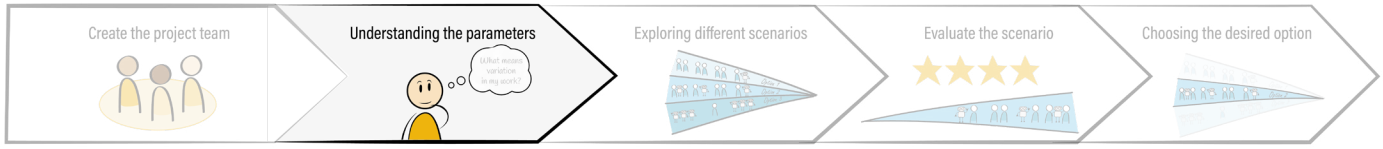
The final project team of the co-design session only consist of **participant 1**: a researcher from Robohouse (PhD student at Delft University of Technology), **participant 2**: the continuous

innovation lead at KLM Engines and **participant 3**: Team Leader Repair Development. This was caused due to last-minute cancellations. Two out of the three participants also arrived late. During the session, it became clear that the participants were not fully aware of the importance of their presence. For example, participant 3 said: *"I didn't know you had to wait for me. I thought I would just join your presentation."* However, an elaborated email was sent to the participants in advance, explaining the goal of the session.

Besides, during the session, it became clear that the continuous innovation lead could not fully represent the workers. The in-depth details about the activities of the workflow and concrete insight on the consequences on the meaningfulness of work missed. For example, participant 3 said: *"I already know five people of my team that could join this session, that know more about the workflow".*

As a conclusion, it is clear the organisation has to be more involved in this step. In this way, the organisation better understands the goal and thus feels more engaged and involved. Besides, the organisation knows who has which knowledge and skills best and therefore can decide which participants to involve. Before the project team is created, it can be determined which knowledge and skills are needed during the session, to help the organisation and FRAIM choose the right participants.

Step 2: Getting familiar with the evaluation criteria



Understanding what makes meaningful work

Figure 36: Participant 1 during the test

Due to delays, there was a lack of time to execute all exercises as intended. The participants were asked to execute exercise 1 for one of the evaluation criteria instead of two. In this exercise, the participants were asked to draw or describe a work experience which gave meaning to one of the evaluation criteria (see appendix M for the completed exercises). The exercise did help to understand the criteria better. However, participant 3 said during the session: *"As I only chose one of the criteria, I am now focused on achieving the highest level of this criterium".* It became clear that this co-design process step is important and should not be rushed. As the participants were able to execute this exercise very quickly, each of the criteria could be treated in a short amount of time.

Understanding how to evaluate

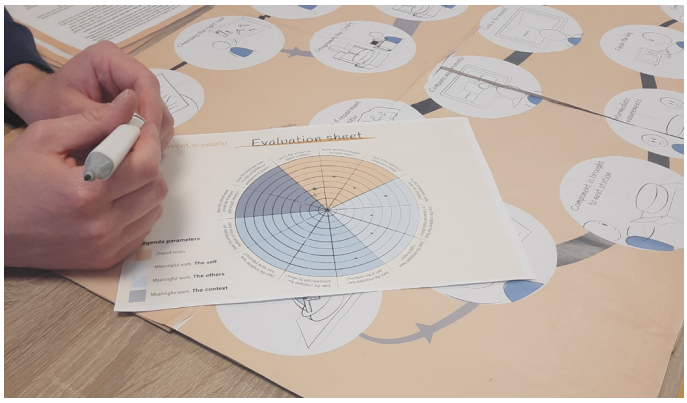


Figure 37 : Evaluating the current workflow

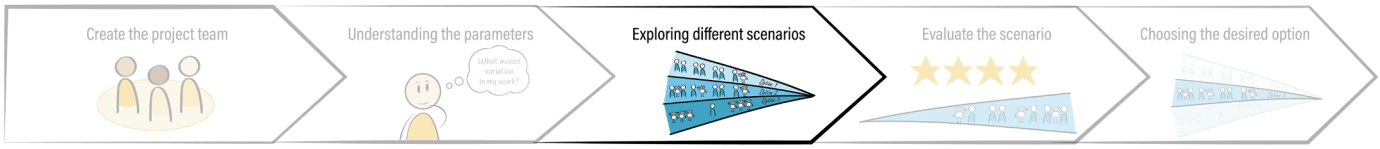
Afterwards, the participants were asked to execute exercise 2, in which they had to evaluate the current workflow on all of the evaluation criteria. This was an excellent way to help the participants understand the workflow better and identify the current weaknesses of the process. Besides, it was a good way to use the evaluation criteria before creating the scenarios. It also

helped the participants to evaluate the scenarios quicker later in the session. During the exercise, interesting discussions occurred about how to evaluate the current workflow. Mostly participants 2 and 3 were involved as they know more about the current workflow. As a result, the robot expert learned a lot about the current workflow. For example, participant 3 said: *"Only 50% of our capacity I actually used, so the criteria regarding capacity should be low".*

However, the participants sometimes found it difficult to rate the evaluation criteria regarding 'meaningful work' as they couldn't ask the actual workers. For example, participant 2 said: *"I think the employees have a goal to reach, but I'm not sure how they really feel about this."*
It was clear participant 2 has less knowledge about the employees' thoughts and feelings than initially assumed, while it also became clear such knowledge is needed for the evaluation. Besides, the criteria regarding the shared vision were not all clear and needed a bit more explanation to be understood. For example, participant 2 asked: *"what is meant with 'the benefits'?",* when the participant were discussing the evaluation criteria 'Do the benefits outweigh the costs incurred?'. Although the criteria are explained in the manual, the participants didn't look into it and posed questions to the researcher.

It can be concluded that this step is an important step of the process and time should be spent on getting a good understanding of the evaluation criteria. Besides, the criteria should be formulated very carefully, so the participants will interpret them as intended.

Step 3: Exploring different scenarios



Sharing knowledge

After the participants gained an understanding of the evaluation criteria, they were asked to execute exercise 3. In this exercise, they were asked to create a scenario of implementing robots if money doesn't play a role. It was expected that the participants would have trouble imagining where to implement robots into the workflow, as the activities are not all obvious to automate. However, the participants didn't have trouble with this at all. This was mainly caused, by the robot & cobot cards. The participants could easily move the cards around the game board. This resulted in the participant trying out different options. As the cards are not permanently attached to the game board, the participants were not afraid to use them. The participants started by looking at the activities one by one and implementing robots wherever possible. Participant 1 said: *"Let's start with 'choosing a component', a robot could pick the component and bring it to the employee."* The cobots or robots selected in advance could not be used for this activity. This is where the dream robot cards came in handy. The participants used one of these cards to come up with the desired robots and verified with participant 1, if this robot would be realistic.

The value of co-design became highly visible during this step of the co-design process. The two participants from KLM explained the activities in more detail to the robot expert and the robot experts shared knowledge about the possibilities and limitations of robots. For example, with the activity 'programming the CMM', participant 3 explained this activity is a big bottleneck in the workflow, because the programming skills needed don't meet the available skills of the employees of KLM Engines. The participant wanted a robot that could execute the measuring tasks without the programming task. The robot expert introduced the KUKA cobot to the other participants and explained what possibilities the cobot provides. It was also interesting to see that what the robot expert would deem as obvious knowledge about cobots, was new to the other participants. The robot expert sometimes had to carefully watch his words. For example, participant 1 said: *"The employee has to push a button to start the robot."* Just as with any machine, the cobot needs to be started before the human can use the cobot to make a movement. However, the other participants were scared, the activity would only contain pushing a button and they couldn't let this thought go.

The employees of KLM Engines

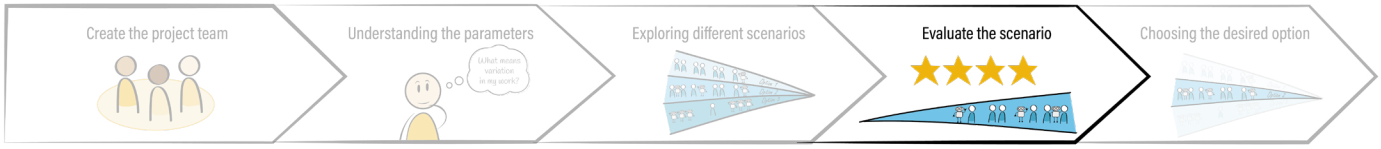
During the session, it became clear some of the activities of the workflow needed more detailed information, which could only have been provided by the employees of KLM Engines itself. As stated before, this was a missing factor and could have provoked even more in-depth discussions. For example, participant 1 stated: *"I don't know the exact actions that have to be taken by the employee and thus I do not exactly know what the cobot should be able to do".*

The game board

Figure 38: Creating a scenario with the game board

The game board includes all the activities of the workflow created in chapter 4. On the board, the activities are illustrated in separate compartments, in a particular order. Due to this way of visualising, the participants also treated the activities as separated, while sometimes, one robot or cobot could be involved in several activities. For example, participant 1 stated: *"Cobot KUKA would cause both 'programming the CMM' and 'using the CMM' to change. As a result, the programming becomes less and the use of the CMM changes in controlling the KUKA cobot."* The participants felt the current game board is too static to discuss these kinds of connections. However, this problem was foreseen and the 'activities sheet' was added to the tool components to note the eliminated and added activities. Nevertheless, the participants found it hard to also focus on more than one activity. For example, if a KUKA cobot would be involved in all measurement task, the activity 'measuring by hand' would disappear. These kinds of consequences were not discussed that thoroughly.

Step 4: Evaluate the scenario



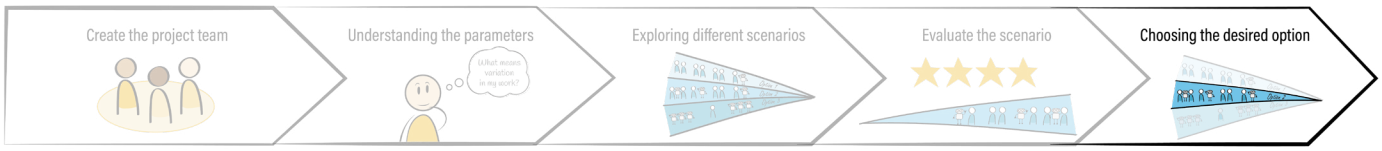
Estimate the consequences

After a scenario was created, the participants were asked to evaluate this scenario with the same evaluation criteria as in step 2. It was easier for the participants to do the evaluation, because they already got familiar with the evaluation criteria in the second step of the process. Even more than with the evaluation of the current workflow, the participants had trouble evaluating the evaluation criteria regarding meaningful work, because the employees themselves couldn't tell them exactly what they thought the consequences of the scenario would be on the meaningfulness of their work.
However, this resulted in interesting discussions, because the participants had to think of the possible consequences (both positive and negative). If an employee had been present at the session, the participants would probably have looked at them for the answers. In this way, the participants are prevented from thinking and reasoning themselves.

Being too positive

The participants tended to estimate all evaluation criteria a bit high. However, due to the variation in stakeholders, some critical questions were asked. For example, when the participants were talking about the evaluation criteria 'Does the employee have social interaction?' the participants first said this criterion was very high. However, participant 1 made the remark that robots taking over the 'bringing the component' activity would result in less social interaction. A remark was made back that if robots would take over some activities, more time was available to have social interaction. Sometimes, a more critical point of view was missed in this step of the co-design process.

Step 5: Choosing the desired option



The last exercise of the tool was choosing the desired option by discussing with the project team which evaluation criteria are most important to the organisation. Afterwards, the evaluation sheets could be compared and one of the scenarios could be chosen. However, due to the lack of time, this exercise could not be executed.

The ultimate goal

During the session, it became clear that choosing one scenario is not the ultimate goal of using the co-design tool. The discussion, getting inspired and realising the consequences of implementing robots are more valuable. Participant 3 said: *"I really get inspired by this tool and want to work on this further."* Participant 1 said: *"It was very interesting and taught me more about which activities to automate."*

Discussing the evaluation criteria

During the session participant 3 said: *"The social interaction might decrease and the employees will not like this, but it would be better for the efficiency."* This shows that he participants were already thinking of which evaluation criteria they find important and which they find less or not important. Determining this for each criterion can help the participants to choose which criteria to take into account in further implementation actions.

9.3 Assessing the design requirements

FRAIM and KLM Engines can use the tool to…

1. …bring together and involve different stakeholders in a fun and engaging way.
   The test of the co-design tool made it clear that different stakeholders are needed to share knowledge in order to understand the consequences of the implementation of robots. The tool includes components that meet the expertise of the different stakeholders and, in this way, involves them in the use of the co-design tool. The robot game board and robot cards helped to understand the basic knowledge, while detailed information could be provided by the participants. However, the current tool does not provide the organisation with a component or exercise to create the project team themselves. This could help to include the right people and convince them to actually join.

2. …get an understanding of the criteria for providing meaningful work for the employees of KLM Engines.
   The co-design the project team with a tool to get an understanding of the evaluation criteria regarding meaningful work. During the test, it became clear that letting the participants think about their own experiences was successful. However, some of the criteria could be even formulated more sharply to avoid participants getting confused about how to interpret the criteria.

3. …get an understanding of the criteria on how to reach the shared vision of the stakeholders involved in the implementation of robots.
   The co-design tool does not provide the project team with a tool to get an understanding of the evaluation criteria regarding the shared vision because these evaluation criteria are straightforward and not open for own interpretation. However, the criteria were not formulated sharply enough for the participants to understand them immediately.

4. …together explore the different possibilities of robotising the organisations' workflow.
   The game board and robot cards helped the participants to easily create different scenarios. As the robot cards could easily be added and removed, it stimulated the participants to make quick changes.

5. …get an understanding of the activities of KLM Engines inspection's workflow.
   Due to the visualisation of the activities of the workflow, the participants could easily discuss the different activities. A participant could point at one of the activities and ask direct questions or talk about specific actions. However, with some of the activities, a deeper understanding of the actions was missing, because none of the participants had this knowledge.

6. …get an understanding of the possibilities and limitations of robots.
   The large robot cards gave the participants some first ideas on the possibilities of robots and cobots. This motivated the participants to use them to create scenarios. The robot expert could use the cards to show alternative possibilities. The visualisations made it easier for the robot expert to communicate the possibilities. Besides, the presence of the robot expert is very important, as he/she can provide more detailed information.

7. …evaluating the scenarios to understand the consequences on the activities of the workflow.
   As stated before, the game board is very static with divided activities, following a particular order. This caused the participants to treat each activity very individually. They found it hard to see the consequences of the other activities. Although an activities sheet was provided to note down these consequences, the participants still weren't able to identify these consequences. As the tool is made with the methodology of game design, the game dynamics are designed to achieve certain aesthetics. Aesthetics is what the game players often recognize as 'fun'. The game dynamics of this co-design thus help to involve the stakeholders in a fun and engaging way.

8. …evaluating the scenarios to understand the consequences on the stakeholders.
   The co-design tool provides the participants with a tool to evaluate the created scenario through the evaluation criteria regarding meaningful work and the shared vision. Filling out the evaluation sheet caused a good discussion about the consequences of these criteria and made it visible. The participants could immediately see which criteria scored low or high. This resulted in the participants being motivated to improve the workflow.

9. …make a well-considered decision for one of the possibilities.
   During the session, the participant didn't have time to make a decision. Thus, this design requirement can not be assessed. As stated before, this design requirement should also not be the ultimate goal of the co-design session and therefore should be reformulated in the next iteration.

Chapter 10
The final concept

In this chapter, the insights from the test (described in chapter 9) are used to improve the design. During the test, it became clear some steps of the co-design steps need improvement, as well as some of the game dynamics.

10.1 A reiteration of the design requirements

In order to make a design that reaches the design goal, a number of design requirements are set up. The next section will explain how these requirements are met.

FRAIM and KLM Engines can use the tool to…

1. …bring together and involve different stakeholders in a fun and engaging way.
2. „get an understanding of the criteria for providing meaningful work for the employees of KLM Engines.
3. …get an understanding of the criteria on how to reach the shared vision of the stakeholders involved in the implementation of robots.
4. …together explore the different possibilities of robotising the organisations' workflow.
5. …get an understanding of the activities of KLM Engines inspection's workflow.
6. …get an understanding of the possibilities and limitations of robots.
7. …evaluating the scenarios to understand the consequences on the activities of the workflow.
8. …evaluating the scenarios to understand the consequences on the stakeholders.
9. „determine which evaluation criteria are important and which are less or not important.

10.2 A reiteration of the co-design tool

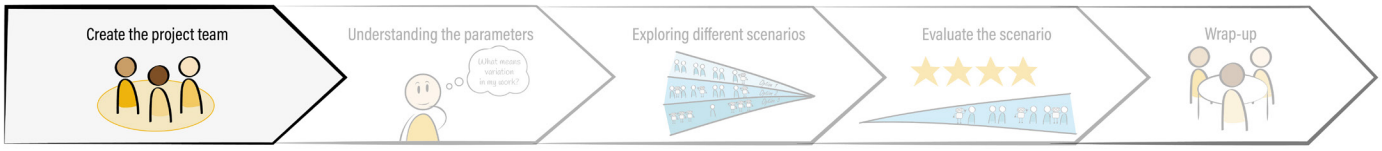
The session

During the session, it became clear that 1,5 hours is not enough time to go through each step of the process. The step 'understanding the evaluation criteria' turned out to be an important step of the process and should not be rushed. Besides, to be able to create and evaluate several scenarios, at least 2 hours are needed. In total, the session will take around 4 hours (see facilitator guide for timetable).

FRAIM as facilitator

During the session, it became clear a facilitator is needed to guide the project team through the co-design session. The facilitator functions as the expert of the co-design tool and knows how the tool should be used and what the intended outcomes are. The co-design tool is created for FRAIM, to be used by FRAIM and KLM Engines. The tool should be designed in such a way, FRAIM can not only provide the expertise of robots, but also facilitate during the co-design session.

Step 1: Create the project team



Instead of creating a project team in advance, FRAIM and KLM Engines should be involved in the creation of the project team. In this way, they are both more involved in the co-design session and it can be made sure, that the needed expertise is available. As a result of the research, the 'needed expertise' can already be determined

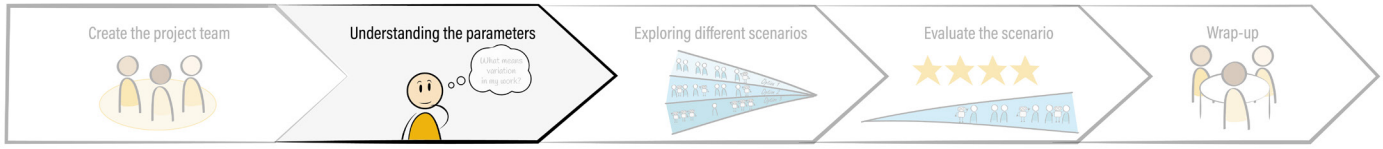
Team member:	Expertise:	From:
1. Facilitator	Expertise in the co-design tool. This team member knows how to use the co-design and can guide the other team members through the co-design session.	FRAIM
2. Robot expert	Expertise in robots and cobots. This team member knows the possibilities and limitations of the different kind of robots.	FRAIM/ Robohouse
3. KLM Engines work process expert	Expertise on the work process of KLM Engines. This team member knows everything about the strength and weaknesses of the activities and actions of the work process of KLM Engines and can thus imagine what the consequences of robotising the work process has on the activities itself.	KLM
4. Employee KLM Engines inspection department	Expertise on what the employees of KLM Engines feel, think and need. This team member is an employee and thus can imagine what the consequences of robotising the work process on the meaningfulness of work are. This team member can also provide the team with detailed information on the activities.	KLM
5. KLM Strategy expert	Expertise on the strategy of KLM. This team member knows everything about the bigger picture, looking at implementing robots. Where does KLM want to go in the future?	KLM
6. Brightsky expert	Expertise on the who is involved in the Brightsky project. This team member knows, which stakeholders need to be taken into account with the implementation of robots.	KLM/ FRAIM

Figure 39: The required team members of the project team

Game dynamic 1: creating the team

Team member cards are made to help FRAIM and KLM Engines choose the right team members (see final toolkit). To make this a fun and engaging activity, the cards are attached on a line and the line is hung in the meeting room, so everyone can see the team members of the project team.

Step 2: Getting familiar with the evaluation criteria



Reformulating the evaluation criteria

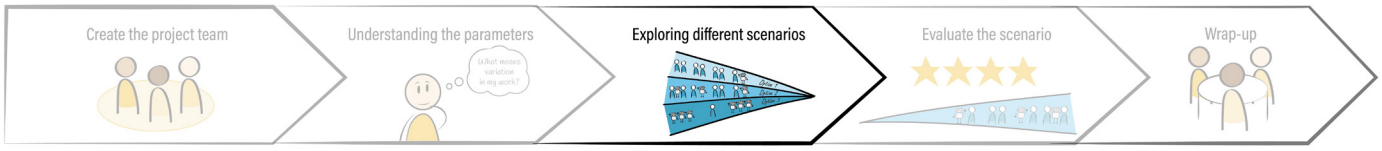
During the session, it became clear the formulation of the evaluation criteria caused confusion with the participants. However, after the criteria were explained further, the participants were able to work with them. Conclusively, the evaluation criteria need to be reformulated.

1. Has the amount of repairs increased? (Repaired vs end up at scrap)
2. Has the capacity increased? (Repairs per time)
3. Do the benefits of implementing robots outweigh the cost of it?
4. Do the challenges of the activities meet the employees' skills? (Not too boring, not too challenging)
5. Does the employee feel the responsibility is balanced? (Not too much, not too little)
6. Does the employee have a goal to reach?
7. Does the employee feel acknowledged by others?
8. Does the employee see and/or get feedback on their work?
9. Does the employee feel equal to others in the organisation?
10. Does the employee have social interaction?
11. Does the overall work provide the employee with enough variation?
12. Does the employee have enough possibilities for development & growth?

Game dynamic 2: evaluate the current scenario

During the session, it became evident this game element worked well, except for the evaluation criteria being too vague. That's why the evaluation criteria are reformulated.

Step 3: Exploring different scenarios



During the session, it became apparent a good base of the workflow is needed in order to create scenarios. Thus, a visualization of the workflow is needed.

Game dynamic 3: game board of the workflow

As stated before, the current game board is too static. As a result, the participants were not able to see the consequences of adding robots in the workflow on the activities. That's why the game board is made out of different building blocks, which can be easily added and removed from the game board. For example, if all measurements are done by cobot and human, the measuring by hand can be removed from the game board. In this way, the team is able to visualize and understand the consequences of robotising the workflow.

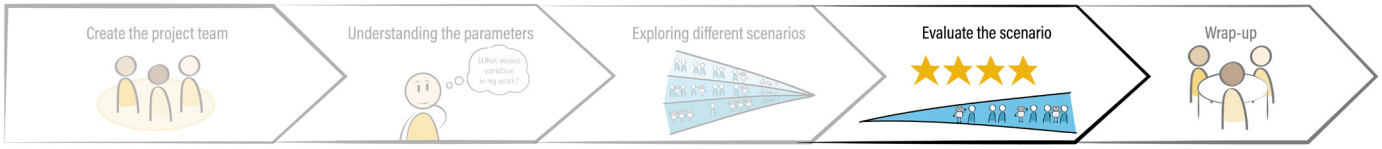
Game dynamic 4: large and small robot cards

The large robot cards provided the team members with basic information about robots and cobots and made it easy for the team to get started. The small robot cards provided the team with an easy way to remove and add robots and in this way create new scenarios easily. This game element will thus be kept the same.
During this step of the co-design process, one could determine that detailed information on the activities was missing. That's why one of the team members should be an employee of the inspection department. This team member knows the detailed action of each activity. Besides, an expert on the workflow should also be included in the team, as he knows the current bottlenecks. Besides, this team member has a good understanding of the consequences of robots on the efficiency of the workflow.

Game dynamic 5: spicing it up

To help the participants get started, they were asked to create a scenario if money didn't play a role. To help the participants to think of different scenarios (not only focussing on rating all evaluation criteria as high as possible), the participants are provided with some 'spice it up' additional options. For example, the team could be split into two groups. One group focuses on creating a scenario to optimise the workflow, while the other group focuses on optimising the meaningfulness of work. Afterwards, the group can come together and discuss the outcomes. Then, the consequences of robotisation become even more clear.

Step 4: Evaluate the scenario

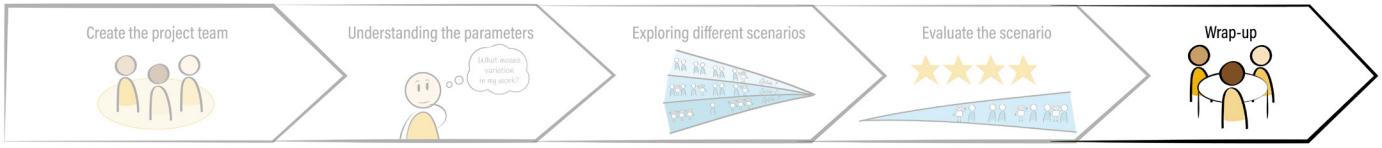


During this step of the co-design session, the team members intended to rate the created scenario high on each elevation criteria. To make sure, the team is able to look more critically at the evaluation criteria, more stakeholders have to attend the session. Each team member has its own point of view and in this way ,deeper and more critical discussions will occur.

Game dynamic 6: evaluation criteria cards

To help the team to understand the evaluation to look critically at the evaluation criteria, the criteria are visualized on criteria cards. The team can look at these cards to see and comprehend where the criteria come from.

Step 5: Choosing the desired option



The last step of the co-design has changed. During the session, one could learn that choosing the desired option should not be the ultimate goal of the session. Instead, getting inspired, sharing knowledge and understanding the consequences of robotising the workflow on all stakeholders is more important. However, the co-design session should have a wrap-up in order to determine what is achieved during the session and to think and evaluate about how to continue.

Game dynamic 7: evaluation criteria cards

The participants are asked to share one key-take away of the co-design session and how they will use this for next steps. In this, way the participants are encouraged to reflect on the co-design session and think about what further steps to take.

10.3 Toolkit materials

An overview of the final toolkit is visualised in figure 40.

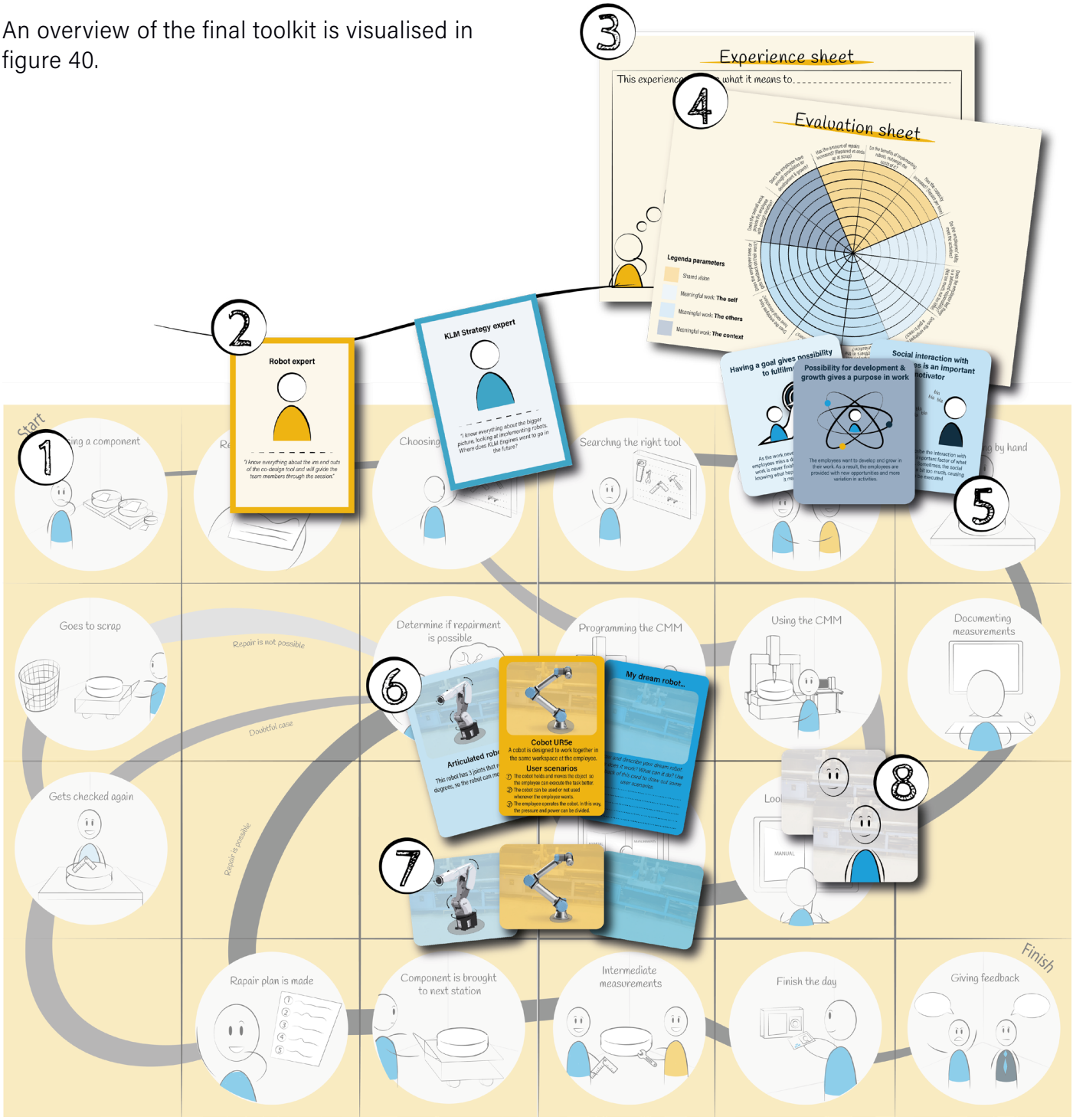


Figure 40: The toolkit of the co-design tool

Materials

1. Gameboard representing KLM Engines' inspection's department
2. Team member cards
3. Experience sheet
4. Evaluation sheet
5. Evaluation cards 'meaningful work'
6. Large robot cards
7. Small robot cards
8. Employee cards

Chapter 11
Evaluation of the concept

In this chapter, the final concept is evaluated. The evaluation is done according to the human-centered design methodology introduced in the introduction. Ultimately, the final concept is assessed on whether it is desirable, feasible and viable.

It is crucial to evaluate the final concept to examine if the co-design tool is desirable, feasible and viable for both KLM Engines and FRAIM. As this is a significant and complex problem, the focus has been on the robotisation of KLM Engines, but does it also fulfil FRAIM's needs?

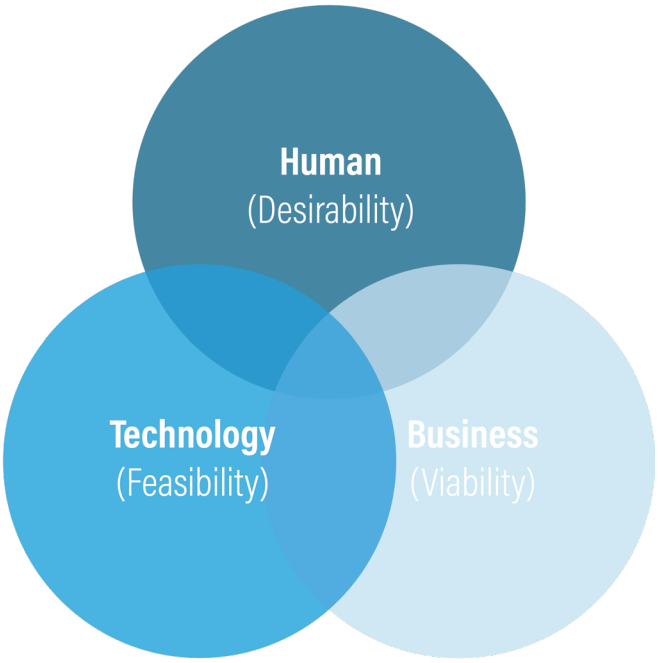


Figure 41: Viability, Feasibility & Desirability

Desirability

In this project, several human-centered research and design methodologies are used. In the research phase, the stakeholders' intentions are identified and used in designing of the co-design tool. Furthermore, the stakeholders are also involved in creating a shared vision. The final concept is a co-design tool, meaning the stakeholders are involved in creating the final design. The end 'product' is not yet determined but depends on what the stakeholders create together. Thus, the co-design tool is not only based on human insights but also includes the humans' input in its use. Additionally, the co-design tool brings different stakeholders and thus diverse expertise together, exploring other possibilities. By evaluating the scenarios, the desirability of the scenario is tested immediately.

The final concept educates FRAIM about the ins and outs of the KLM Engines' workflow and employees. At the same time, FRAIM can educate KLM Engines about the possibilities and limitations of robots. Knowledge is provided by the game dynamics and the exchange of expertise by the participants.

It can be concluded that the final concept is desirable for both KLM Engines and FRAIM, as

Viability

they are provided with the knowledge and skills they lack to create a solution together. During the project, a future shared vision is created to ensure the final concept contributes to 'optimising' the organisation for the long term. Especially with a costly investment, such as robotisation, the innovation must contribute to long-term impact. On the one hand, in the co-creation session for creating a shared vision, it was suggested that the aviation industry might change entirely and the industry as we know it now might not exist anymore.

As the final concept considers the current workflow, it does not include the other future possibility. However, by making the final concept dynamic, the impact on the workflow becomes visible and different future options can be explored. Besides, by involving a strategy expert, critical questions about the viability of the scenarios will be raised. On the other hand, the current concept assumes KLM Engines will still repair aircraft and other related Engines.

The final concept only concerns the workflow of KLM Engines. After finishing the project at KLM, FRAIM needs to create another concept for the following organisation. This means the co-design can not be considered very viable. This project did not only provide FRAIM with the co-design tool, but also with an approach and methods to tackle the challenge of robotising an arbitrary workflow. FRAIM can use these methods in future projects.

Considering viability, this project doesn't take the aspect of financial resources into account. It is expected that the stakeholders will address

Desirability

this topic during the use of the co-design tool. However, it is essential to acknowledge that this should be researched further (this will be further discussed in chapter 13).

The combination of expertise in robots and expertise in the organisation provides KLM Engines and FRAIM to discuss the feasibility of

the created scenarios. The questions that can be answered are: "What can be done?" (expertise in robots) and "Can the organisation do it?" (expertise in KLM Engines). The co-design tool also visualises the effect of robotisation on the workflow. In this way, FRAIM and KLM Engines can discuss what activities must be executed by the employees and if the needed skills are present.

Conclusion

The co-design tool can certainly be considered desirable, viable and feasible. However, as in any design project, more work can be done to improve the three factors (these will be further discussed in chapter 13). The focus of the co-design tool is mainly on the desirability aspect by including stakeholders throughout the whole process and the feasibility by combining different expertise. Especially for the viability, there is still a lot of room for improvement to ensure the co-design tool provides KLM Engines and FRAIM with a good tool for the future.

Section 5

Evaluating the project

In this section, the project is evaluated. In chapter 12, the project is concluded and an answer is given to the research questions. In chapter 13, the project itself is evaluated and design recommendations are set up. In chapter 14, a personal reflection of the graduation process is given.

Chapter 12
Conclusion

In this chapter, conclusions about the project will be drawn. This chapter will give an answer to the research questions and reflect on the different sections.

This project started with the question: How can we help FRAIM & KLM Engines to im-plement robots within the parameters of the stakeholders' values? A human-centered de-sign approach is used to answer this question. In a human-centered design approach, technological feasibility is combined with the organisations' and employees' values, needs and resources.

Robots are getting more accessible in the industry, forcing organisations to use the newest technologies to compete with others. The original robot is made to take over human tasks if it can execute them faster than humans. However, it is acknowledged that this way of implementing robots, affects the meaningfulness of work negatively. Cobots were introduced as a way to solve this problem, but as with many innovations, research should be done on how to do this right.

This project includes a so-called fuzzy front end, because, at the beginning, it is not yet clear what the actual problem is and what direction the project should go. That's why elaborated research was carried out.

A stakeholder analysis was done to discover which stakeholders to involve in the im-plementation of robots. Here, the KLM Group, the government, and the employees are identified as essential stakeholders.

During a co-creation session, participants representing the stakeholders were gathered to share their needs and values and to explain their intentions for implementing robots. The contradictions and similarities were exposed. These were compromised and trans-formed into a shared vision for the implementation of robots. Giving meaning to 'opti-mising' the workflow. This shared vision is: *'In the future, KLM Engines will have a hu-man-technology balanced workplace that enables the organisation to repair more and bet-ter, so the process becomes more efficient and sustainable in order to become number one in the marketplace.'*

The stakeholder that has little power and thus is often forgotten with the implementa-tion of robots, is the employee. However, they are most affected by it. As this project tries to involve the human, themes which make work meaningful for the employees of KLM Engines are identified. The nine themes are conditions of meaningful work, which can be negatively or positively affected by the implementation of robots.

The insights of the research are carefully analysed in order to identify the right problem. As all research was carried out with the stakeholders involved, it became clear that the actual challenge occurred in these stakeholders' knowledge and skills gap. The stake-holders are unaware of the other's needs and values. However, the knowledge of how to serve these needs and how this will affect the stakeholders is already there, divided among the stakeholders. This challenge resulted in the following design goal: *'The goal is to design a co-design tool which enables the essential stakeholders involved in robotis-ing KLM Engines' workflow to exchange expertise in order to explore the possibilities and limitations of robots and understand their consequences on the stakeholders' values.'*

As this design goal was created in several iterations, the choice for a co-design was al-ready made. This choice is made, because the challenge fits well with the concept of co-design. Co-design is often used to bring stakeholders together, so they can share knowledge and skills in order to create a design that couldn't be created alone. Before the co-design was created, design requirements were set based on the research in-sights.

An analysis of co-design tools was made to identify design directions. Game design was chosen and this concept was explored further. A game design uses gamification, which is the use of game elements, to make a co-design engaging and fun. In this pro-ject, game design allows the participants to explore different scenarios and share their expertise. Game design consists of aesthetics, dynamics and mechanics. The aesthet-ics 'fellowship', 'discovery' and 'expression' are chosen as they serve the design goal the most. The game dynamics of the co-design tool are designed to achieve these aesthet-ics.

The creation of the co-design consisted of two parts. Firstly, a process was created that the participants should go through with the help of the co-design tool. This process is based on the design requirements and is meant to break down the design goal in smaller steps. Secondly, per

step, the game dynamics were created. As an elaborated test was done, this project consists of a complete iteration of the process and game dynamics.

The first step of the co-design process was the creation of a project team. The co-design session must present the expertise needed to explore the possibilities of robotis-ing the workflow and understanding the consequences. The team members should rep-resent the stakeholders involved during the research phase, plus robort experts from FRAIM.

The second step of the co-design session is getting an understanding of the evaluation criteria. As stated before, the stakeholders have different needs and values, which can be seen as conditions to 'optimise' the workflow. The team members need to under-stand these conditions to evaluate the scenarios of robotisation and understand the consequences for the stakeholders.

The third step of the co-design session is creating scenarios. The stakeholders often don't know the possibilities and limitations of robots, while FRAIM doesn't know the ins and outs of the workflow. By exploring different scenarios, knowledge is shared.

The fourth step of the co-design session is evaluating scenarios. The stakeholders need to understand the consequences of the stakeholders. Serving all stakeholders' needs ensures they keep involved and provide the KLM Engines with the required re-sources, for example, financial support.

The fifth step is wrapping up the session. The team members have shared knowledge and skills to create different scenarios. Afterwards, they evaluated the scenarios ac-cording to the conditions created according to their values and needs. The team know wraps up the co-design session by discussing what they've learned and how they take these learnings into further workflow development.

The co-design tool consists of a toolkit, including elements that help the team go through the co-design process.

It can be concluded that FRAIM and KLM Engines mostly needed help bringing knowledge, expertise and skills together to explore the possibilities of robotising the workflow. Furthermore, the values must be exposed to understand the consequences of robotising on these stakeholders. Acknowledging that these values have contradic-tions and thus might not all be served by implementing robots.

What can FRAIM learn from this project?

The challenge within robotising the workflow of an organisation is to bring together the right stakeholders to share their knowledge and skills. As a result, the possibilities and limitations of robotising their workflow are discovered and the consequences on the stakeholders are identified. While this project focuses on KLM Engines, some conclusions can be drawn in order to help FRAIM go through the process with another organisation.

Before the stakeholders can be gathered, some prior research should be done:

- The essential stakeholders should be identified. These stakeholders have either high power (by providing resources) or high interest (and depending on the work). This can be done through interviews with the organisation's employees or literature research.
- The stakeholders' values and needs must be identified. It is not only important for FRAIM to know why the stakeholders require robots, but also the stakeholders themselves should realise their own and others' values. Taking these values into account with the development of the organisation, keeps all stakeholders satisfied and engaged.
- A future vision must be created. This vision should include all essential stakeholders' values. As a result, not only the current stakeholders' values but also the future ones can be taken into account. This can be done through participatory research or trend research.
- The employees who get most affected by the implementation of robots should be involved. This project focuses on the meaningfulness of work. Meaningful work contributes to job satisfaction and personal well-being.

FRAIM should also function as a facilitator, to bring the essential stakeholders together to share knowledge and use their expertise in order to explore the possibilities and limitations of robotising the workflow. The co-design is just a means to achieve this goal and understand the consequences. The research insights are in this co-design used as evaluation criteria for the scenarios, to assess if the scenarios contribute to the stakeholders' values.

The design tool should be treated as dynamic and adjustable. It helps FRAIM and any future organisation to realise the implementation of robots according to the stakeholders' values, including the company's goal and the employee's need for meaningful work.

FRAIM should keep acting. An essential insight from this project is the demand to keep talking and testing. With each research or design step of this project, new insights were gathered. These insights helped to continue the project and create the co-design tool. FRAIM should also keep talking to employees and organisations and test their innovations regularly to ensure that the values of the stakeholders are met.

Chapter 13
Reflecting on the project

In this chapter, a reflection on the project is discussed. The approach followed steps and outcomes will be reflected on. Besides, future research & design recommendations will be given.

Limitations of the project (content)

Preparation

The project has a fuzzy front end, which means a lot was unclear at the beginning of the project. Besides, my lack of prior knowledge about FRAIM, robots and KLM Engines resulted in the problem being unidentified for a long time. The project actually required some more preparation time, to determine the main focus of the project.

The stakeholders

In chapter 2, three essential stakeholders are identified. During the research phase, the stakeholders are involved to ensure their needs and values are taken into account. However, the final participants were only a representation of the stakeholders, with similar intentions. For example, the government was represented by a participant of KLM Engines with a high interest in the sustainability of the organisation. However, as the participant is not from the government, but from KLM Engines, the actual values and needs will probably differ.
That said, as the stakeholders are represented by humans with personal values and needs, the insights are also depending on them. To prevent these personal values from outshining the business values, the co-creation session for the shared vision, included an exercise in which the participants could share their individual intentions. Afterwards, the participants were asked to let these presumptions go during the rest of the session. However, it is impossible to completely remove this bias.

The workflow

The workflow that is mapped out consists of the activities of a normal work day at the inspection department. The main work activity of the inspection department is measuring. However, it was difficult to dive deeper into the actual measuring actions. What tools are used? What are the actions of using the CMM machine? During the context mapping session, it became clear that the measuring activities are not necessarily making work meaningful. However, during the co-design session, some details on the measuring activities were lacking.

The evaluation criteria

The shared vision and themes of meaningful work are transformed into evaluation criteria. These can be seen as conditions for 'optimising' the workflow from the stakeholders' point of view. However, the evaluation criteria do not show how important they are considered. This is partly on purpose, as the project team can determine the importance during the co-design session. Partly, because the importance did not emerge during the research phase.

The co-design session

During the co-design session, the co-design tool was tested to discover if the tool would reach the design requirements and how the tool could be improved. The project team was carefully created, so the needed expertise is present during the co-design session. However, not all participants showed up. This was caused partly by the fact that the importance was not enough emphasized in the invitation and partly because student projects are generally not prioritised.

Viability

One aspect of the human-centered design approach is including the viability of the innovation. In this project, the viability is researched by including a KLM E&M strategist in the co-creation of the shared vision. This stakeholder is responsible for representing the organisation's needs. In the case of KLM Engines, this evolves mostly around increasing profit or decreasing costs. During the co-design session, the participants have to estimate if this is actually achieved by the created scenario. However, it is difficult to know if it will actually be profitable in both the short and the long term The project only focuses on the shared vision, created during the co-creation session. It neglects the other possible future scenarios.

Other departments

The research question concerns KLM Enginen, while this project only focuses on the inspection department. It was needed to scope down the project, to go through the whole design process in the given time. The mapped-out workflow is of the inspection department, this is also the one used in the co-design tool. To customise the co-design for other departments, these workflows also have to be mapped out.

Research and design recommendations

The co-design tool

This project includes an elaborate test and iteration of the co-design tool. As stated before, not all participants showed up, which resulted in a lack of expertise. Therefore some assumptions and estimations had to be made. It would be a advised to test the co-design tool again. This time making sure all participants are there.

Other future visions

As stated before, the co-design is based on the future vision created in the co-creation session. However, this vision is based on the knowledge and skills of the participants involved. Further research could be done on other future visions through, for example, a trend analysis. Other future visions could also be transformed in evaluation criteria, to be used in the co-design tool. By considering other visions, a more viable outcome could be created.

Other departments

As aforementioned, the focus of the co-design tool is on the inspection department of KLM Engines. The tool has to be adapted to other departments' workflow to be able to use the co-design tool for other departments. However, the co-design helps KLM Engines to learn about the possibilities and limitations of robots and to understand the consequences of implementing robots on the stakeholders' values. By applying the tool to one department, this goal is already achieved and the knowledge could be used to determine how to implement robots in the other departments. Furthermore, it will show which insights fromt this project are department related and which not.

Other organisations

As this project is executed on behalf of FRAIM, it would be an excellent opportunity to explore how the outcomes of this project can be used in other organisations. In the conclusion, the learnings of this projects are presented. These learnigns can be used by FRAIM in collaboration with other organisations.

If research is carried out at other organisations, it can determined which research insights are dependent on the individual organisation and which can be applied in the general context.

Chapter 14
Personal reflection

In this chapter a personal reflection is given. What did I learn from this project? What did go well and what didn't? What would I do different next time?

Finding a project that fits you completely is complex, time-consuming, and maybe even impossible. However, this graduation project is my last project as a student and from the moment I started searching for a project, I was highly motivated to make it a successful one. The first time Mieke referred me to this project, I was not very enthusiastic. What do I, as a strategic designer, have to do with robotics, a technology I don't know much about? However, as I liked the work Mieke does, I decided to dive deeper into the possibilities around this project. Instead of avoiding a topic, I don't know much about, I considered it a massive, interesting new challenge.

From the start, it was clear that this project would be complex, with many stakeholders involved. I did not know much about the topic or stakeholders, so a fuzzy front-end project was set up. It was a challenge to discover which and how stakeholders could be involved. To scope the project, I decided to focus on KLM Engines and then on only the inspection department early on. Setting boundaries is something I find very difficult. In this project, I tried to set some from the beginning. However, the research phase still took very long, while I was searching for the right direction. As a result, the workload wasn't distributed proportionately, as I had to work very hard during the design phase. Nevertheless, this resulted in a complete project, including an elaborated research and design phase.

In the research phase, a combination of different methodologies was used. These methods I often used during my internship at Muzus. However, this was the first time setting a project up from scratch and doing all the research alone. In this project, research was done with different stakeholders from different levels of education and profession, a huge challenge that needs different approaches.

An important learning objective of this project is using all stakeholders' insights to identify the right problem. It wasn't easy accepting the fuzziness of the project and keep making progress. I tried to cope with this difficulty by regularly zooming in and out on the project. This sometimes resulted in diving too deep into the project, while it made it too general at other moments. Nevertheless, it helped me manage the complexity and dive deep enough to create a concrete design.
Another learning from collaborating with stakeholders is communicating with different people. Stakeholders with diverse expertise speak other languages than a designer and it is always a challenge to find a good way to communicate with them. Nevertheless, as a designer, I am already used to working with different stakeholders. However, within this project, another challenge occurred, as I had to bring stakeholders together and make sure they would understand each other as well.

A key learning for me throughout the project was how to ask for help. More specifically, how to plan out all the relevant problems that I have identified, the answers that I have, the answers that I still need to figure out and lastly the answers for which I need assistance. Asking peers for help not only helped me zoom in and out of the project, but also helped me incorporate new ideas and problems that sometimes go missing in the "tunnel vision". This project illustrated that other people can offer different perspectives and opinions. Incorporating differing views helped me strengthen the reasoning of my decisions.

Sometimes I took research or design steps that did not end up in the final version of this project, thus felt like a waste of time. However, now I realise that taking the first step is sometimes needed in order to set limits and boundaries to your research and to figure out what you do not know and where you need help.

As for the design phase, I wanted to make the first concept, test and evaluate it, so this evaluation could be used to create an iteration. My supervisory team motivated me to do the test before the green light of this project, which gave me proper time to evaluate the co-design tool and take it a step further. This was a pre-set learning objective, as my projects usually end after a first ideation round.

References

1. AmsterdamLogistics (2021) Extra geld voor verduurzaming luchtvaart in project BrightSky op Schiphol. Retrieved from https://amsterdamlogistics.nl/extra-geld-verduurzaming-luchtvaart-project-brightsky-schiphol/

2. Amabile, T. M. (1997). Motivating Creativity in Organizations: On Doing What You Love and Loving What You Do. California Management Review, 40(1), 39–58. https://doi.org/10.2307/41165921

3. Ashmos, D. P., & Duchon, D. (2000). Spirituality at Work A Conceptualization and Measure. Journal of Management Inquiry, 9(2).

4. Barbosa, G. F., Shiki, S. B., & Da Silva, I. B. (2020). R&D roadmap for process robotisation driven to the digital transformation of the industry 4.0. Concurrent Engineering, 28(4), 290–304. https://doi.org/10.1177/1063293x20958927

5. Bailey, C., & Madden, A. (2016). What Makes Work Meaningful - Or Meaningless. MIT Sloan Management Review.

6. Brandt, E., & Messeter, J. (2004). Facilitating Collaboration through Design Games. Proceedings Participatory Design Conference. https://doi.org/10.1145/1011870.1011885

7. Burkett, I. (2017). An Introduction to Co-design. The Australian Centre for Social Innovation. http://ingridburkett.com/wp-content/uploads/2017/09/Introduction-to-Codesign-2.pdf

8. Cambridge Dictionary. (2022). Robotics definition. Retrieved February 9, 2022.

9. Cambridge Dictionary. (2022). process definition: Retrieved June 22, 2022, from https://dictionary.cambridge.org/dictionary/english/process

10. Charalambous, G., Fletcher, S., & Webb, P. (2015). Identifying the key organisational human factors for introducing human-robot collaboration in industry: an exploratory study. The International Journal of Advanced Manufacturing Technology, 81(9–12), 2143–2155. https://doi.org/10.1007/s00170-015-7335-4

11. Cruickshank, L., & Evans, M. (2012). Designing creative frameworks: design thinking as an engine for new facilitation approaches. International Journal of Arts and Technology, 5(1), 73. https://doi.org/10.1504/ijart.2012.044337

12. Duke, R. D. (1980). A Paradigm for Game Design. Simulation & Games, 11(3), 364–377. https://doi.org/10.1177/104687818001100308

13. el Makrini, I., Elprama, S. A., van den Bergh, J., Vanderborght, B., Knevels, A. J., Jewell, C. I., Stals, F., de Coppel, G., Ravyse, I., Potargent, J., Berte, J., Diericx, B., Waegeman, T., & Jacobs, A. (2018). Working with Walt: How a Cobot Was Developed

14. Evans, M., & Terrey, N. (2016). Evidence-based policy making in the social sciences (1ste editie). Amsterdam University Press.

15. EVS. (2021). What are the Different Types of Industrial Robots. EVS Robot. Retrieved 29 maart 2022, van https://www.evsint.com/industrial-robots-types/

16. Galvagno, M., & Dalli, D. (2014). Theory of value co-creation: a systematic literature review. Managing Service Quality, 24(6), 643–683. https://doi.org/10.1108/msq-09-2013-0187

17. Ghee, R. (2017, 13 februari). Air France-KLM's 'customer intimacy' strategy: new technologies, human interaction and innovation. Future Travel Experience. Retrieved 3 maart 2022, from https://www.futuretravelexperience.com/2017/02/air-france-klms-customer-intimacy-strategy/

18. Giacomin, J. (2014). What Is Human Centered Design? The Design Journal, 17(4), 606–623. https://doi.org/10.2752/175630614x14056185480186

19. Guendelsberger, E. (2019, 18 juli). I Worked at an Amazon Fulfilment Center; They Treat Employees Like Robots. Time. Retrieved 4 maart 2022, from: https://time.com/5629233/amazon-warehouse-employee-treatment-robots/

20. Hunicke, R., LeBlanc, M., & Zubek, R. (2004, July). MDA: A formal approach to game design and game research. In Proceedings of the AAAI Workshop on Challenges in Game AI (Vol. 4, No. 1, p. 1722).

21. Järvinen, A. (2005). Theory as Game: Designing the Gamegame. Proceedings of DiGRA 2005 Conference: Changing Views. http://www.digra.org/wp-content/uploads/digital-library/06276.43287.pdf

22. Kazadi, K., Lievens, A., & Mahr, D. (2016). Stakeholder co-creation during the innovation process: Identifying capabilities for knowledge creation among multiple stakeholders. Journal of Business Research, 69(2), 525–540. https://doi.org/10.1016/j.jbusres.2015.05.009

23. Lee, D. (2019). Human staff will always be needed, Amazon insists. BBC News. Retrieved 4 maart 2022, from https://www.bbc.com/news/technology-48590628

24. Lingmont, D. N., & Alexiou, A. (2020). The contingent effect of job automating technology awareness on perceived job insecurity: Exploring the moderating role of organisational culture. Technological Forecasting and Social Change, 161, 120302. https://doi.org/10.1016/j.techfore.2020.120302

25. Maher, L., & Robert, G. (2018). Experience Based Co-Design. https://ahha.asn.au/EBCDtoolkit/files/downloads/EBCD%20toolkit%20Final.pdf

26. McDonagh, D., Hekkert, P., Van Erp, J., Gyi, D., & Van Erp, J. (2003). Design and Emotion. Amsterdam University Press.

27. Ministerie van Algemene Zaken. (2022, 13 mei). Rijksoverheid stimuleert duurzame energie. Duurzame energie | Rijksoverheid.nl. Retrieved 21 juni 2022, from https://www.rijksoverheid.nl/onderwerpen/duurzame-energie/meer-duurzame-energie-in-de-toekomst#:%7E:text=Nederland%20werkt%20aan%20een%20energiesysteem,2%2Dreductiedoel%20van%2055%25.

28. Nakamura, J., Csikszentmihalyi, M. (2014). The Concept of Flow. In: Flow and the Foundations of Positive Psychology. Springer, Dordrecht. https://doi.org/10.1007/978-94-017-9088-8_16

29. Newcombe, R. (2003). From client to project stakeholders: a stakeholder mapping approach. Construction Management and Economics, 21(8), 841–848. https://doi.org/10.1080/0144619032000072137

30. NOS. (2020). Waar ging het mis tussen KLM, de vakbonden en Hoekstra? Retrieved 3 maart 2022, from https://nos.nl/artikel/2355053-waar-ging-het-mis-tussen-klm-de-vakbonden-en-hoekstra

31. Pratt, M., Lepisto, C. & Doug A. Doing Well, Doing Good and Doing with: Organizational Practices for Effectively Cultivating Meaningful Work. Purpose and Meaning in the Workplace, edited by Bryan J Dik et al., American Psychological Association, 2013, pp. 173–96.

32. Privitera, M. B., & Pancioli, A. (2015). Contextual Inquiry for Medical Device Design. Elsevier Gezondheidszorg. https://doi.org/10.1016/B978-0-12-801852-1.00006-X

33. Rauankyzy, A. (2020) The Influence of robots on human life and their application in the modern world. Science and practice: implementation to modern society.

34. Rezghi Rostami, A., Valmohammadi, C., & Yousefpoor, J. (2014). The relationship between customer satisfaction and customer relationship management system; a case study of Ghavamin Bank. Industrial and Commercial Training, 46(4), 220–227. https://doi.org/10.1108/ict-10-2013-0067

35. RoboHouse. (2022, 7 juli). About _. Retrieved 4 augustus 2022, from https://robohouse.nl/about/

36. Rosso, B. D., Dekas, K. H., & Wrzesniewski, A. (2010). On the meaning of work: A theoretical integration and review. Research in Organizational Behavior,

30, 91–127. https://doi.org/10.1016/j.riob.2010.09.001

37. Rothausen, T. J., & Henderson, K. E. (2018). Meaning-Based Job-Related Well-being: Exploring a Meaningful Work Conceptualization of Job Satisfaction. Journal of Business and Psychology, 34(3), 357–376. https://doi.org/10.1007/s10869-018-9545-x

38. Sailer, M., Hense, J. U., Mayr, S. K., & Mandl, H. (2017). How gamification motivates: An experimental study of the effects of specific game design elements on psychological need satisfaction. Computers in Human Behavior, 69, 371–380. https://doi.org/10.1016/j.chb.2016.12.033

39. Sainato, M. (2020). 'I'm not a robot': Amazon workers condemn unsafe, grueling conditions at warehouse. The Guardian. https://www.theguardian.com/technology/2020/feb/05/amazon-workers-protest-unsafe-grueling-conditions-warehouse

40. Sangasubana, N. (2014). How to Conduct Ethnographic Research. The Qualitative Report. https://doi.org/10.46743/2160-3715/2011.1071

41. Smids, J., Nyholm, S., & Berkers, H. (2019). Robots in the Workplace: a Threat to—or Opportunity for—Meaningful Work? Philosophy & Technology, 33(3), 503–522. https://doi.org/10.1007/s13347-019-00377-4

42. Spinuzzi, C. (2005). The Methodology of Participatory Design. Technical Communication, 52(2).

43. Technische Universiteit Delft. (z.d.). FRAIM. TU Delft. Retrieved 3 maart 2022, from https://www.tudelft.nl/innovatie-impact/samenwerken-met-tu-delft/samenwerken/fraim

44. Tsarouchi, P., Matthaiakis, A.S., Makris, S. & Chryssolouris, G. (2017) On a human-robot collaboration in an assembly cell, International Journal of Computer Integrated Manufacturing, 30:6, 580-589, DOI: 10.1080/0951192X.2016.1187297

45. Vaajakallio, K., & Mattelmäki, T. (2014). Design games in codesign: as a tool, a mindset and a structure. CoDesign, 10(1), 63–77. https://doi.org/10.1080/15710882.2014.881886

46. Van der Bijl-Brouwer, M., & Watson, R. (2015). DESIGNING FOR THE DEEPEST NEEDS OF BOTH PUBLIC SERVICE CONSUMERS AND PROVIDERS; INNOVATION IN MENTAL HEALTH CRISIS RESPONSE In: Proceedings of the 20th International Conference on Engineering Design (ICED15), Vol. nn: Title of Volume, Milan, Italy, 27.-30.07.2015

47. Visser, F. S., Stappers, P. J., Van der Lugt, R., & Sanders, E. B. N. (2005). Context mapping: experiences from practice. CoDesign, 1(2), 119–149. https://doi.org/10.1080/15710880500135987

48. Vysocky, A., & Novak, P. (2016). HUMAN – ROBOT COLLABORATION IN INDUSTRY. MM Science Journal, 2016(02), 903–906. https://doi.org/10.17973/mmsj.2016_06_201611

49. Welfare, K. S., Hallowell, M. R., Shah, J. A., & Riek, L. D. (2019). Consider the Human Work Experience when Integrating Robotics in the Workplace. IEEE.

50. Wierzbowski, P. (2019). Cobotization As A Key Element In The Functioning Of Smart Factories And A Next Step In The Automation Of Logistic Processes. Transport Economics and Logistics, 82, 171–183. https://doi.org/10.26881/etil.2019.82.15

51. Wrzesnieuwski, A., LoBuglio, N., Dutton, J. E., & Berg, J. M. (2013). Job Crafting and Cultivating Positive Meaning and Identity in Work. Advances in Positive Organizational Psychology, 1(281–302).

52. Zamenopoulos, T. and Alexiou, K. (2018). Co-design As Collaborative Research. Connected Communities Foundation Series. Bristol: Bristol University/AHRC Connected Communities Programme.

Appendices

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APPENDIX A: EXPERT INTERVIEW

Expert interview KLM Engines (Dutch)

Interviewee: Jelle Menges
Interviewer: Tosca Horstink
Datum: 11-03-2021
Achtergrond: Jelle werkt bij KLM E&M als continuous improvement lead.
Doel van het interview: bevestigen en genereren van de interne structuur, het proces en de betrokkenen. Een eerste kijk in de visie op de automatisering van het proces van KLM E&M.

Voorstelronde Tosca & Jelle

Werken bij KLM E&M

1. Wat doe je op dit moment bij KLM E&M? "Ik ben continuous Improvement Lead. Ik ben eigenlijk altijd bezig met het verbeteren van de werkplek voor de werknemers en ben daarom ook veel met hen in contact."
2. Kun je me vertellen hoe je bij KLM E&M terecht bent gekomen?
    a. Wat heb je gestudeerd? "Bedrijfskunde"
    b. Hoe ben je nu bij deze functie gekomen?
3. Waarom heb je voor KLM (E&M) gekozen?
4. Voldoet KLM E&M aan je verwachtingen tot nu toe?
    a. Waarom wel? Of waarom niet?

Structuur & proces bij KLM E&M

Structuur

1. Kun je vertellen hoe KLM E&M in elkaar zit? Hoe zit het hiërarchisch in elkaar? "Dit is best wel gecompliceerd. We bestaan uit drie verschillende organisaties; KLM, KLM Airfrance & Airfrance zelf. Deze hebben alle drie een eigen CEO. Binnen deze organisaties is er een aparte E&M afdeling. Deze bestaat uit drie verschillende subafdelingen; engines, airframe en components. Deze afdelingen hebben elk hun eigen manager."
2. *De interne structuur die van te voren is gemaakt laat ik zien* Klopt dit een beetje? Wat klopt er wel? Wat klopt er niet? "Dit is de structuur die past bij de afdeling comnponents, wij zitten dus iets anders in elkaar. De verschillende afdelingen bij Engines heb je net gezien."
3. Welke stakeholders moeten er worden toegevoegd/verwijderd?
4. Wie nemen de belangrijke beslissingen? "Dat ligt eraan hoe belangrijk de beslissing is. Als we kijken naar de implementatie van robots moeten we vooral kijken naar de EVP van E&M en de VP van Engines binnen KLM. Ook zullen de E&M afdelingen van KLM Airfrance en Airfrance ook meekijken, misschien dat ze zelf ook dingen kunnen overnemen. Binnen E&M (KLM) is er een geldpotje. De EVP van E&M bepaald wat er met dat geld gebeurd."

Repair & Maintenance Proces

1. * Het vooraf gemaakte proces wordt laten zien* Klopt dit proces? Wat klopt er niet? Wat klopt er wel? "Dit proces is dus meer het proces bij de line maintenance. Bij ons werkt het zo: de motoren worden eerst uit elkaar gehaald bij disassembly in zogenoemde modules. De modules die moeten worden onderzocht worden verder uit elkaar gehaald in kleinere onderdelen. Deze onderdelen worden vervolgens schoongemaakt. Daarna worden ze op verschillende manier gecontroleerd op scheurtjes, intern en extern. Dan gaan de onderdelen naar inspectie, hier worden ze verder onderzocht en wordt er een plan opgesteld voor onderhoud. Vervolgens kunnen de onderdelen worden gerepareerd (wanneer mogelijk). Als de onderdelen zijn gerepareerd, worden ze terug gestuurd naar inspectie, waar ze worden gecontroleerd. Voldoen de onderdelen nog aan de eisen? Dan kunnen de onderdelen weer in elkaar worden gezet tot een volledige motor."

2. Welke stappen moeten er worden toegevoegd/verwijderd?
3. Wie zijn er betrokken bij de stappen? "Op elke afdeling werken een aantal werknemers. Deze werknemers wisselen niet tussen de afdelingen en werken dus alleen op hun eigen afdeling."
4. Welke gereedschappen worden er gebruikt bij deze stappen? "Er zijn worden meer dan 1000 soorten gereedschappen gebruikt."
5. Zijn er, zover jij weet stappen die heel goed lopen of stappen die beter zouden kunnen gaan? "Bij het schoonmaken is er een machine aanwezig die nog volledig moet worden aangevoerd door een werknemer. Ik ken iemand die artrose heeft, doordat hij altijd deze taak wil uitvoeren. Daarnaast is er veel ziekteverzuim, omdat het werk toch fysiek zwaar is. Een aantal werknemers zitten nu bijvoorbeeld veel achter de computer omdat ze geen fysiek werk meer kunnen uitvoeren.
Daarnaast zijn er vooral bij de reparatie afdeling nog veel taken die met de hand moeten worden uitgevoerd. Hierdoor duurt het lang en het zijn niet altijd de leukste en meest uitdagende werkzaamheden. Soms werken werknemers 2 weken aan een taak en blijkt achteraf dat het onderdeel niet meer voldoet aan eisen, dan is het werk voor niks geweest. Dat is natuurlijk frustrerend.
Werknemers gaan ook vaak al voor de eindtijd van de shift naar huis. Het is er een soort van ingeslopen door corona. Het komt denk ik ook doordat er nog steeds veel wrok zit door de reorganisatie. Hier is veel onvrede ontstaan bij de werknemers."
6. Waar ligt dat aan?/Hoe komt dit? (Bijvoorbeeld: ligt dit aan de werknemers, het management, de tools of het algemene proces?) Zie boven.

Automatisering
1. Wat is er in het verleden gedaan qua automatiseren/robotisering? "We hebben een aantal machines. Sommige machines moeten nog worden aangestuurd door de werknemer, maar we hebben ook een fully automated machine. Deze wordt geprogrammeerd en aangezet. Daarna kan hij niet meer worden uitgezet. Er is ook één robot aanwezig. Deze is aanwezig bij de scheurcontrole en kan zelf vele metingen uitvoeren."
2. Wie is er op dit moment bezig met het automatiseren van KLM E&M? "PLANT leaders zijn vooral bezig met het bedenken wat er moet gebeuren. Zoals je hebt gezien is het proces nogal ingewikkeld. Er zijn zoveel verschillende taken, dat we niet meer weten waar te beginnen."
    a. Welke rol spelen zij? (Beslisser, implementer, executer)
    b. Welke externe partijen zijn er betrokken?
3. Wat vind je van de huidige automatisering?
    a. Waarom?

Toekomst visie van KLM
1. Wat is de missie van KLM E&M? "We willen meer reparaties kunnen uitvoeren. Daar zijn een aantal redenen voor: zo kunnen we meer reparaties uitvoeren en hoeven we minder onderdelen weg te gooien, daarnaast hoeven we minder onderdelen bij de OEM's te bestellen (dit scheelt kosten en tijd) en we kunnen meer externe reparaties doen, waardoor de omzet omhoog gaat."
2. Waar denk jij dat KLM E&M naar toe moet? "We moeten een manier verzinnen hoe we die reparaties kunnen uitvoeren. Er moet wel echt iets gebeuren, anders kunnen we niet meer opboksen tegen de competitie."
3. Welke doelen zou jij stellen? "Ik zou eerst bijvoorbeeld kijken hoe we het onderdeel repair kunnen verbeteren. Hier is nog weinig geautomatiseerd. Ook gebeurd het regelmatig dat een onderdeel bij inspectie wordt afgekeurd en we er later achter komen dat dit onderdeel nog prima gerepareerd had kunnen worden."
4. Wat denk je dat hier voor nodig is?

Outro (nog vragen & opmerkingen?)

Expert interview KLM Engines (English)

Interviewee: Jelle Menges
Interviewer: Tosca Horstink
Date: 11-03-2021
Background: Jelle works as continuous improvement lead at KLM E&M.
Goal of the interview: confirm and generate the internal structure, process and stakeholders. A first look at KLM E&M's vision on automation of the process.

Introduction round Jelle & Tosca

Working at KLM E&M

1. What is your function at KLM E&M?
2. Can you tell me how you ended up at KLM E&M?
    a. What did you study?
    b. How did you come to this position?
3. Why did you choose KLM (E&M)?
4. Does KLM E&M meet your expectations so far?
    a. Why? Or why not?

Structure & process at KLM E&M

Structure

1. Can you tell us how KLM E&M is structured? How is it structured hierarchically?
2. *I show the internal structure that was created beforehand* Is this right? What is right? What is not right?
3. Which stakeholders should be added/removed?
4. Who takes the important decisions?

Repair & Maintenance Process

1. * The pre-made process is shown* Is this process right? What is wrong? What is right?
2. Which steps need to be added/deleted?
3. Who is involved in the steps?
4. What are the tools used during this steps?
5. Are there, as far as you know, any steps that are going very well or steps that could go better?
6. What is the reason for this? (For example: is it because of the employees, the management, the tools or the general process?)

Automation

1. What has been done on automation/robotisation at KLM E&M in the past?
2. Who is currently involved in the automating at KLM E&M?
    a. What role do they play? (Decision-maker, implementer, executer)
    b. What external companies are involved?
3. What do you think of the current automation?
    a. Why?

Future vision of KLM

1. What is KLM E&M's mission?
2. Where do you think KLM E&M should go?
3. What goals would you set?
4. What do you think it takes?

Outro (any questions & comments)

APPENDIX A: OBSERVATIONS

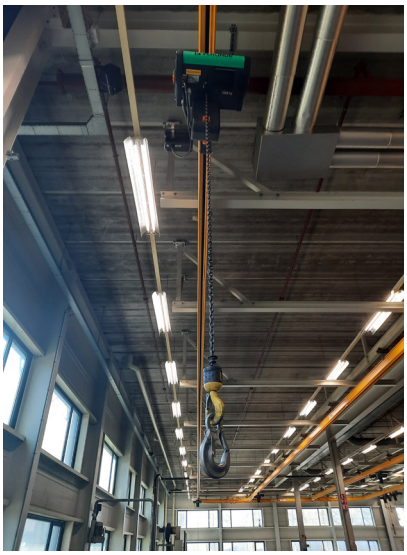
The observations

Before doing research at KLM Engines, I visited KLM Engines twice. The first time, I went alone to interview Jelle (a continuous innovation lead) and the second time I went with the other members of Delt University of Technology's Brightsky team. The first visit gave me the opportunity to meet some of the employees, learn about the process and see the activities being executed with my own eyes. There was plenty of time to focus on those parts of the work process I was most interested in.

A cleaning machine controlled by hand.

Several cleaning baths

Tool to move components from one to another cleaning bath



Hook to lift components

Tool to measure cracks in components

Robot used to identify cracks in the components

The second time, I went with other members from Delft University of Technology's Brightsky team. These are people doing research in psychology, robotics and cognitive robotics. It was interesting to see how these people from other disciplines focus on different things, while observing at KLM Engines. The person specialised in Robotics focused on the current robots and on activities that could be robotised. The person specialised on psychology, mainly focused on the behaviour of the employees.

A component that ended up at scrap.

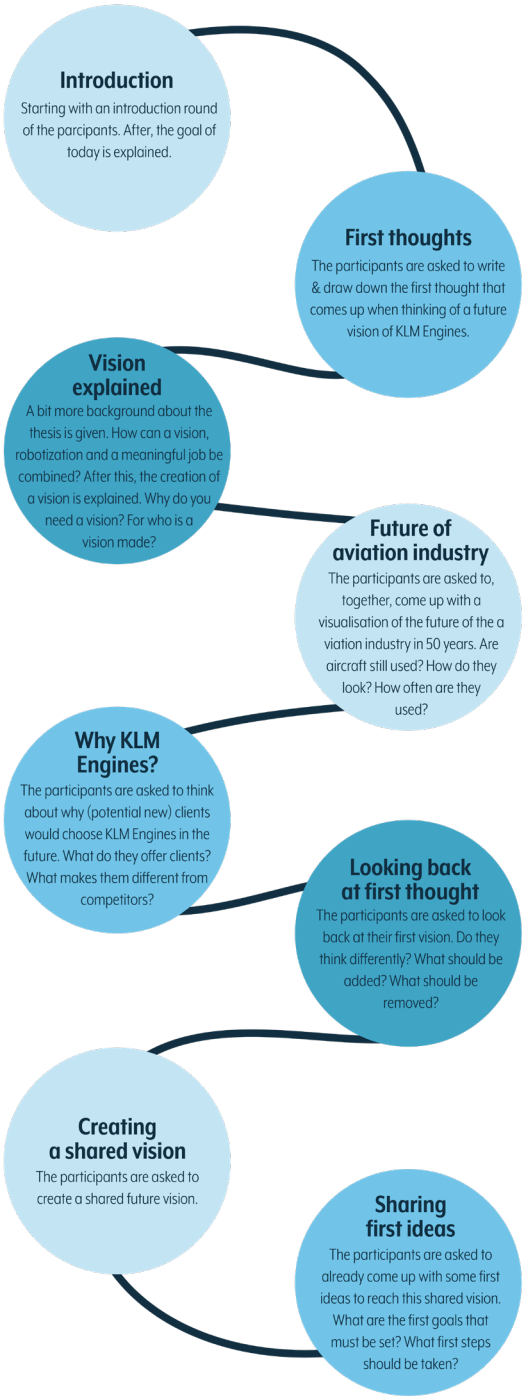
The very tiny cracks at the surface of the material.

A component that currently takes a lot of time to repair.

APPENDIX A: CO-CREATION SESSION

Process of the session

For this session, a process was followed, illustrated in the figure on the side. For each exercise a template was created .The participants could use this tenplate to draw & describe their thoughts.



The sessions

In the first exercise, the participants were asked to spill their first thoughts. This exercise gave the participants the opportunity to talk about their current feelings and thoughts and aftewards share them the other participants to park them aside. The results of this exercise includes mainly, the more or less, obvious problems KLM Engines is facing. Insights that came forward were: sustainability, becoming CO2 neutral, automatization and providing employees with a good job.

In the second exercise, which was done after a short introduction into visioning, the project and the literature around a meaningful job, the participants were ask to draw or write down how the aviation industry will look in 50 years. This exercise already stimulated the creativity of the participants. Some good questions occured; can we still speak of a aviation industry? Will we still use aircrafts in the future? If yes, when and to where? If data becomes a big part of the aviation industry, how do we secure the customers safety? The participants concluded that men will speak about a general transport sector, in which all transport methods are easily connected. They also predict there will be transport methods that currently aren't there yet, which will take care of the transportation within Europe, while aircraft will only transport people over long distances. They also thought, the focus within transport will shift completely to a service-orientated sector, in which experience and convenience of the whole journey and even beyondwill be most important. Keywords of this exercise were: integral thinking, service-oriented and transport (instead of aviation).
In the third exercise, the participants were asked to think about why a potential client would choose KLM Engines in the future. Why would they choose KLM instead of one of the competitors. In the introduction, they were told a vision is about what you offer to the client rather than the organisation's characteristics. This was quite a challenge for the participants, as this was already a discussion point for years. They immediately thought about sustainability, as this is currently one of the major focus points. However, they recognized sustainability is going to be a must, rather than a value proposition. Eventually, the participants came up with some other ideas, such as being service-oriented or changing to a refurbished service.
In the fourth exercise, the participants were asked to look back at their first thoughts. The participants realised their first thoughts were not that futuristic. Besides, they realised they should focus on creating value for their clients.

In the fifth exercise, the participants were asked to create a vision together. They still concluded sustainability should play a part in their vision. However, they also recognized they needed something more distinctive. A discussion started about what to do if engines don't have to be repaired that often anymore. The participants stated that they would need a different business model; the refurbished engine, which is cheaper, but almost at the same quality as a normal engine. In this way they could attract new clients. However, they still had to think about the value they would create for the client. They discussed that they should offer their clients a completely transparent service. In this way, their clients always know what is happening to their engines, when it should be done and how much is costs. Then, the client can plan when to pick up and use the engine again. The participants predict the customer relationships will improve and they would be able to learn from one another. Getting data in from their customers would help them to stay in front of the OEM's. The participants concluded that the ultimate goal should be, to become smarter than the OEM. This became the starting point of their vision visualisation. In order to become smarter than the OEM, they offer their client a new product: the refurbished engine (of any kind of transport method) and they do this remotely, so engines don't have to be shipped over the whole world anymore.

The participants during the session

The templates

Opdracht 1: Mijn eerste gedachte...

Opdracht 2: De luchtvaartindustrie over 50 jaar ziet er zo uit...

Opdracht 3: Zo zou een klant ons beschrijven over 10 jaar...

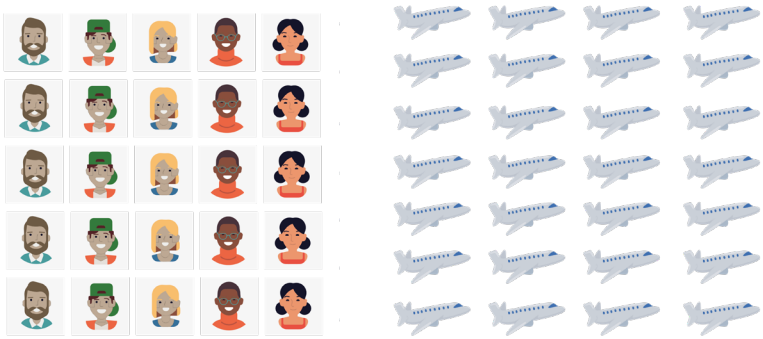
Opdracht 4: Terugblikken op de eerste visie

Opdracht 5: Eerste ideeën

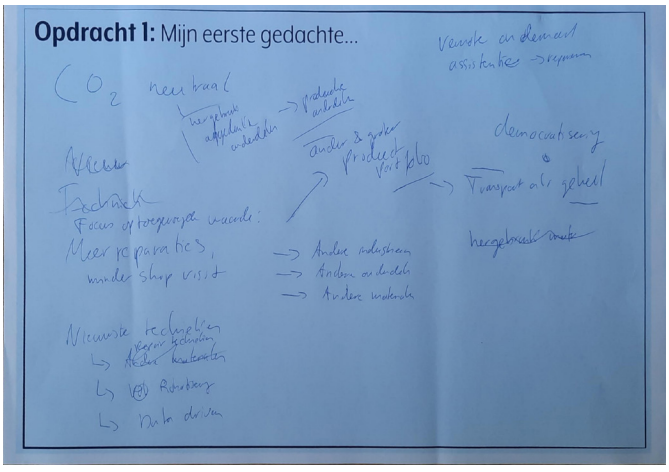
Gezamenlijke visie

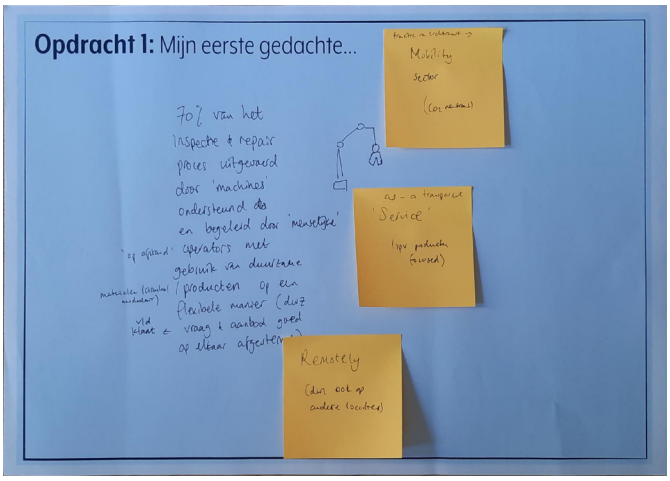
Additional materials

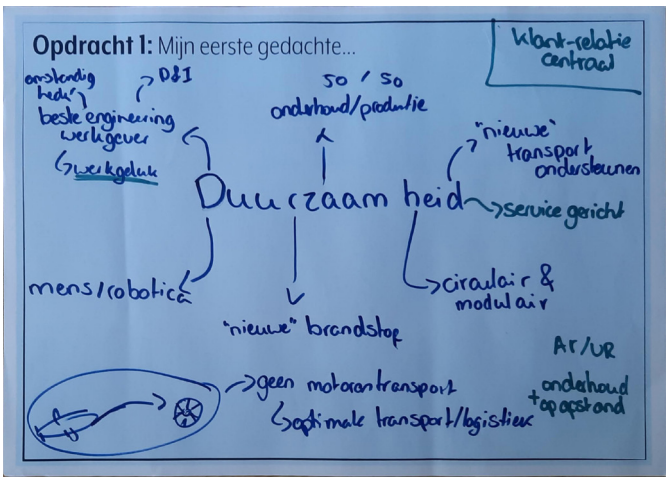
The participants were provided with some tstickers which they could use on the tamnples.

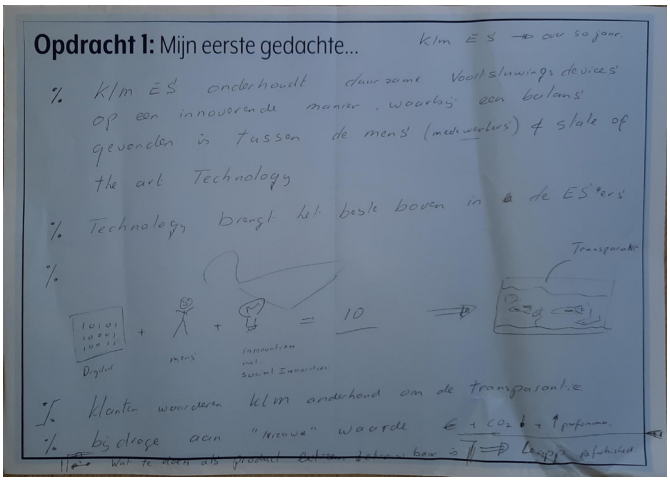


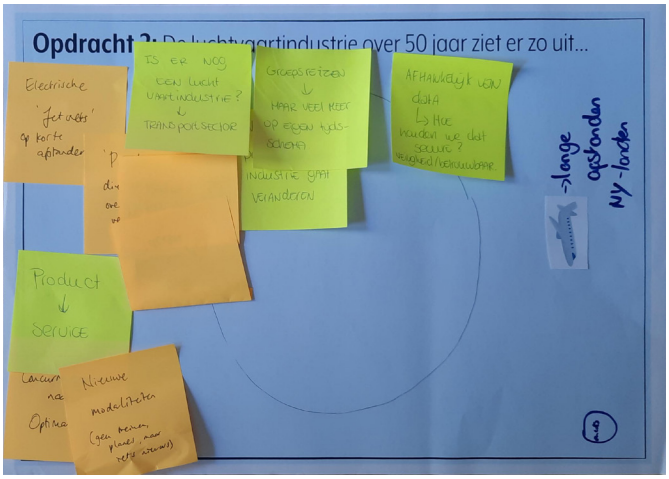
Completed templates

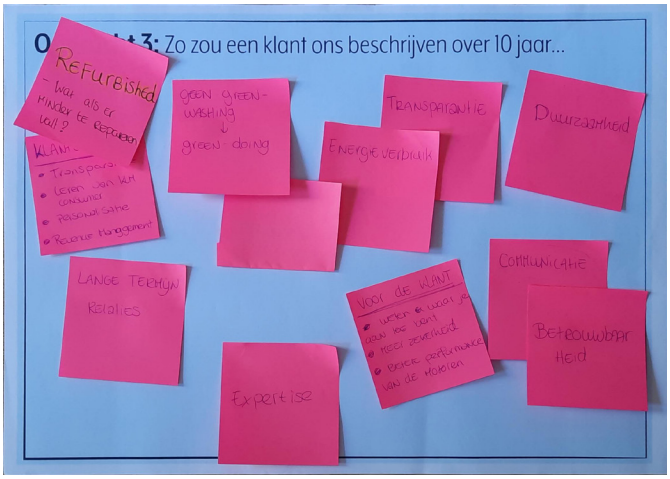


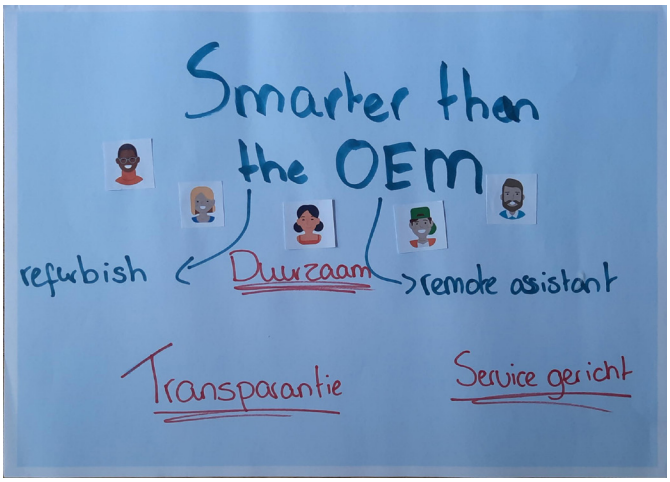


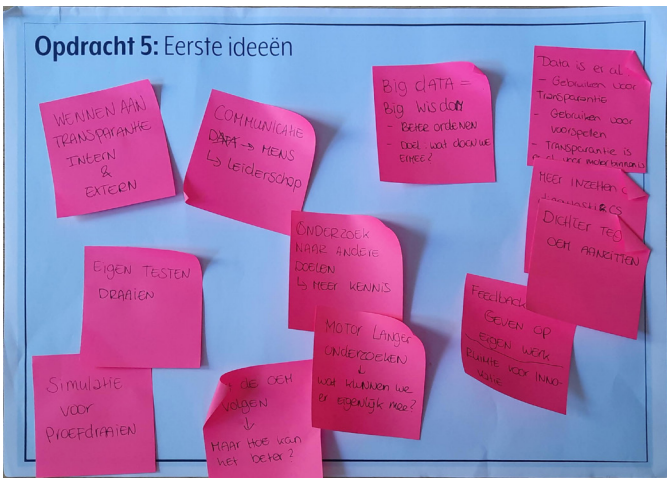




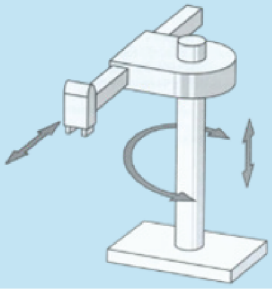
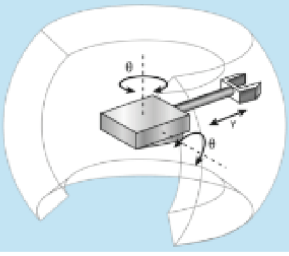

Opdracht 2: De luchtvaartindustrie over 50 jaar ziet er zo uit...
Electrische 'jet' over op korte afstanden
IS ER NOG EEN LUCHTVAARTINDUSTRIE? TRANSPORTSECTOR
Groepsreizen
MAAR VEEL MEER OP EIGEN TIJDSSCHEMA
INDUSTRIE GAAT VERANDEREN
AFHANKELIJK VAN data
Product
SERVICE
Nieuwe modelletten
-> lange afstanden NY-London


Opdracht 3: Zo zou een klant ons beschrijven over 10 jaar...
REFURBISHED
GEEN GREEN-WASHING
green-doing
TRANSPARANTIE
Duurzaamheid
ENERGIEVERBRUIK
KLANT
LANGE TERMIJN RELATIES
VOOR DE KLANT
COMMUNICATIE
Betaalbaarheid
Expertise


Smarter than the OEM
refurbish
Duurzaam
remote assistant
Transparantie
Service gericht


Opdracht 5: Eerste ideeën
WENNEN AAN TRANSPARANTIE INTERN & EXTERN
COMMUNICATIE DATA -> MENS
Leiderschap
BIG DATA = Big WIS DOM
- BEHEER ONDERNEMEN
- DOEL WAT DOEN WE EIGEN?
Data is er al
- Gebruiken voor Transparantie
- Gebruiken voor voorspellen
- TRANSPARANTIE is
MEER INZETTEN
DICHTER TEGEN OEM AANKOMEN
ONDERZOEK NAAR ANDERE DOELEN
MEER KENNIS
EIGEN TESTEN DRAAIEN
MOTOR LANGER ONDERZOEKEN
SIMULATIE VOOR PROEFDRAAIEN
DE OEM VOLGEN
MAAR HOE WORD HET BETER?

APPENDIX D: INDUSTRIAL ROBOTS

Type of robot	How does it work?	Used fo
 Cartesian Robots	This robot is also called linear robot or granty robot and works on three linear axes (X,Y,Z). They move straight over these three lines. The robot is flexible as you can easily adapt the speed, precision, stoke length and size.	- Material proces - Sealing tasks - Loading and ur - Palletizing tasks
 SCARA Robots	The SCARA robot consist of three parts that are attached to the base. The part attached to the base can turn from left to right, as well as the part connected to this one. The last part can move up and down.	- Palletizing - Loading - Assembly - Laser engraving - Soldering
 Articulated Robots	This robot has 3 joints that rotate 360 degrees, so the robot can move in 6 axis.	- Arc welding - More complex a - Packaging - Foundry and fo - Steel cutting - Material handli
 Cylindrical Robots	This robot is a combination of a linear and a rotation part. In this way the arm can move up and down, back and forth and rotate around it's own axis.	- Foundry and fo - Coating - Die-casting - Loading and ur - Simple assembl
 Delta Robots	This robot consists of three arms attached to the base. These arms can all move back and forth. Besides, the base can move up and down.	- Sorting product - Packaging - Low-force asse - Pick and place
 Polar Robots	This robot has two joints that can move 360 degrees and one linear part that moves back and forth.	- Die-casting - Welding - Injection moldi - Material handli

r...	Pros	Cons
sing (3D printing) nloading s.	- Affordable - Quite versatile - Can be programmed online - Good accuracy - Take large payload	- Only one axe movement is possible - Take up a lot of space - Complex installation process
   g	- Good accuracy - Take large payloads - Fast & flexible - Don't take much space, but have a big workspace.	- Can only be attached to a plane surface. - Require a controller
 assembly rging tasks ng	- Way more flexible than other robots. - Covers a large working space - High speed - Large payloads	- Expensive - Require a controller - Complicated to program
rging works nloading y tasks	- Take large payloads - Can turn 360 degrees one way. - Don't take much space	- Limited rotary motion - Poor accuracy - Not as versatile as other options.
s mbly tasks	- Very fast - Large workspace - Advanced software makes them very accurate and efficient	- Can only handle very light payloads. - Wear and tear of parts by high movements. - Expensive
  ng ng	- Can reach under and above objects. - 360 degrees coverage span - Large workspace	- Lot of supervision and control needed. - Poor accuracy - Not ideal to execute repetitive tasks.

APPENDIX E: CONTEXT MAPPING SESSIONS

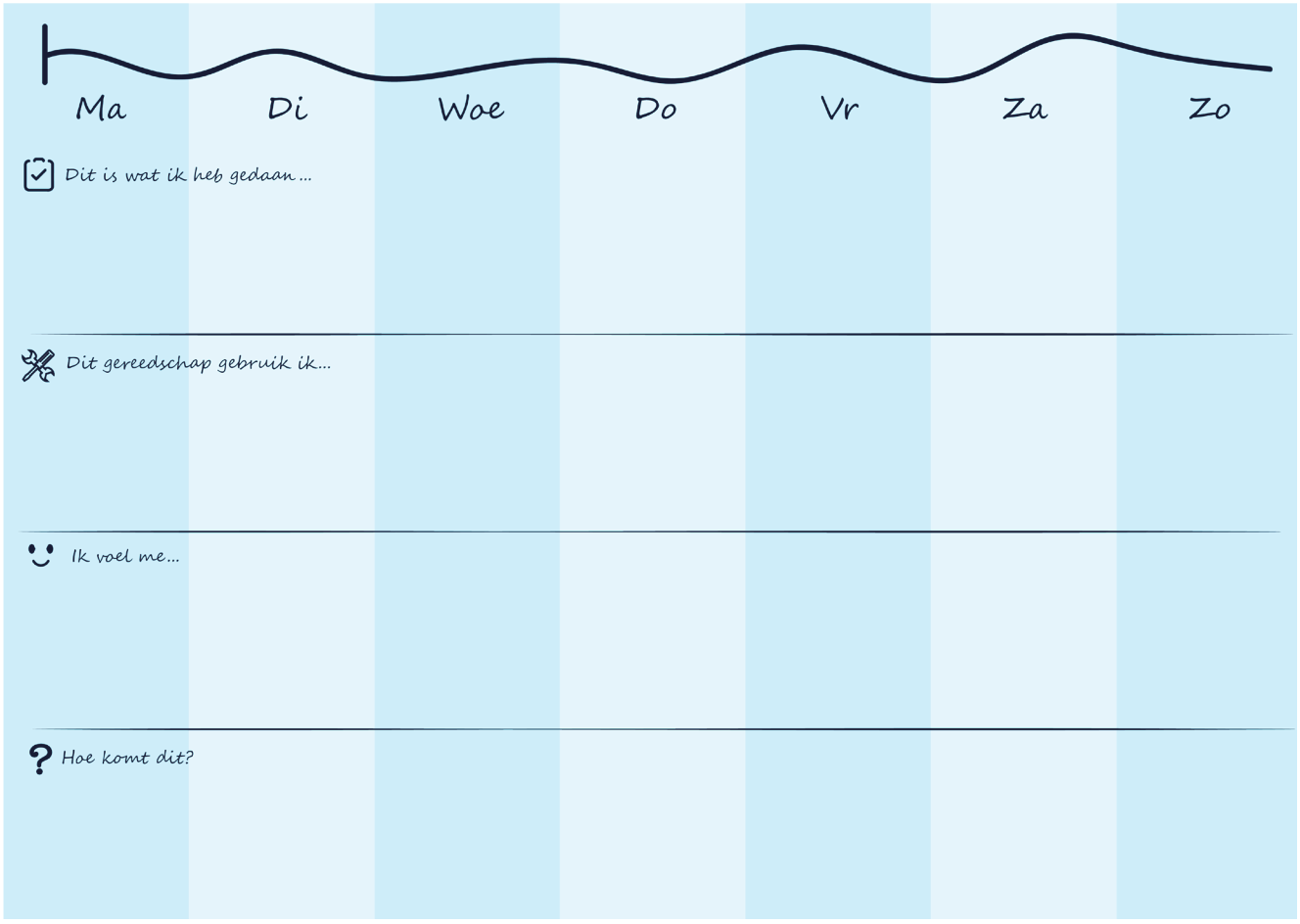
The sessions

During the session, the participants were asked to write down their thoughts on post-its, which could be put on the template (see below). However, the participants were not used to participating in creative sessions and felt very uncomfortable using any of the tools. That's why it was decided to make notes of what wassaid by the participants and in this way fill in the template. In the second session, the participants were asked to write down one thing that made their job enjoyable and one thing that made their job less enjoyable. This was used as a starting point to open up the discussion. This approach worked better. Initially, the first layer of the template was made to identify the work tasks which the employees execute during the week. However, it soon became clear the participants wanted to focus on other activities of their work, such as 'chatting to colleagues' or 'giving feedback'. Eventually, a workflow could be created. Then the participants were asked to talk about how they were feeling during these activities. In the beginning, the participants felt uncomfortable talking about this, but after a few minutes, the participants started talking. Nevertheless, questions needed to be asked and sometimes a discussion had to be stopped to go back to the actual topic.

During the first session, only participants older then 50 years joined the session, while in the second session an participants younger than 30 joined. It was interesting to see these differences. While the older generation didn't feel appreciated by the younger generation, the younger generation felt like the older generation doesn't want to listen.

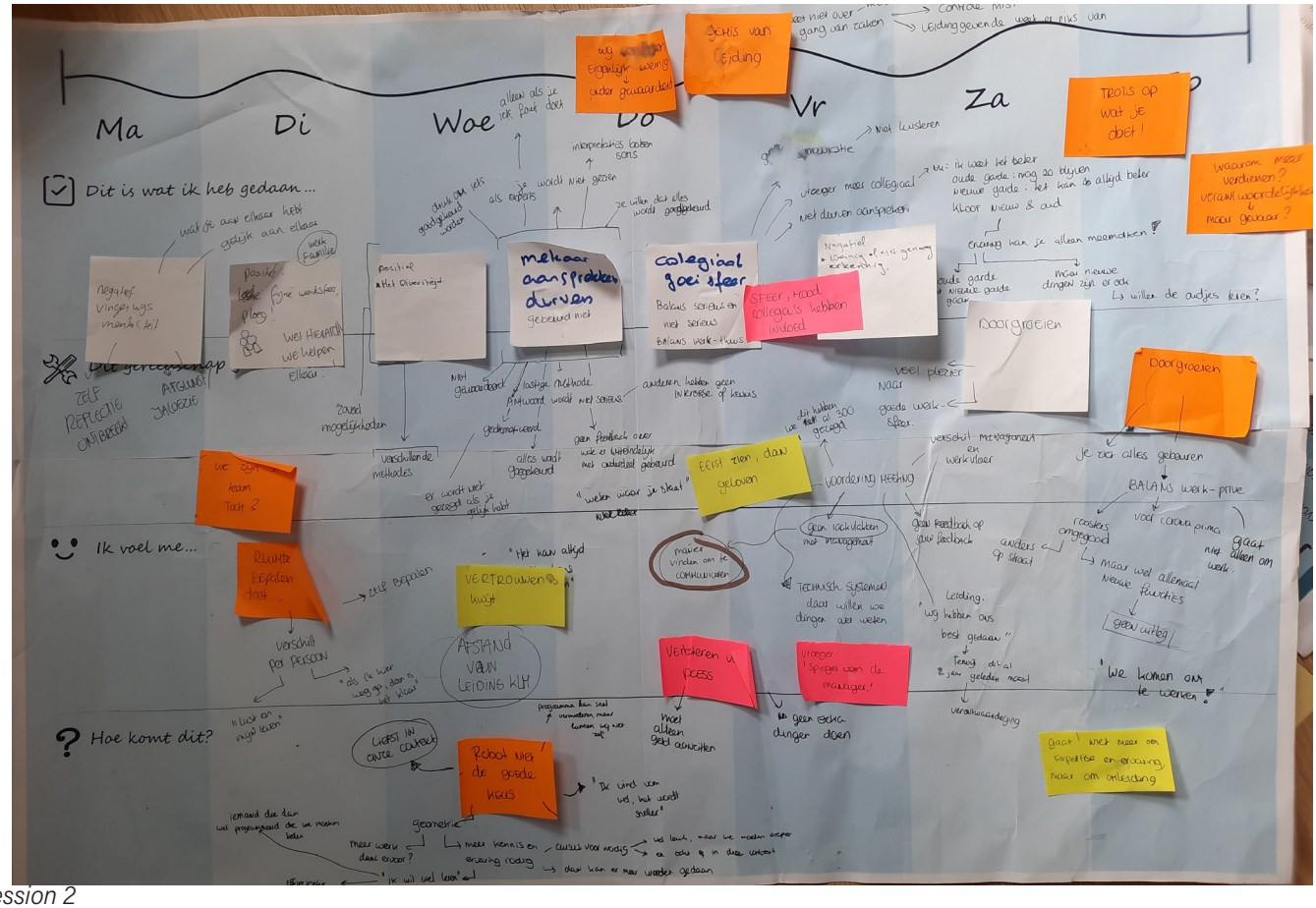
Participants session 1

Template context mapping session



Completed templates

Session 1



Session 2

Questions

Introduction of the project

Introduction round:

1. What is your name?
2. What is your function?
3. Why did you choose this work?

The work week

1. What does a working week look like?
2. What are the different tasks?
3. What do you like to do?
    a. Why?
4. What do you dislike about your tasks?
    a. Why?
5. What emotions do you feel during the day?
    a. Which emotions are predominant?
6. What is the reason for this?
7. What do you like best about the week?
    a. Why?
8. What do you find the least fun moment of the week?
    a. Why?
9. What do you think of the working atmosphere?
    a. Why do you think that?
    b. What needs to change to create the ideal working atmosphere?
10. What do you think of the workplace?
    a. Why do you think that?
    b. What needs to change to create the ideal workplace?

Tools & machines

1. What tools & machines are commonly used?
2. How does it work?
3. Do you experience any discomfort with this?
4. What do you need to use these tools & instruments?
5. Which tool/machine do you like to use the most?
    a. Why?
7. Which tool/machine do you like to use the least?
    a. Why?

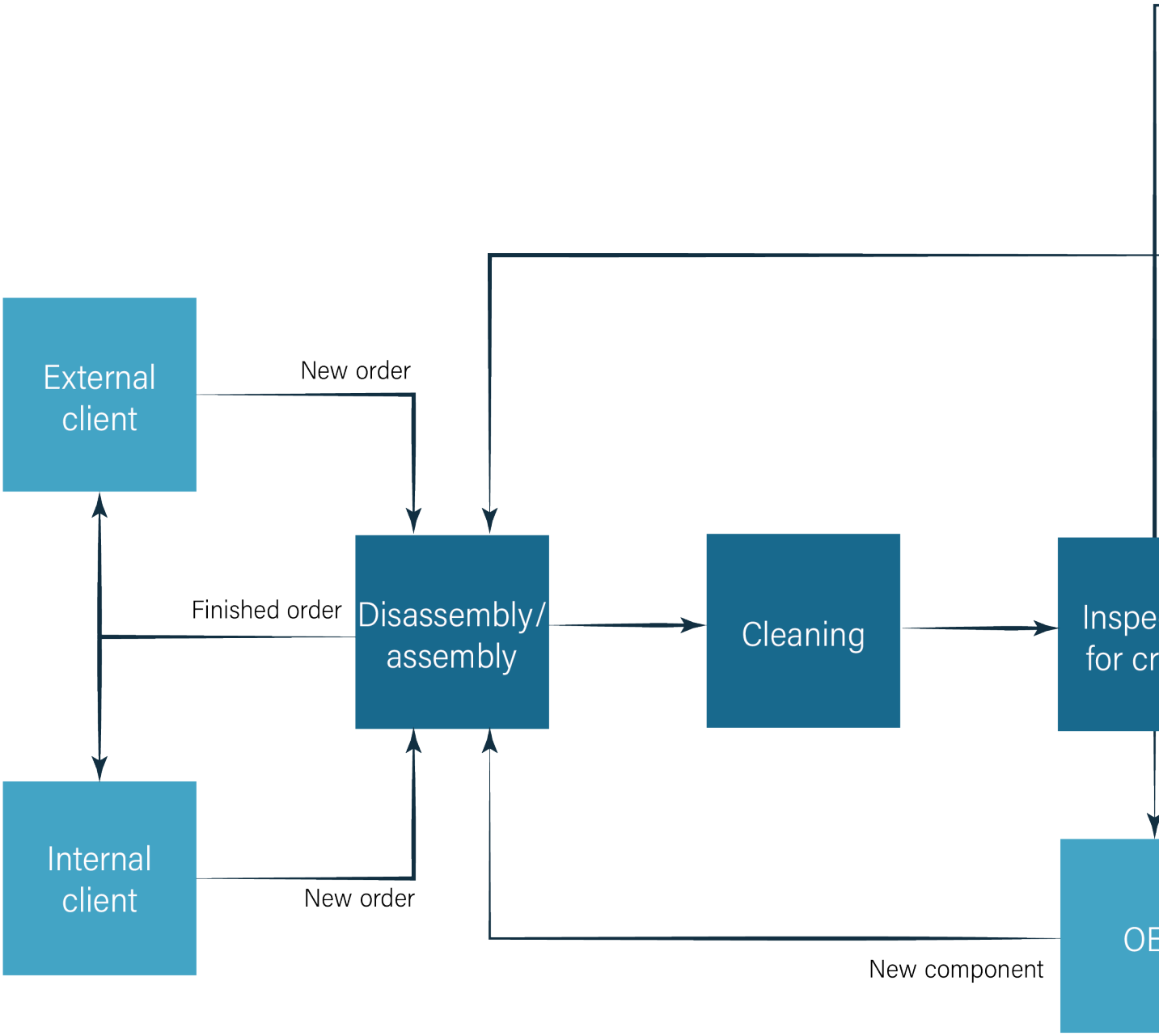
Future

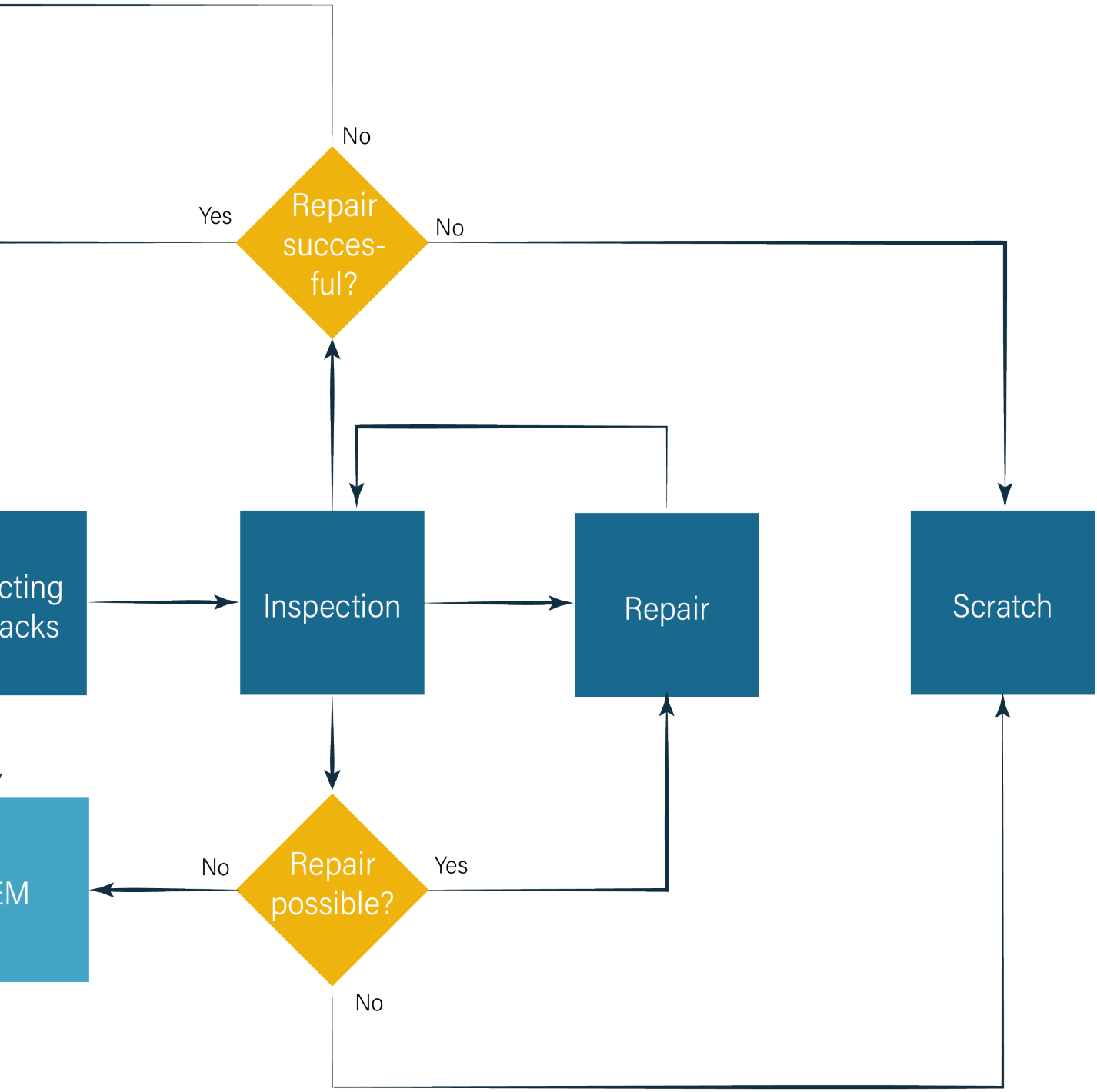
1. What must absolutely not disappear from the work?
    a. Why?
2. What would you rather not see disappear?
    a. Why?
3. What do you want to change?
    a. Why?
4. What could possibly change for you?
    a. Why?
5. How would you like this to change?
6. What are you worried about in the future?
    a. Why?

Additional questions:

1. Is there anything else you would like to learn?
2. How is the relationship with colleagues?

APPENDIX F: MAPPED OUT WORKFLOW




No
Yes
Repair succes-ful?
No
cting acks
Inspection
Repair
Scratch
EM
No
Repair possible?
Yes
No

If an Engine has to be repaired it follows a certain process, consisting of several steps. Each step is executed in a so-called cell. Working on aircraft engines brings a lot of safety issues. That's why it is important that the procedures in each step are executed correctly. Employees need to gain licenses to be authorized to execute these procedures. This gives all employees a lot of responsibility and skills. Therefore, KLM Engines is seen as an organisation that has a lot of in-house expertise. The employees all work at one department in an established team.

Internal and external clients

At first, an external or internal client gives the order to repair an engine. The internal clients are the employees at KLM whocheck the aircraft owned by KLM. Just as cars need regular check-ups, aircraft, including the engines, also must be checked every few years. The Operational Control Centre (OCC) plans the inspection, either after a fault was detected or when it is time for a periodic inspection. The external clients are the airlines outside KLM, who don't have their own engineering and maintenance department and clients outside the aviation industry who use similar engines, such as the navy and the electrical industry.

Disassembly/assembly

After the order has been made, the repair process start with the disassembly of the engine. Each engine consists of many components, which needs to be separated for further inspection. How the engine needs be disassembled depends on the type of engine. Information on how to do this, can be found in a manual. Currently, employees are only working on one engine at the time. However, they are planning to change this, so employees can work on two engines at the same time. The engine is first disassembled into modules, only the module that has a fault is dissembled into separate components. The employees use many different tools for the disassembly of an Engine and most tasks are performed by hand, which requires a lot of different skills from the employee.

Cleaning

After the components are separated, they are sent to the cleaning department. Here they are put in salty water baths and other cleaning baths. As some components are heavy, they are lifted by a chain hook. If needed they are spray-cleaned in a closed room, which is currently be done by hand. This is a physically hard task to perform, but is very liked by one of the employees.
Checking for cracks: The cleaned components are checked for any cracks. This can be on the surface or inside the material. Here different techniques and machines are used. There are, for example, ultrasound and infra-red machines. This is a department that works a lot with semi-automated machines and robots, which have to be controlled by the employees.

Inspection

After the component is checked for cracks, they are sent to the inspection department. Here they analyse the component and determine what needs to be done. The tasks that need to be executed, mostly consists of measuring tasks. Again, many different tools are used for this. The employees so experienced that they sometimes can determine a crack or fault by stroking the component with their fingertip. In such instances, the crack of fault is so small it can not be identified by any tool or machinery. At this cell, advice for the next step is given. They decide if the component can be repaired internally or externally, or they decide that that the component cannot be repaired anymore and has to be thrown away. This gives the employees at the inspection department a lot of responsibility, if they give the wrong advice, it can cost the organisation a lot of money and time.

Repair

Then it is time to execute the actual repair. In short, repair means to either add or remove a layer of material. This is done in many different ways, such as milling, sanding, 3D printing and welding. The repair process is done with both machines and by hand. Due to safety reasons, the aviation industry works with incremental steps. The repair has to be executed very precisely. Removing too much can lead to a component to be thrown away, causing costs to increase. During this stage, there is a large variation of tasks. Some

employees with a higher level of education are allowed to do more difficult tasks, such as welding. While other, less experienced employees can only do more simple tasks. Most of the tasks have to been done by hand, again using many tools. This also requires these employees to have a lot of knowledge and skills to handle all of them.

Back to inspection

At inspection the employees check if the components are repaired correctly. They execute some tests and measure if the component still meets the required tolerances. If the component doesn't meet the requirements, there are two options. Either an agreement is made with the OEM and the component can still be used, or the component has to be thrown away.

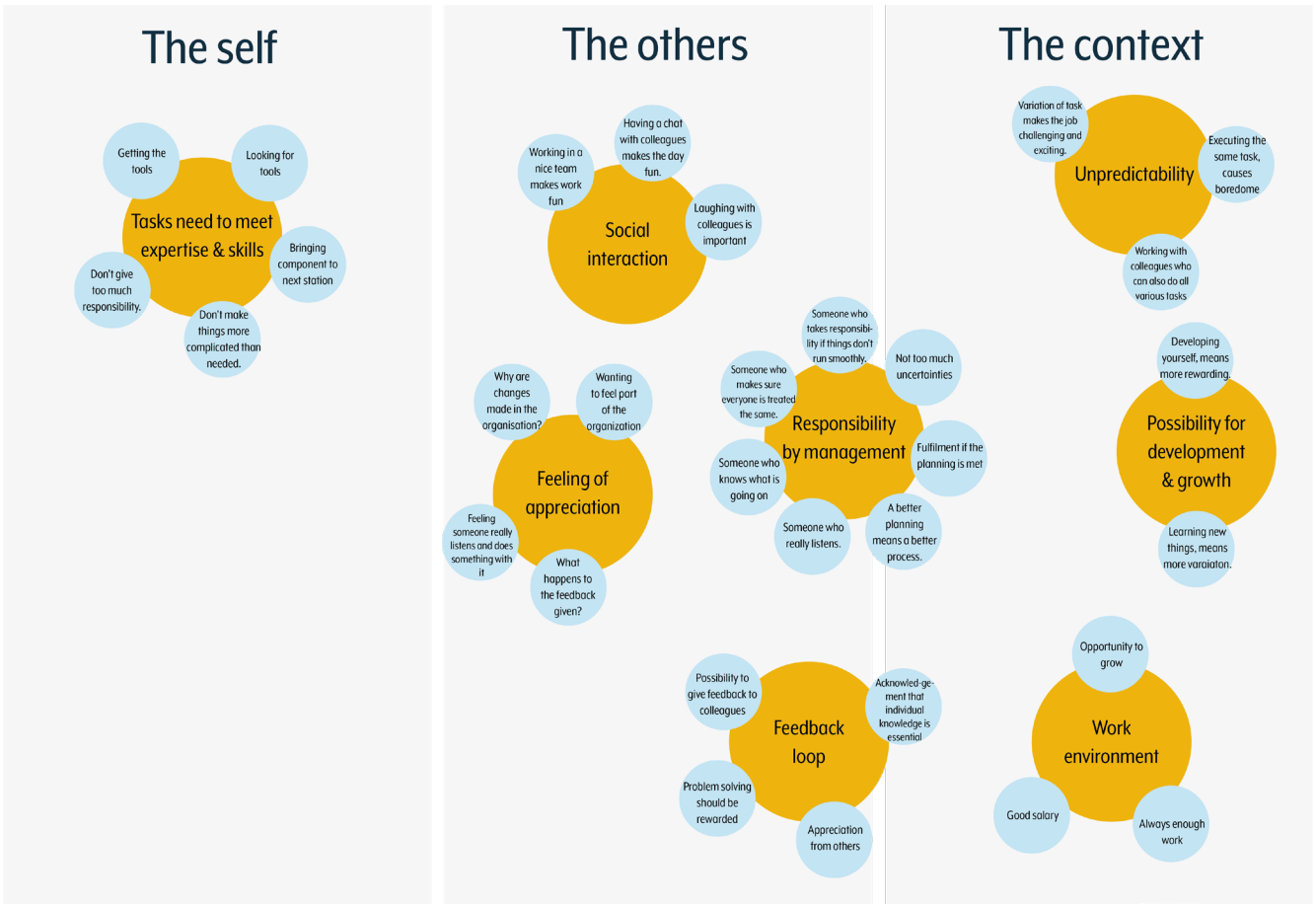
Disassembly/assembly

At the end of the process, after the components are repaired and tested, they are sent back to the disassembly/assembly cell where to put the components together into a completed engine. After this, the engine can be sent to the client

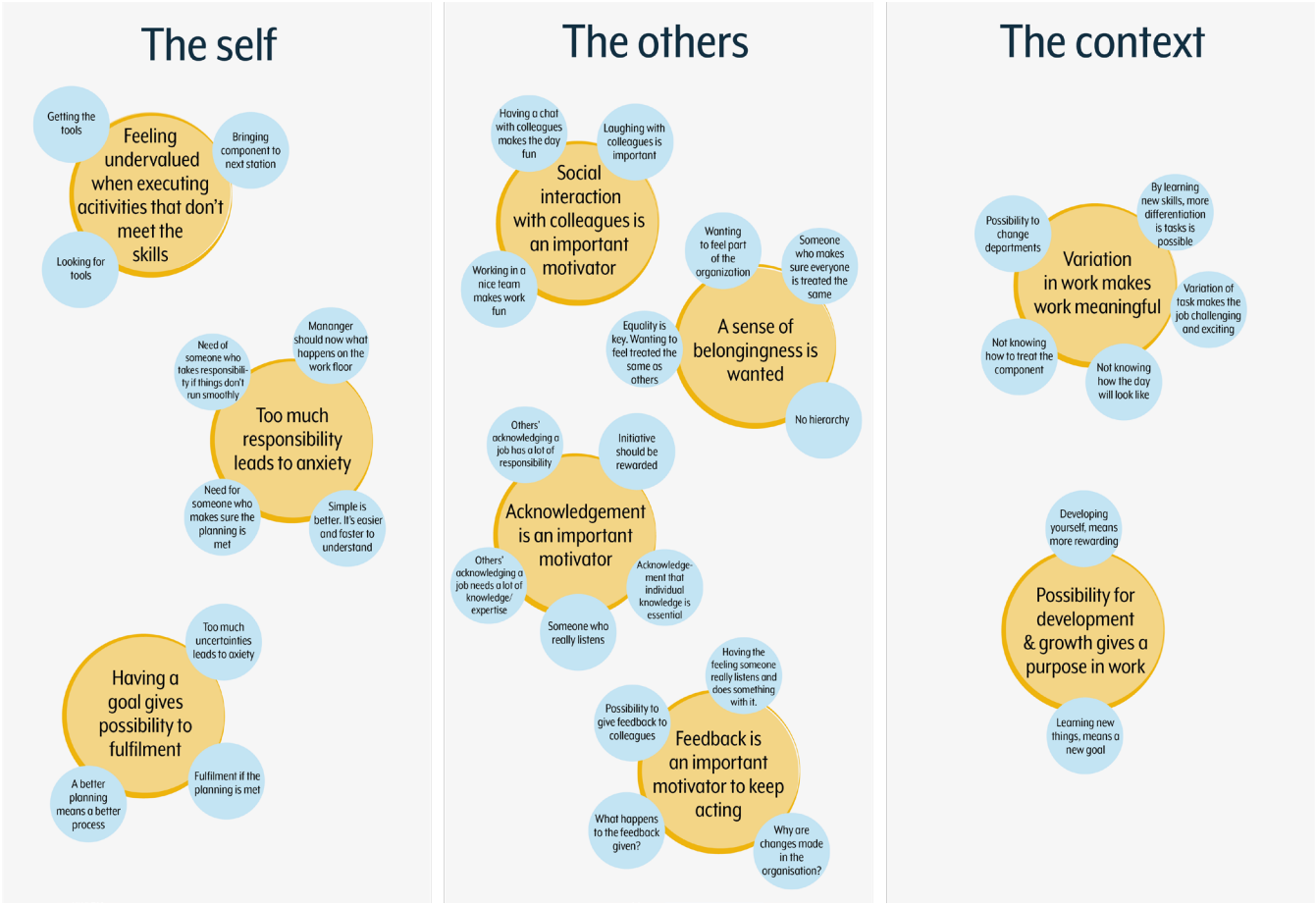
APPENDIX G: CLUSTERING ITERATIONS

Iteration 1

Iteration 2



Iteration 3



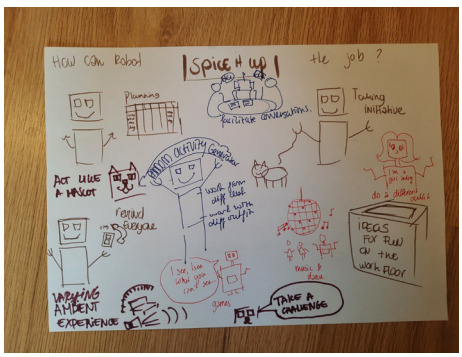
APPENDIX H: IDEATION WITH PEERS

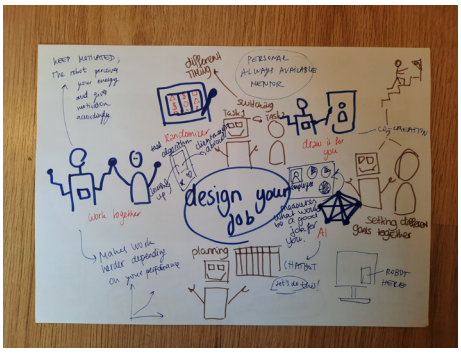
The session

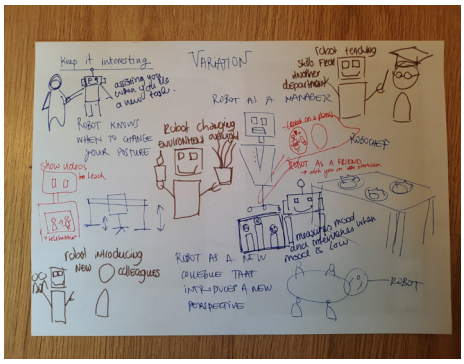
The session with peers was organised to obtain new perspectives on all of our theses. All participants prepared a session of one our to gather ideas. This session took place after all insight of the research at KLM Engines were gathered. The shared vision and the themes regarding the meaning of work were identified. However, at this point I was not sure how to continue. The biggest concern was; what to design for KLM and what to design for FRAIM?

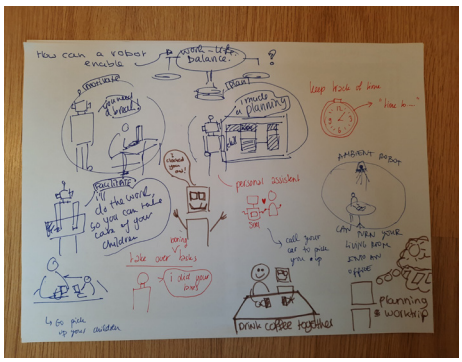
Before, answering this question I wanted to explore how robots could be used to fulfil these themes. The most interesting theme I identified was variation in work and thus I used this theme during the exercises of this session.
The participants were first asked to brainstorm about how to variate in work. These insights were clustered. Then the participants were asked how robots could enable this type of variation thorugh the 'how can you' method. The clusters resulted in the following questions: 'how can robots enable a work-life balance?' 'how can robots enable keep work interesting' 'how can robots enable employees to design their job' 'how can robots enable the employee to spice up their work? The 'how can you' method is used to quickly come up with a lot of ideas. The participants all get one minute to draw and describe new ideas. In the first round, this will result in the most obvious ideas. In the second round, the ideas already become more 'out of the box'. This will increase, with the number of rounds. These ideas show that using robots in different ways, have a different effect on the employees' jobs. It also shows there are a lot of possibilities. Lastly, the participants were asked to come up with ideas on what to deliver to FRAIM and KLM. These idea are used in the ideation of the final concept.

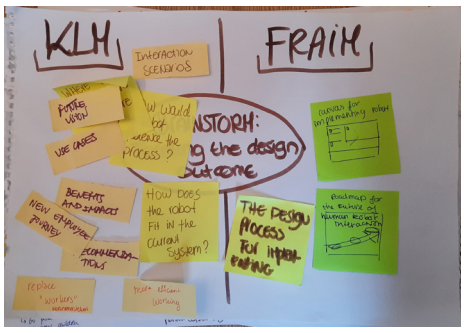
The results











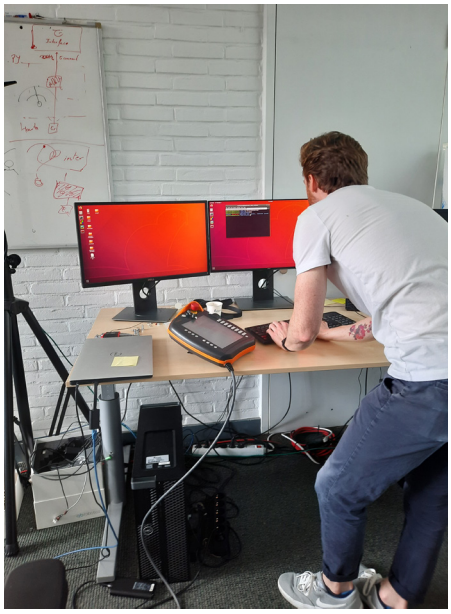
APPENDIX I: VISIT ROBOHOUSE

The visit

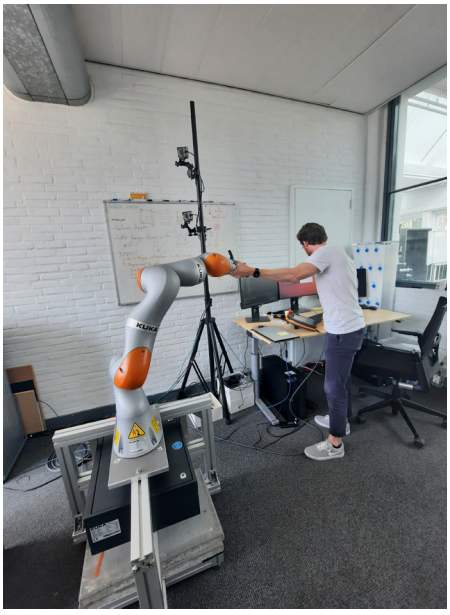
To learn more about the cobots used by FRAIM, a visit was made to robohouse. Here, three cobots are researched. It was interesting to see how these cobots were programmed and controlled. During this visit, a team member of KLM's Brightsky team joined the visit and told us he never thought about cobots and the possibilities they provide. This made me realise, the co-design needed a part in which the possibilities and limitations could be explored.

Cobot FRANKA in it's starting position

Cobot FRANKA in a different position



Micah programming the cobot, using a desk computer and a tablet



Micah programming and testing cobot FRANKA.

Cobot FRANKA moving around like a real arm

APPENDIX J: IDEATION CO-DESIGN TOOL

Existing games analysis

Take-aways

- This game enables the player to create their own context using pre-made components.
- This is a good game to manipulate actions and understand consequences.
- This game is very individual an is hard to play with several people.
- The goal of the game is not clear (this makes it boring after a while)

Take-aways

- This game enables the players to build their own play board with consisting components.
- This game enables the players to add and remove components from the game board, during the game.

Take-aways

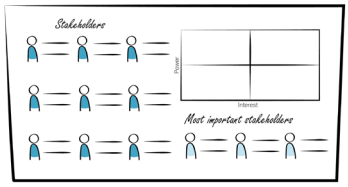
- This game forces the players to make a decision of which directions to go in and shows well what the consequences are (both positive and negative).

Take-aways

- In this game, all cards represent different aspects of the game.
- The information on each cards is different and has a different meaning for the participant.
- In this game, the participant has to choose what is the best option for him/her and in this way considers what the consequences are and if thes are worth it.

Visualising the work flow

1.



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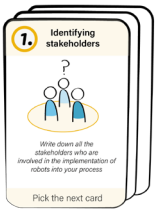
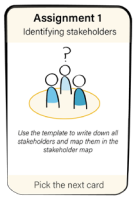


1 & 2 Combined



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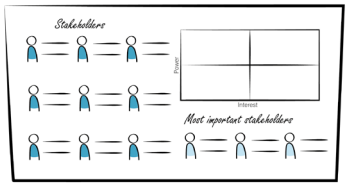

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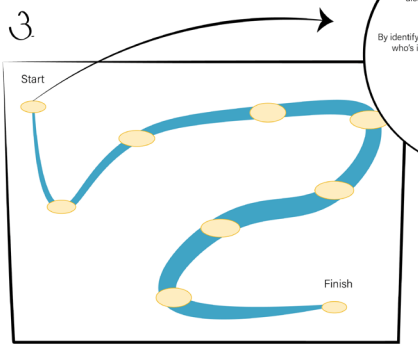

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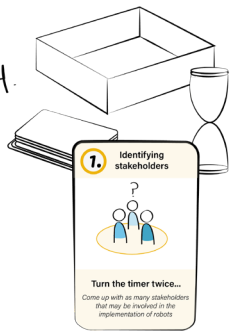
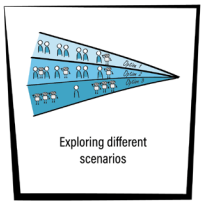
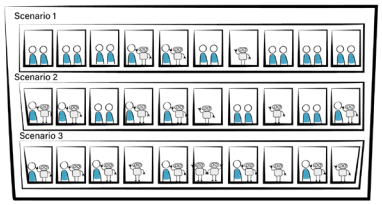
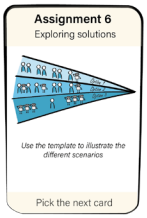
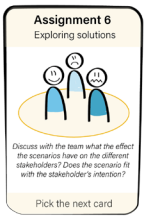




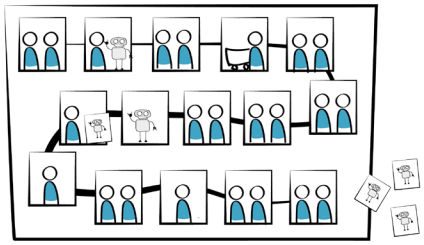


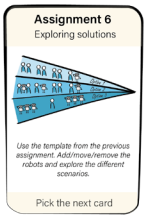


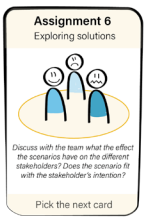


1.

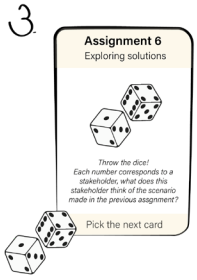
2.



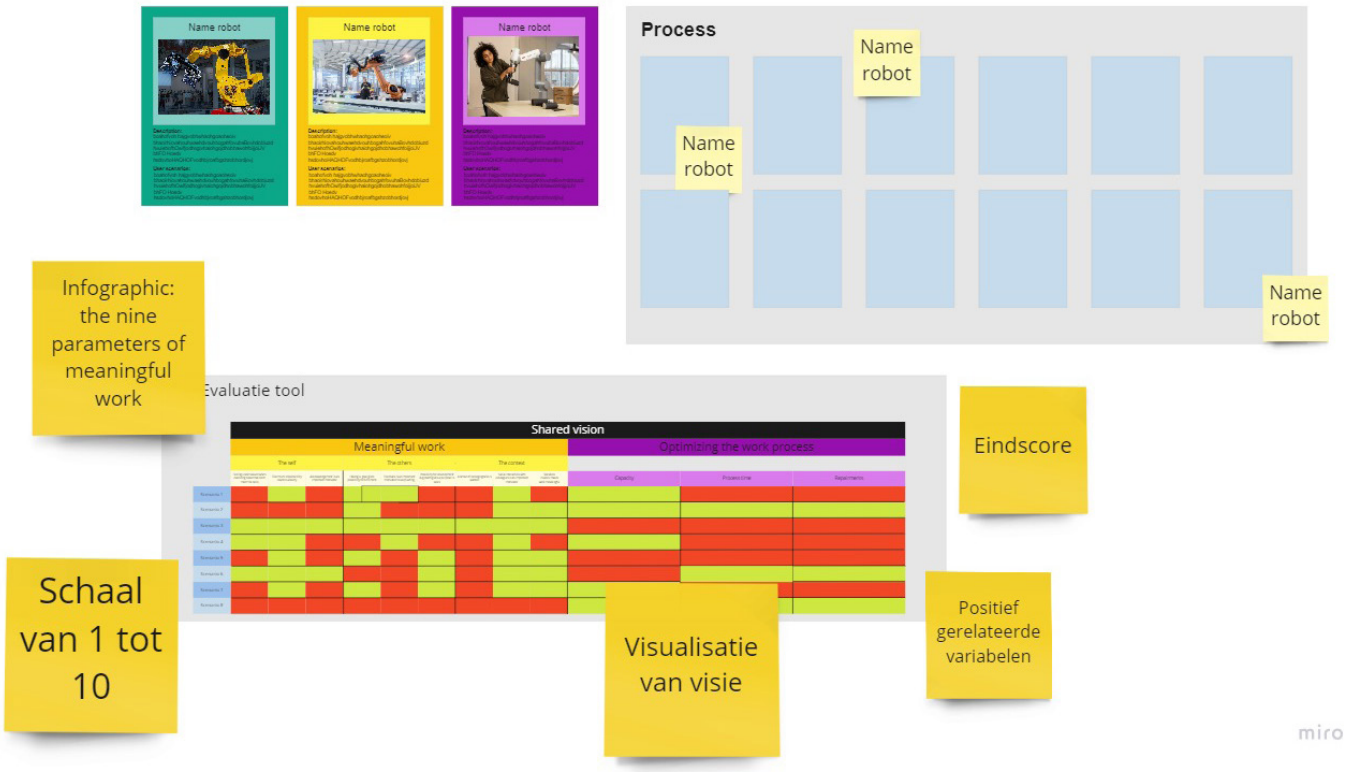




3.



The concept

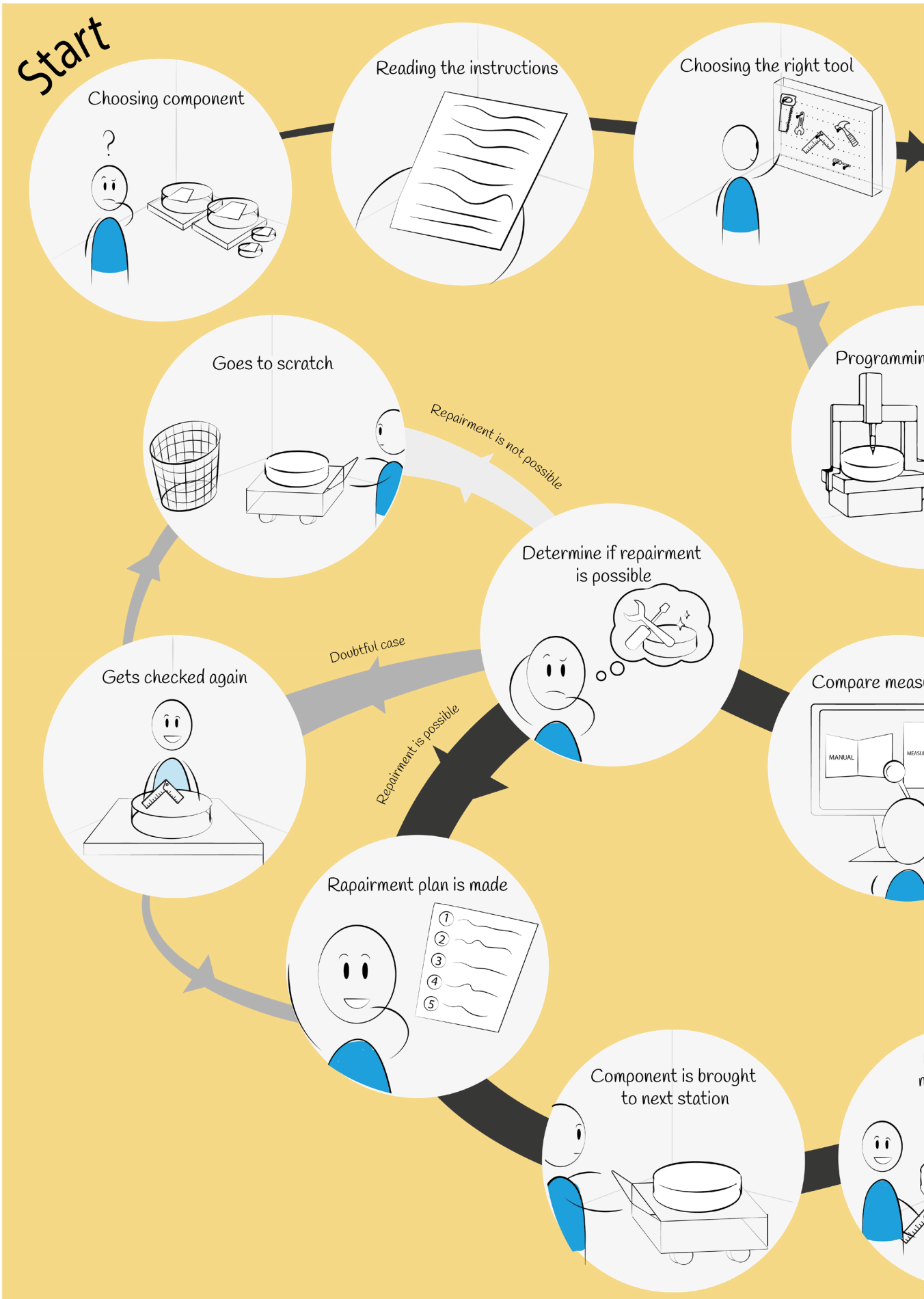


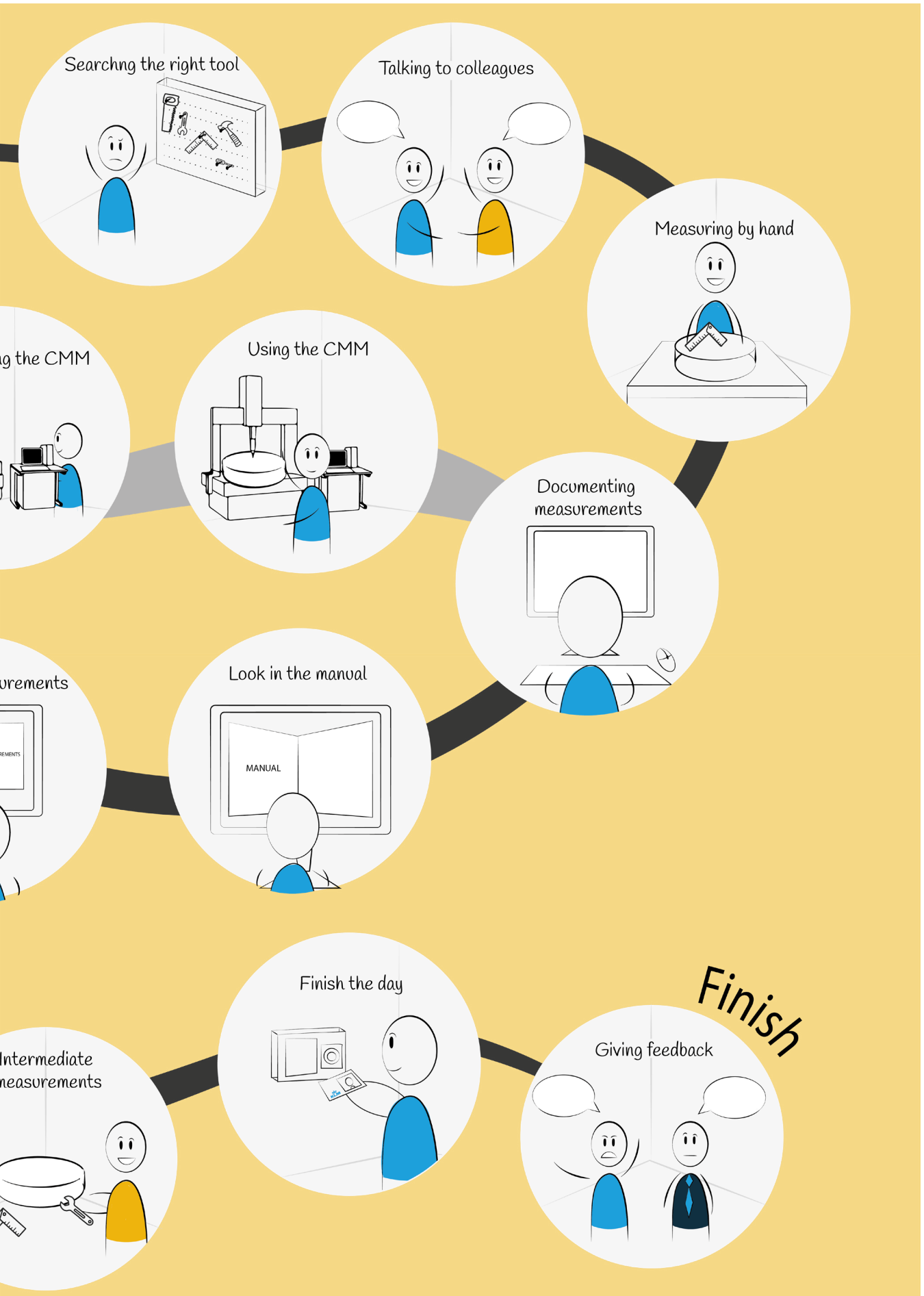
First version evaluation sheet

Evaluation sheet

	Shared vision			Meaningful work								
				The self			The others				The context	
	Are more repairs possible?	Are the overall costs becoming less?	Is the working process becoming more efficient?	Does the employees skills meet the activities?	Does the employee feel there is a balanced responsibility?	Does the employee have a goal to reach?	Does the employee feel part of the company?	Does the employee feel acknowledged by others?	Does the employee have social interaction?	Does the employee get feedback on their work?	Does the overall work, provides the employee with enough variation?	Does the employee have enough possibilities for development & growth?
Scenario 1												
Scenario 2												
Scenario 3												
Scenario 4												
Scenario 5												
Scenario 6												
Scenario 7												
Scenario 8												
Scenario 9												
Scenario 10												
Scenario 11												
Scenario 12												
Scenario 13												
Scenario 14												
Scenario 15												

APPENDIX K: TOOLKIT MATERIALS (VERSION 1)

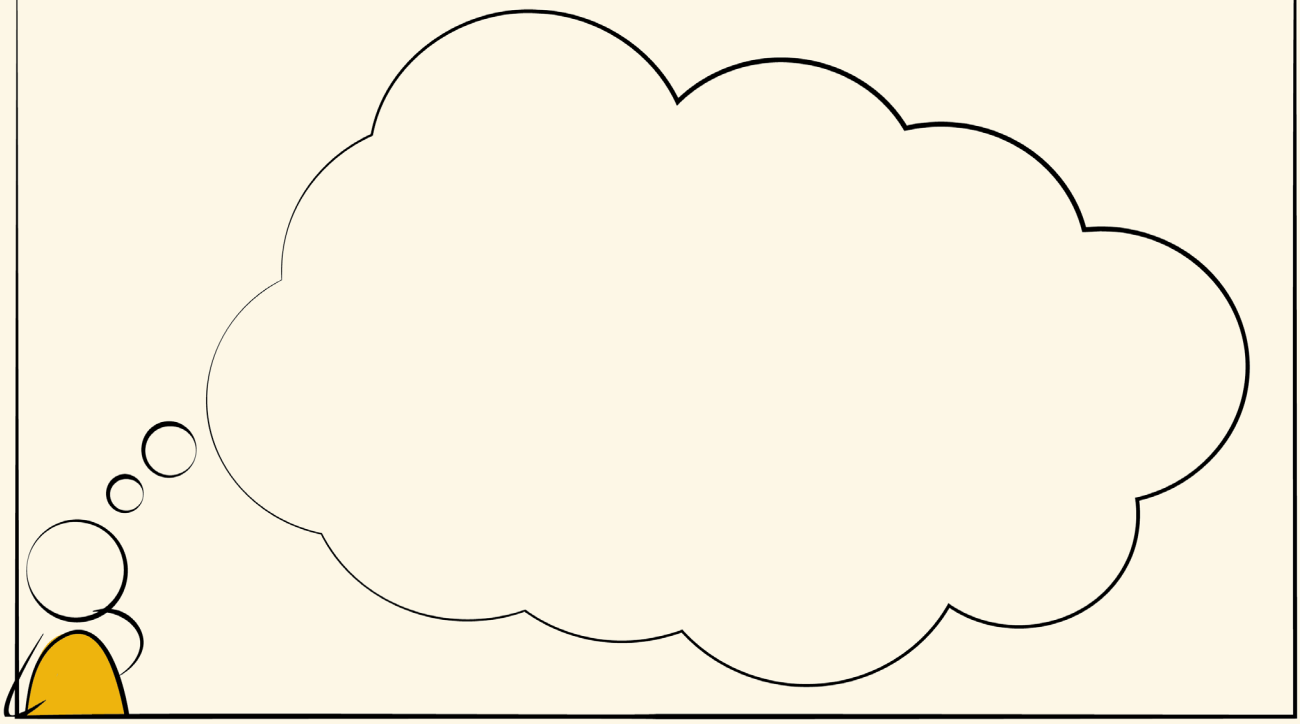



Searchng the right tool
Talking to colleagues
Measuring by hand
Using the CMM
Documenting measurements
Look in the manual
MANUAL
Finish the day
Giving feedback
Finish

Experience sheet

Experience sheet

This experience explains what it means to.



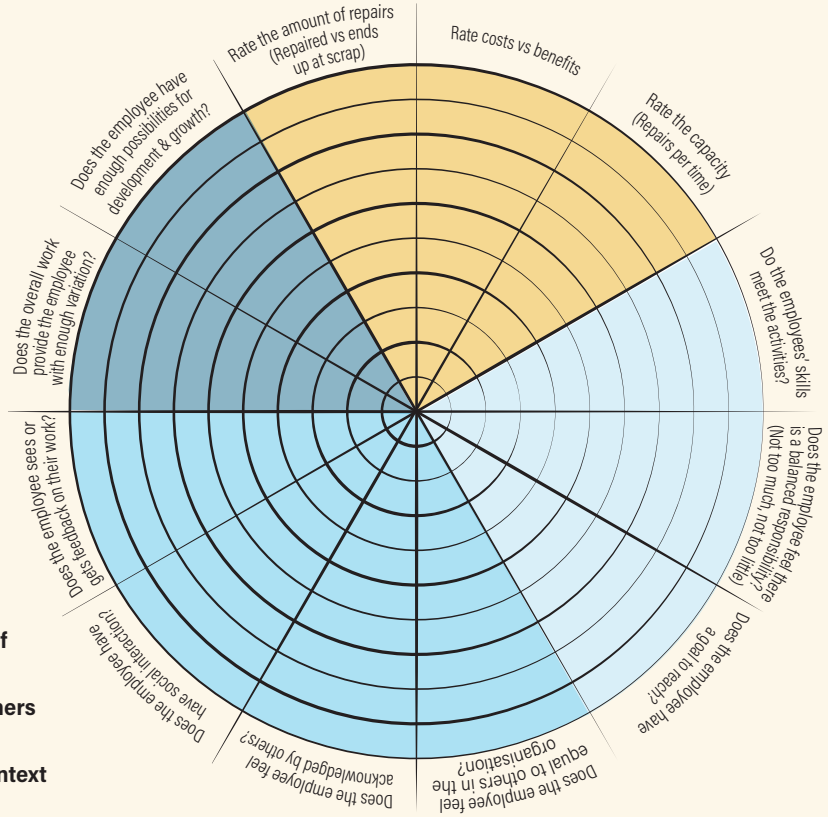
Final activities sheet

Activities sheet

Activities eliminated	New occuring activities

Final evaluation sheet

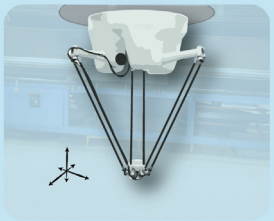
Evaluation sheet



Legenda parameters

- Shared vision
- Meaningful work: **The self**
- Meaningful work: **The others**
- Meaningful work: **The context**

Large robot cards



Delta robot

This robot consists of three arms attached to the base. These arms can all move back and forth. Besides, the base can move up and down.

Used for...
- Sorting products
- Packaging
- Low-force assembly tasks
- Pick and place

Pros
- Very fast
- Large workspace
- Advanced software makes them very accurate and efficient

Cons
- Can only handle very light payloads
- Wear and tear of parts by high movements
- Expensive

Articulated robot

This robot has 3 joints that rotate 360 degrees, so the robot can move in 6 axis.

Used for...
- Arc welding
- More complex assembly
- Packaging
- Foundry and forging tasks
- Steel cutting
- Material handling

Pros
- Way more flexible than other robots
- Covers a large working space
- High speed
- Large payloads

Cons
- Expensive
- Requires a controller
- Complicated to program

Polar robot

This robot has two joints that can move 360 degrees and one linear part that moves back and forth.

Used for...
- Sorting products
- Packaging
- Low-force assembly tasks
- Pick and place

Pros
- Very fast
- Large workspace
- Advanced software makes them very accurate and efficient

Cons
- Can only handle very light payloads.
- Wear and tear of parts by high movements.
- Expensive

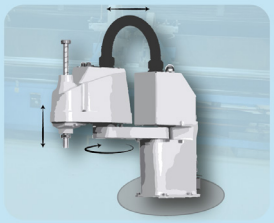
SCARA robot

The SCARA robot consist of three parts that are attached to the base. The part attached to the base can turn from left to right, as well as the part connected to this one. The last part can move up and down.

Used for...
- Palletizing
- Loading
- Assembly
- Laser engraving
- Soldering

Pros
- Good accuracy
- Take large payloads
- Fast & flexible
- Don't take much space, but have a big workspace

Cons
- Can only be attached to a plane surface.
- Requires a controller



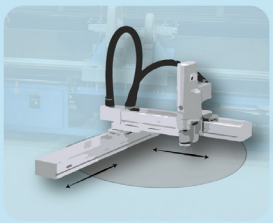
Cylindrical robot

This robot is a combination of a linear and a rotation part. In this way the arm can move up and down, back and forth and rotate around it's own axis.

Used for...
- Foundry and forging works
- Coating
- Die-casting
- Loading and unloading
- Simple assembly tasks

Pros
- Take large payloads
- Can turn 360 degrees one way
- Don't take much space

Cons
- Limited rotary motion
- Poor accuracy
- Not as versatile as other options



Cartesian robot

This robot is also called linear robot or granty robot and works on three linear axes (X,Y,Z). They move straight over these three lines. The robot is flexible as you can easily adapt the speed, precisi-on, stoke length and size.

Used for...
- Material processing (3D printing)
- Sealing tasks
- Loading and unloading
- Palletizing tasks

Pros
- Affordable
- Quite versatile
- Can be programmed online
- Good accuracy
- Take large payload

Cons
- Only one axe movement is possible
- Take up a lot of space
- Complex installation process

My dream robot...

Draw and describe your dream robot. How does it work? What can it do? Use the back of this card to draw out some user scenarios.

.....

.....

.....

.....

.....

1.

2.

3.

Cobot UR5e

A cobot is designed to work together in the same workspace at the employee.

User scenarios

1. The cobot holds and moves the object so the employee can execute the task better.
2. The cobot can be used or not used whenever the employee wants.
3. The employee operates the cobot. In this way, the pressure and power can be divided.

Cobot FRANKA

A cobot is designed to work together in the same workspace at the employee.

User scenarios

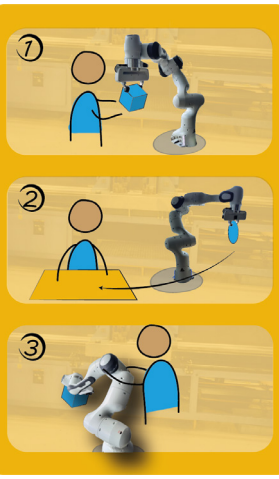
1. The cobot holds and moves the object so the employee can execute the task better.
2. The cobot moves the object to the employees work space.
3. The employee operates the cobot. In this way, the pressure and power can be divided.

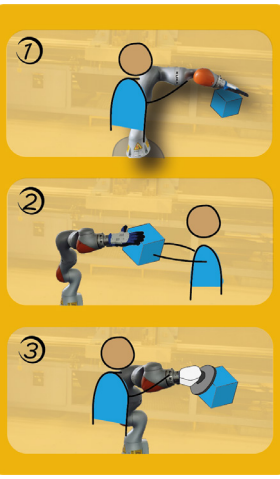
Cobot KUKA

A cobot is designed to work together in the same workspace at the employee.

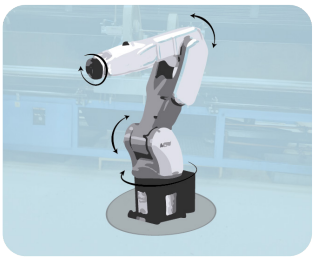
User scenarios

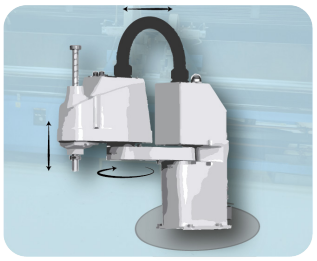
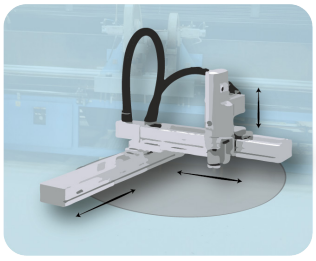
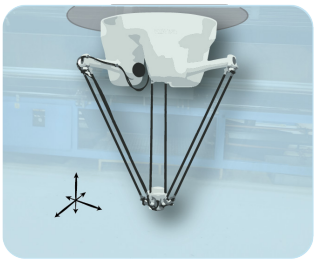
1. The employee can move the object around, by operating the cobot.
2. The cobot and employee can both work on the object at the same time.
3. The cobot can be handle many different tools, for example a grinding machine.

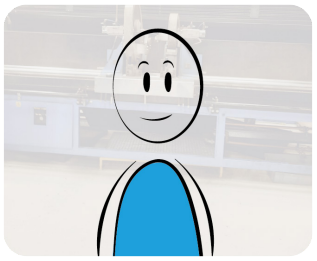




Small robot cards




The final manual

Manual

A co-design tool for KLM Engines & FRAIM

Index

Introduction

The technology of robots is improving rapidly and becomes more accessible in many industries. More and more organisations, including KLM Engines feel the need to automate their work process. The competition forces KLM Engines to make drastic changes, to keep up. How to do this the right way is a complex question.

That's why this tool is designed. It can be used by KLM Engines to explore and evaluate the possibilities of robotizing their work process. The focus of this tool is on the work process of the inspection department and only includes the activities of this process. To design this tool, research has been carried out on both the vision of KLM Engines and on what makes work meaningful according to the employees of KLM Engines. The insights of this research have been used to create this tool. This manual will explain how to use the tool and also provides you with the insights of the research that has been conducted. Read this manual carefully, before using the tool.

Components

The tool consists of several components:

- Experience sheets (A4).
- A work process sheet on which the KLM Engines inspection work process is mapped out (A1 sheet).
- Large robot cards on which different kind of robots are explained (14 pieces).
  - 6 light blue cards with the industrial robots currently used most.
  - 3 yellow cards with cobots used at Robohouse.
  - 5 empty blue cards, which can be used to draw and describe your dream robot.
- Small robot cards which correspond with large robot cards and can be moved around the work process sheet (50 pieces).
- Small worker cards which can be moved around the work process.
- Activities & evaluation sheets on which the activities that are eliminated and added can be noted & the different scenarios can be evaluated (A4 sheet).
- Markers to draw on the dream robot cards.
- A pen to fill in the activities & evaluation sheet.

Besides, the team needs one mobile phone to set timers and take pictures.

Instructions

1. Getting familiar with the evaluation criteria

Before we can start using the tool, it is important to get familiar with the evaluation criteria. The evaluation criteria are a result from the research done at KLM Engines and are explained at page 9-11. However, before rushing to those pages, we start with an exercise to get an understanding of the criteria.

Exercise 1: My experience

Let each team member take two experience sheets. Choose two of the evaluation criteria below. Make sure all criteria are covered at least once.

This experience explains what it means to...

1. ...execute work activities that meet my skills.
2. ...have balanced responsiblity.
3. ...have a goal to reach.
4. ...get feedback on my work.
5. ...feel part of the company.
6. ...have social interaction.
7. ...feel acknowledged.
8. ...have variation in my work.
9. ...have opportunities for development & growth

Think of an experience in your work that explains the meaning of these criteria. Set a timer for 5 minutes and draw/describe this experiences on the experience sheets. Afterwards, set a timer for 5 mintues and let each team member present and explain their experience sheets.

2. Evaluating the current scenario

Exercise 2: Evaluating your current work process

Take the evaluation sheet which says "current scenario". The twelve evaluation criteria are placed on a circle diagram. The circle consists of ten levels going from low (the middle of the circle) to high (the border of the circle)

Set a timer for 5 minutes.

Discuss with the team how the current work process could be rated on the different evaluation criteria, going from high to low. Place dots for each criteria and connect the dots, so a diagram occurs (see "Examples" for how to do this correctly").

3. Creating the first scenario

Time to start using the tool. First of all, put all components on the table. Make sure the work process sheet is in the middle of the table and everyone has a good overview of this sheet. The

work process sheet visualises all the steps of the process and follows a particular path. Sometimes several paths are possible, these are visualised with the different colours of lines. The 14 large robots cards illustrate and explain the possibilities of robots. The small robot cards corresponds to the bigger ones and can be used to move around the work process sheet.
Besides, the tool includes small worker cards, which can also be moved around the work process sheet.

Exercise 3: If money doesn't play a role, how would you implement robots?

Set a timer for 10 minutes. Discuss with the team where in the work process you would implement robots and what they would do if money didn't play a role. Place the small robot cards on the work process sheet and write down on 'activities sheet 1' which activities areeliminated and which new activities occur. Make a picture of the created scenario with your smartphone. If the team is satisfied with the scenario, fill in the evaluation shift together. How would you rate all twelve critera? Don't be afraid to start a discussion.

3. Exploring scenarios

As seen, this creates an clear overview of the effect of the scenario on the evaluation criteria. You may see, the meaningful work part has scored low, while the shared vision part has scored high. However, this is just one of the possible scenarios.
Time to create more! Set a timer for 50 minutes.

Exercise 4: Move around the robot cards.

What if you use another type of robot or what happens if you replace an industrial robot with a cobot? Remove or add robots in each step of the work process. Use the dream card robot to create your own robot. What would be the ideal robot? What can it do? Create a new scenario. Right down the activities eliminated and fill in the evaluation sheet again. Try to create at least 5 different scenarios. You can use the previous scenario as a starting point, or you can ask "what if" questions. For example: "what if we only focus on meaningful work" Don't forget to make a picture after finishing a scenario. Fill in the activities and evaluation sheet for each scenario.

4. Choosing a scenario

Move around the robot cards and create new scenarios until you cannot think of a new one anymore.

Exercise 5: Choosing the desired option

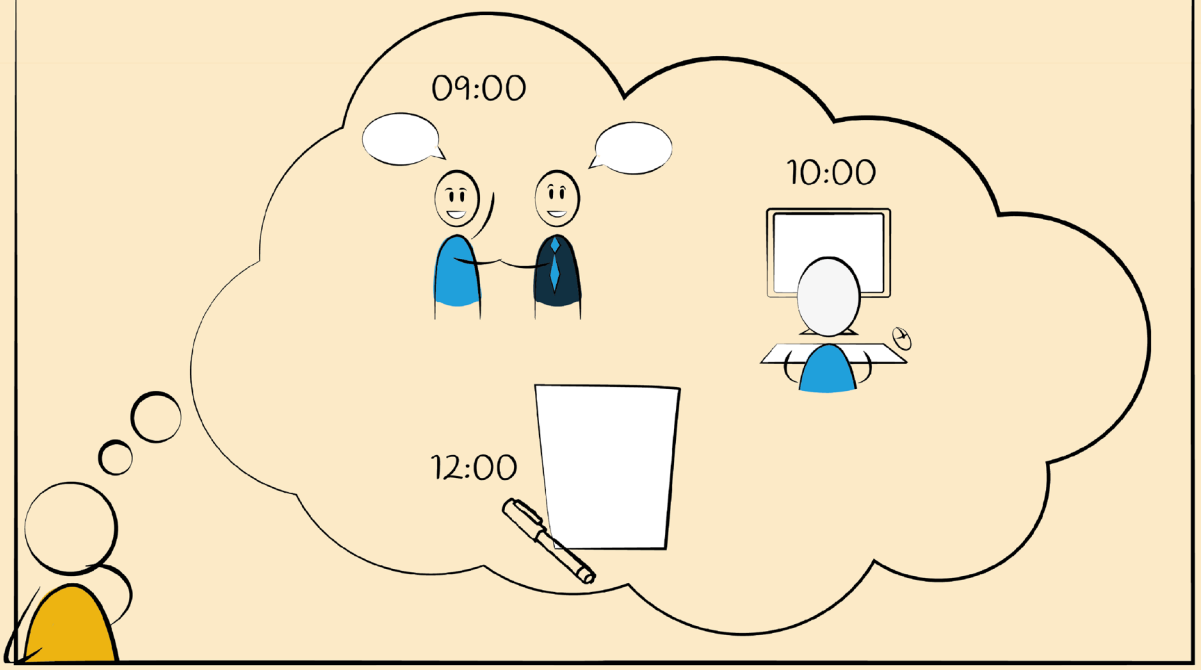
Now it is time to look back on the created scenarios and the evaluation sheets. Which criteria are most important to your organisation? What scenario corresponds best with the organisation? This scenario is the first step in robotizing your work process and empowers the organisation in the next steps. Set a timer for 10 minutes.

Examples

1

Experience sheet

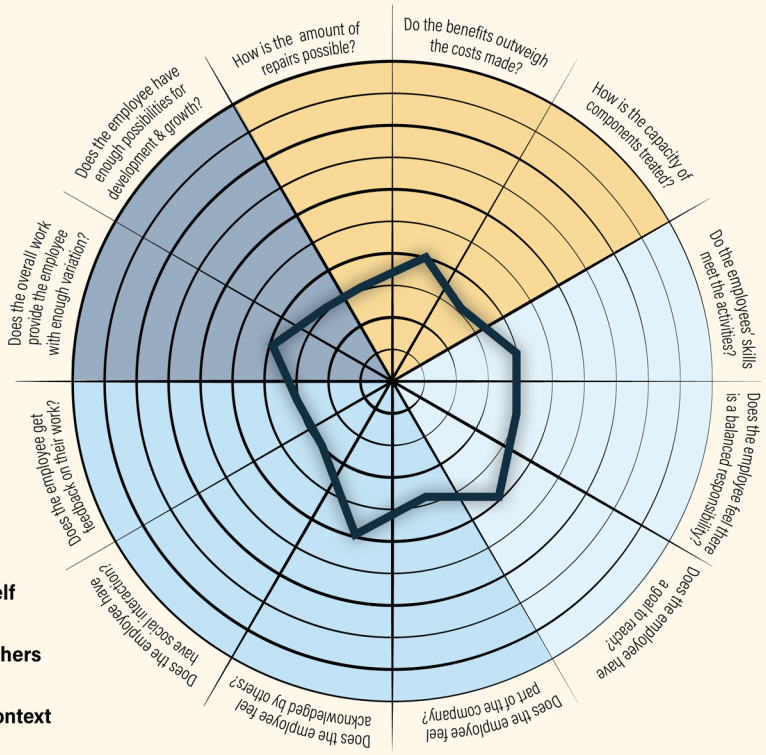
This experience explains what it means to. *have variation in work*



2

Current scenario

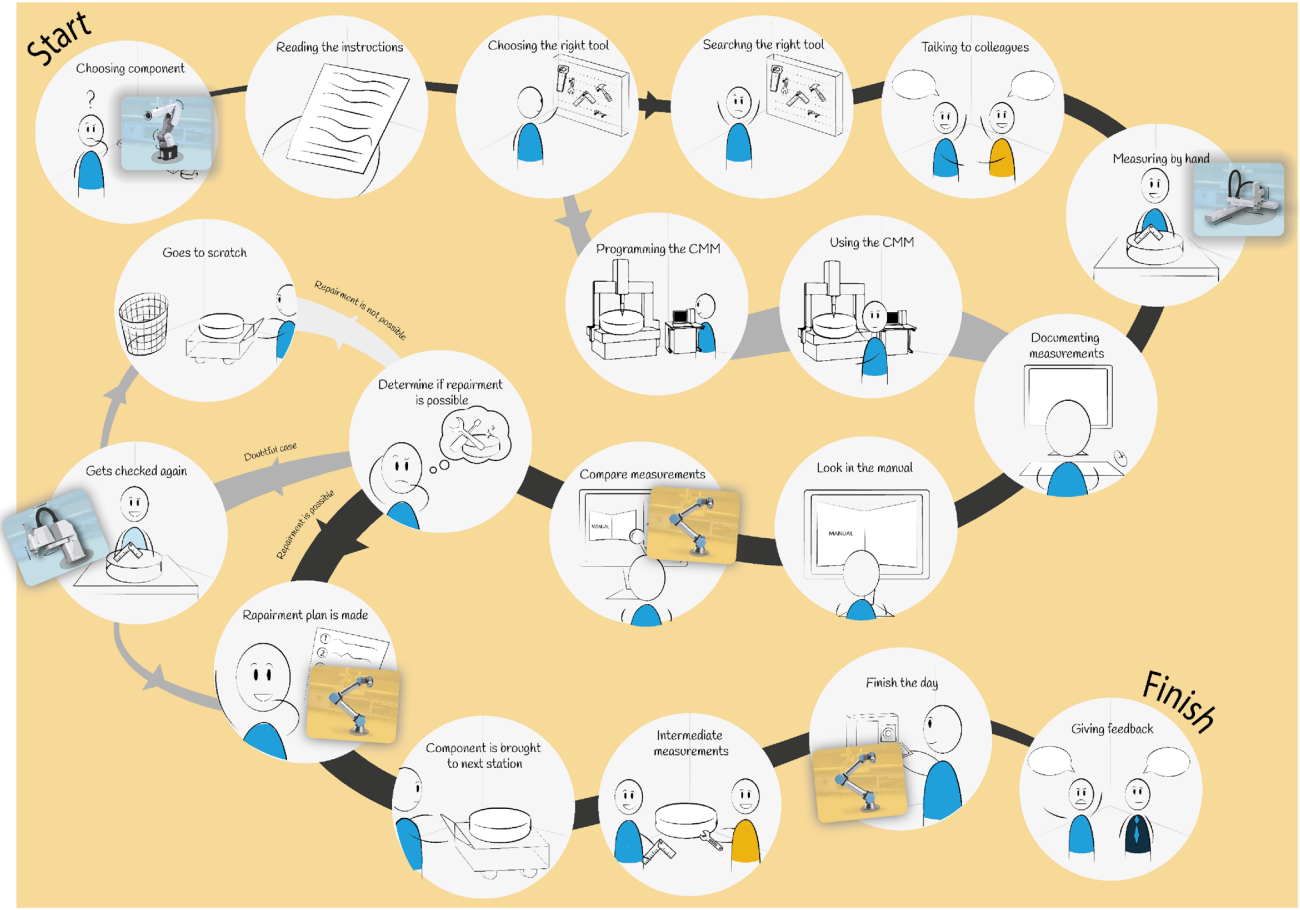
Evaluation sheet



Legenda parameters

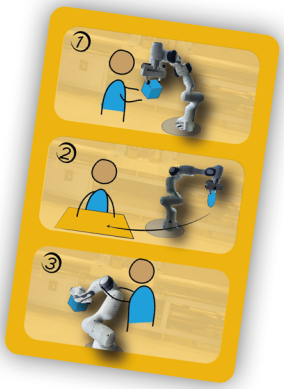
- Shared vision
- Meaningful work: **The self**
- Meaningful work: **The others**
- Meaningful work: **The context**

3



SCARA robot

The SCARA robot consist of three parts that are attached to the base. The part attached to the base can turn from left to right, as well as the part connected to this one. The last part can move up and down.



Used for...
- Sorting products
- Packaging
- Low-force assembly tasks
- Pick and place

Pros
- Very fast
- Large workspace
- Advanced software makes them very accurate and efficient

Cons
- Can only handle very light payloads.
- Wear and tear of parts by high movements.
- Expensive

Cobot KUKA

A cobot is designed to work together in the same workspace at the employee.

User scenarios

1. The employee can move the object around, by operating the cobot.
2. The cobot and employee can both work on the object at the same time.
3. The cobot can be handle many different tools, for example a grinding machine.

4

ario 1

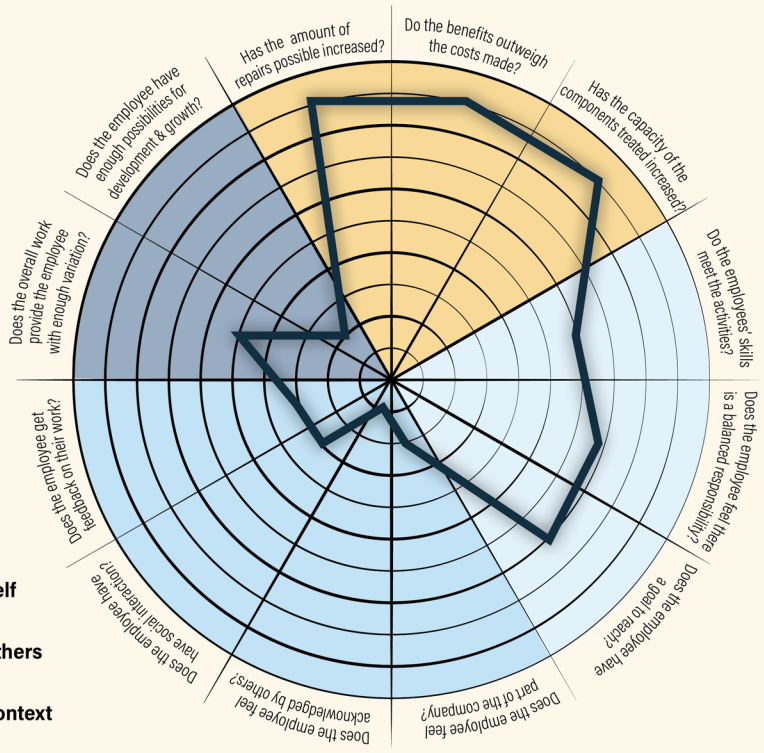
Activities sheet

Activities eliminated	New occuring activities
Bringing the component to the next station	Programming the articulated robot
Less social interaction	

5

Scenario 1

Evaluation sheet



Legenda parameters

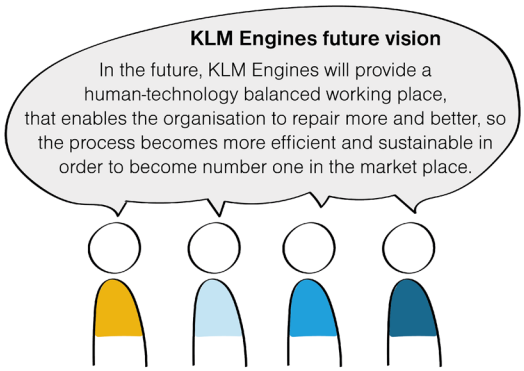
- Shared vision
- Meaningful work: **The self**
- Meaningful work: **The others**
- Meaningful work: **The context**

The evaluation criteria

The evaluation criteria used for the evaluation sheet are a result of the research done with different employees of KLM Engines. The research consists of two parts. The identification of the stakeholders intentions, which has resulted in a shared vision and the identification of themes that play a role in the meaningfulness of work of the employees' of KLM Engines. Where the evaluation criteria are coming from and how they are intented to be used is explained here.

Shared vision

The shared vision created by different stakeholders within KLM Engines has been illustrated in the following illustration.



Three important factors in this vision are: a more efficient work process, a more sustainable work process and creating a human-technology balanced working place. These factors are written in two three evaluation criteria.

Has the possible amount of repairs increased?

If more components can be repaired, less new components have to be ordered. In this way, a circulair process becomes more achieveable. Next, less time gets waisted, waiting for the components to arrive. An other result of ordering less new components is the costs decreasing.

Do the benefits outweigh the costs made?

If the amount of components treated in the same time increases, the total profit increases. This can be realised by decreasing the executing time.

Has the capacity of the components treated increased?

Implementing new technologies seem like a good solution to make the process more sustainable and more efficient. However, new technolgoies bring higher costs. That's why the the profit provided by the technology has to balance out the costs.

Meaningful work

Next to the shared vision, there is also the human aspect which the should be taken into account with the implementation of robots. Most work processes cannot be automated and thus a collaboration between robots and humans has to be created. Making sure, the human is still provided with meaningful work, results in more job satisfaction and productivity. Research is done on wha tmakes the work of the employees of KLM Engines meaningful. The insights are clustered and made into themes. The themes are divided into three categories that come from the literature of what is needed to provide employees with meaningful work. The categories are; the self, the others and the context. These themes are used as paramaters for this tool.

The self

The self includes personal motivations, values and beliefs. Humans usually have a personal purpose and work that corresponds with this purpose is seen as more meaningful. In the research, three themes are identified that fit is in this category.

Do the employees' skills meet the activities?

This parameter is a result from the theme: feeling undervalued when executing tasks that don't meet the skills. The employees explained they thought activities like "searching for a component" or "bringing the component to the next station" were useless. However, these tasks still have to be executed, the employees only think that their skill are too high for these kind of tasks.

Does the employee feel there is a balanced responsibility?

This parameter is a result from the theme: too much responsibility leads to anxiety. Most employees explained that they don't like the responsibility of a teamleader position and that they are satisfied with the execution work.

Does the employee have a goal to reach?

This parameter is a result from the theme: having a goal gives possibility to fulfilment. The employees explained it is demotivating to not have a daily target or goal. As the amount of work is always increasing, they never experience the feeling of "finishing the work".

The others

The others include colleagues, friends, family and society. Social interaction with others in the organisation can give a sense of belonginness. Also recognition from others affects the meaningfulness of work. In the research, four themes are identified that fit in this category.

Does the employee get feedback on their work?

This parameter is a result from the theme: feedback is an important motivator to keep acting. The employees explained they are both missing feedback from colleagues on the quality of their work, which could help them improve their work, and they are missing feedback on what happens to the component after it leaves their department. The employees don't if the repair has been succesful and thus don't know if their work was useful or not.

Does the employee feel part of the company?

This parameter is a result from the theme: a sense of belongingness is wanted. The employees explained they want to feel part of the organisation. They find it important to know when something within the organisation changes. Next to that, they want to be treated the same as their colleagues. An attitude of "If they are allowed, we are allowed" dominates.

Does the employee have social interaction?

This parameter is a result from the theme: social interaction with colleagues is an important motivator. When the employees were asked what makes their work enjoyable, the first anwer is: "the colleagues". Having a coffee together, working next to eachother and starting/finishing the day together, all important activities for the employees.

Does the employee feel acknowledged by others?

This parameter is a result from the theme: Acknowledgement is an important motivator. The employees explained they find it important that others acknowledge their work requires particular skills, knowledge and experience. This helps to keep motivated.

The context

The context includes the work circumstances (the working place & conditions), possibilities for self-development, facing challenges and task specific factors. In the research, two themes are identified that fit in this category.

Does the overall work, provides the employee with enough variation?

This parameter is a result from the theme: variation in work makes work meaningful. When the employees were ask which activity of their work they enjoyed the most, they explained that the variation of the activities is what makes it enjoyabe and interesting even after many years of working.

Does the employee have enough possibilities for development & growth?

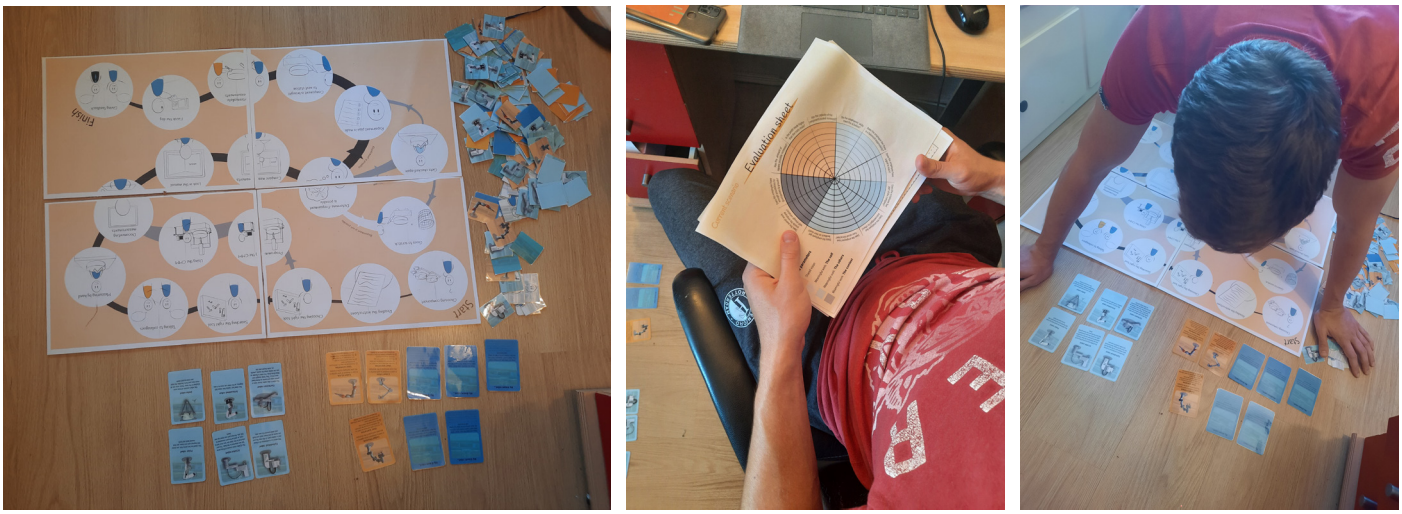
This parameter is a result from the theme: possibility for development & growth gives a purpose in work. The employees explained that the possibility for development and growth was one of the reasons they have been working at KLM Engines for many years. This possibility gives them a prospect for learning a new skill, a variation in the job and reaching a new goal.

APPENDIX L: PRE-TESTING THE TOOL

The pre-test

The goal of the pre-test was mainly to test if the tool could be used and if everything was clear. The test was done with a participant without any knowledge of the working process or robots. In the actual test, both expertise are present and thus the tool can be used way better.

The participant was given all the materials and the manual. The participant was asked to walk through the manual and execute the exercises. The particpant was aked to talk out loud during the test, so I could make notes and remarks. It became clear the manual needed some more explanation on how the exercises should be executed, so this was added to the manual. As predicted, the participant could come up with scenarios, but missed knowledge on what activities were actually added or eliminated. This is the reason why the tool is normally used as a co-design tool, involving robot experts and KLM Engines working process experts, so the effect of implementing robots becomes clear and tangible.

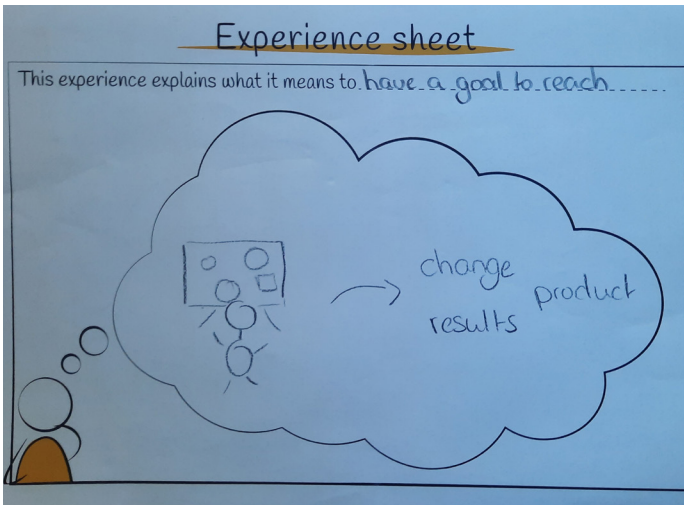


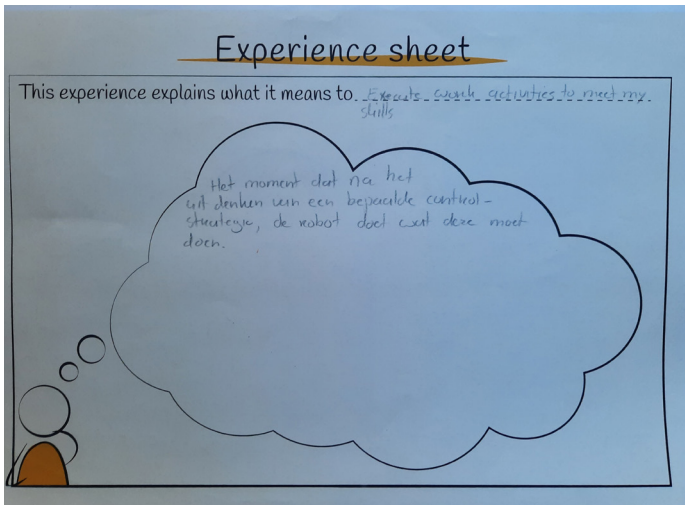
Pre-testing the co-design tool. The tool materials (left), using the evaluation sheet (middle), exploring the robot cards (right)

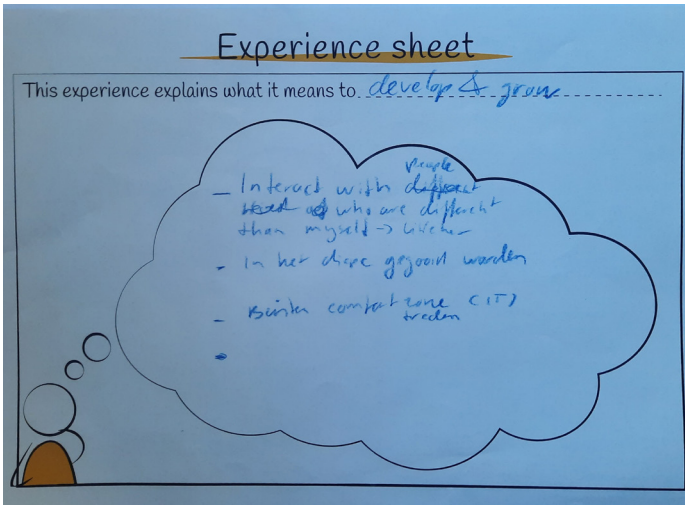
The participant liked the function of the evaluation sheet, because a clear diagram occured. Sometimes, the participant needed some guidance in what sheet to use. One concern is, that it might take quite long to create one scenario. However, as some of the evaluation criteria are not concerning the individual activity, rather than the activities together, the choice has been made to not make any changes in the game board itself. However, it is something to take into account with the design of the co-design game for FRAIM.

APPENDIX M: COMPLETED TEST MATERIALS

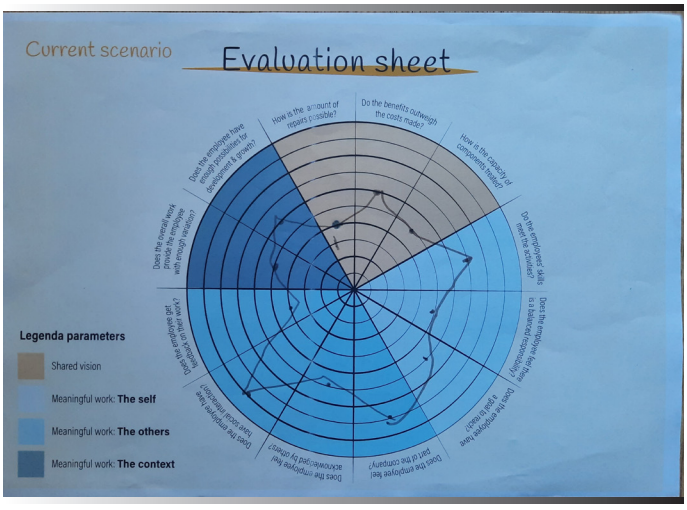
Experience sheets







Evaluating the current workflow



Activities sheet