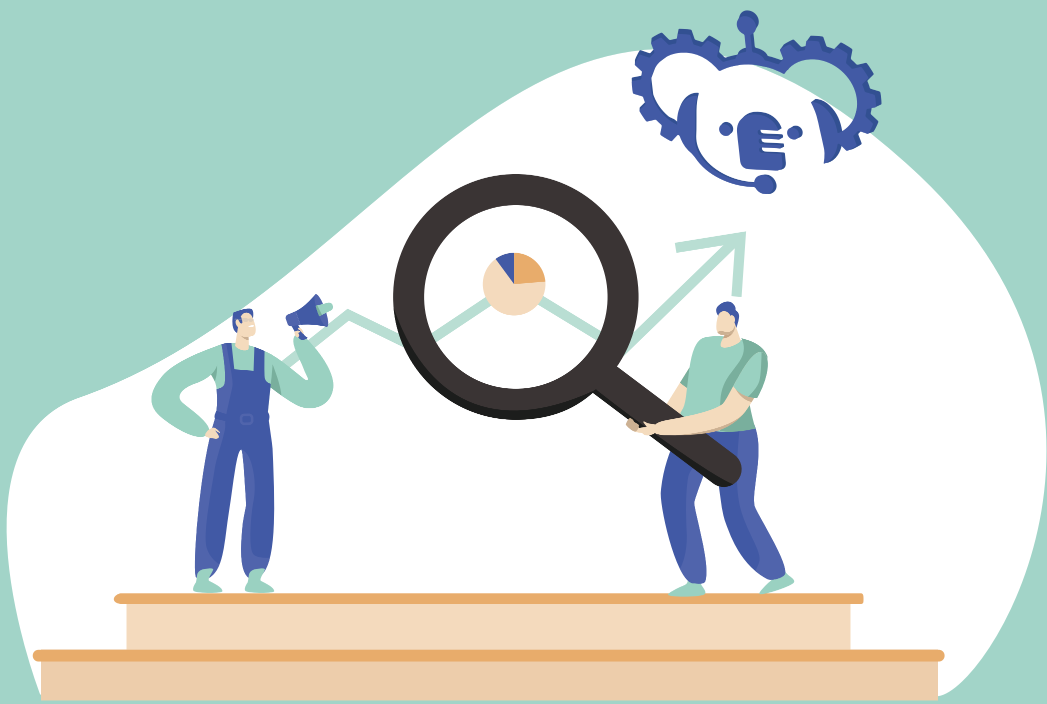


# Setting the stage for expertise and exploration

## Reframing COALA's Digital Intelligent Assistant (DIA) within the Diversey factory

# PREFACE

The Executive Chair & Co-Founder of Socos Labs said:

“Artificial intelligence and machine learning, as a dominant discipline within AI, is an amazing tool. In and of itself, it’s not good or bad. It’s not a magic solution.” – Vivienne Ming

This view of AI aligns with my view of AI within this thesis. The thesis you are about to read, “Setting the stage for expertise and exploration”, reframes the Digital Intelligent Assistant of the COALA consortium by applying the frame creation method. The context of this thesis is a Diversey factory in the Netherlands which tries to collect production line insights through its factory operators. Previously, Diversey introduced a digital tool to collect production line knowledge. However, this initiative proved to be unsuccessful and, therefore, will the Digital Intelligent Assistant be introduced. As mentioned by Vivienne, AI is not a magic solution, and simply replacing one tool with another does not guarantee success. Therefore, I explore the underlying themes in the context of the Diversey factory through interviews with operators, support staff and management.

This thesis is part of the graduation requirements for the Strategic Product Design Master at the Industrial Design Engineering faculty of the TU Delft. From September 2021 until March 2022, I conducted the research as part of the TU Delf COALA group for Diversey. Throughout my thesis, several challenges arose from access to the context and operators to grasping the complexity of the problem definition. Nevertheless, there was always someone from my supervisory or COALA team who could support me.

In the end, the thesis concludes the new frame for the Digital Intelligent Assistant with an accompanying strategy that addresses the underlying themes of the original problem definition. I hope this thesis can assist designers and managers in implementing AI solutions by looking at the deeper themes within their context and realizing AI is a powerful but not a magic solution.

Enjoy your reading!

# ACKNOWLEDGEMENTS

During this thesis, I have learned more than I could have imagined. These learnings were not possible if I did not have support throughout these six months. Therefore, I would like to thank several people that helped me during this graduation project. First, I would like to thank my supervisory team: Sander, Jacky, and Zoltan. Sander, thank you for the weekly meetings, which always ran late as we went off at a tangent, as well as for your patience and expertise while I explored the unique method of frame creation. Jacky, thank you for being able to delve into this project halfway through and help me with writing and structuring the project. Lastly, Zoltan, thank you for allowing me to explore the strategic aspect of COALA even though there was no direct benefits for the TU Delft COALA team.

This brings me to the second team I would like to thank, the TU Delft COALA team. Thank you all for your input during the creative sessions and for elaborating on the previous experiences with COALA partners. Specifically, I would like to thank Samuel for being a second mentor, especially at the beginning of this project. Next, I would like to thank the operators, support staff, and management of the Diversey factory for their participation in the interviews and for allowing me to visit the factory. In particular, I want to thank Barnabas, who assisted me during the factory visits and facilitated the interviews on-site.

Lastly, I would like to thank the experts in service design, AI systems, consumer behaviour, human relations, and change management for their input and inspiration.

# EXECUTIVE SUMMARY

Intelligent and connected services have become essential in the manufacturing industry. The surge of these services has even started a new phase of industry; industry 4.0. The COALA consortium aims to develop a service to assist operators within this new industry. The COALA consortium is an European Union Programme and aims to develop a Digital Intelligent Assistant (DIA). The DIA supports operators in situations characterised by cognitive load, time pressure, and little or zero tolerance for quality issues with trustworthy AI components.

Diversey is one of the consortium’s partners and perceives COALA’s DIA as a viable solution to their stoppage challenge on their production lines in the factory. These stoppages can be caused by various bottlenecks, which are hard to determine due to the production lines’ complexity and processes. Therefore, this thesis explores how to prepare for AI service adoption within the factory of Diversey.

However, management from the Diversey factory has attempted to identify the bottlenecks by collecting production information through operator data entries. Unfortunately, the operators did not provide the tool with quality data entries. Therefore, replacing this tool with the DIA most likely not succeed, especially when the new tool utilises AI technology that requires learning data to generate insights.

In order to explore this resistance toward new tools within the factory, I used the frame creation method of Dorst. This method excels at finding innovative solutions for problem definitions with previously unsuccessful attempts. The method explores underlying themes within the context to reframe the problem definition and find new solution spaces. The themes are formulated from interviews with management, eight support staff employees across four departments, a team lead, and six operators.

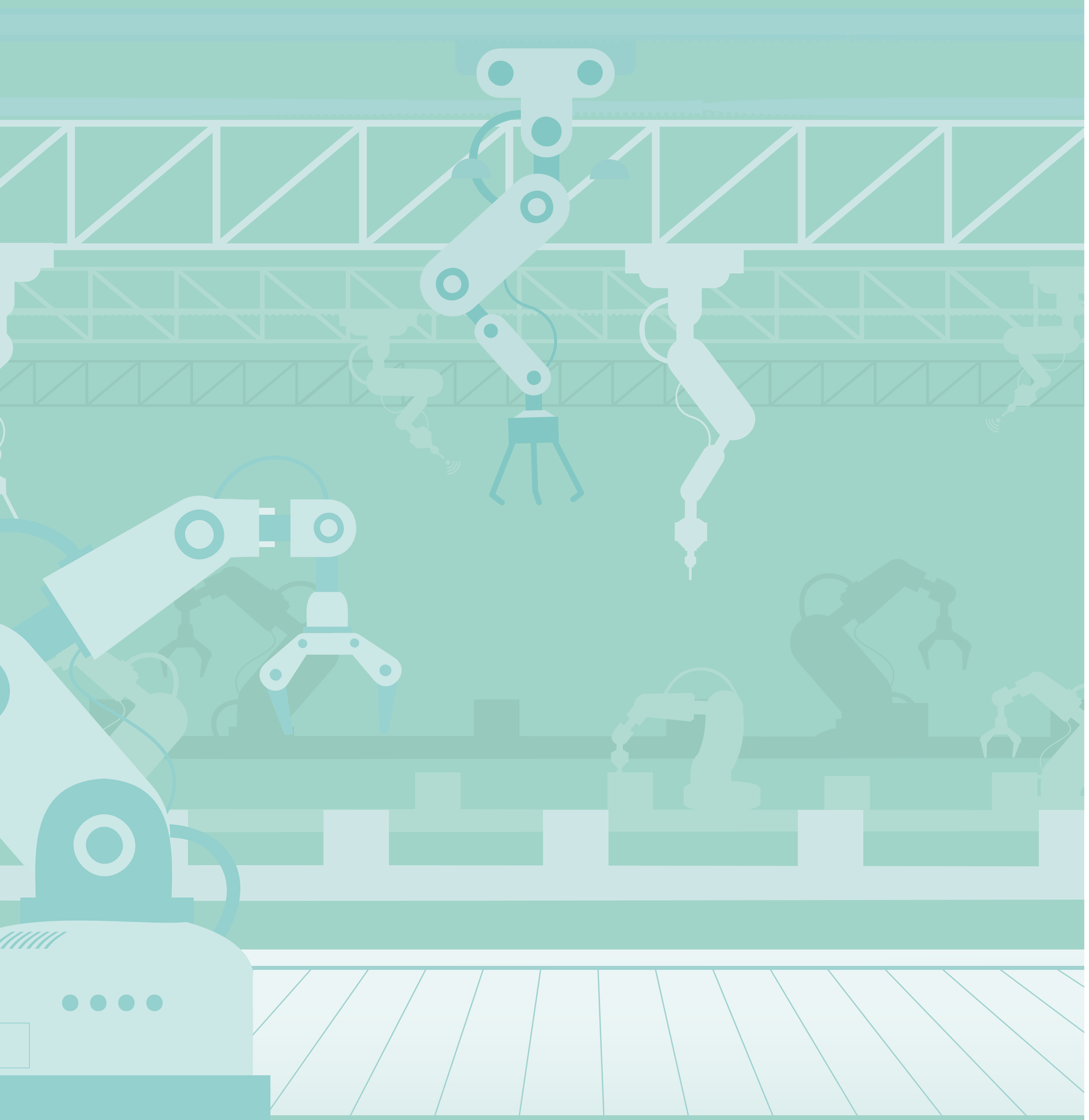
Four themes are generated by analysing the values, interactions, and ‘currency’ exchanged between stakeholders. These themes regarding new tools describe the unclear contributions to operators’ work, the lack of acknowledgement regarding operators’ role and expertise towards production improvements. These themes result in a lack of trust between operators and management, which diminish the willingness to adopt new tools. Additionally, management expresses concerns about the themes expertise and consistency, which are essential to the manufacturing industry.

In order to address these themes, COALA’s DIA is reframed *as a stage for expertise and exploration*. Instead of simply requesting data entries, operators are put in the spotlight where they can showcase their knowledge and expertise. Additionally, this stage provides a space for operators to explore production improvements through collaboration with COALA’s DIA.

The framing of the problem definition addresses the data collection aspect of COALA’s DIA. However, AI systems change over time as the systems adapt to the data input. Additionally, the thesis did not assess the users’ perception of the current DIA interface. Therefore, I recommend further research into human-AI interaction with regards to the system’s evolution over time and the interface.

Lastly, the themes are generated from one production line’s operators who are experiencing the most stoppages. The themes cannot directly be generalised to other production lines as the number of stoppages, or other contextual factors can influence the themes.

# TABLE OF CONTENTS



# 1. INTRODUCTION



## 1.1. Acceptance of change

It has been two years since COVID-19 reached the Netherlands, and most measurements have been withdrawn. However, some changes made out of necessity, like working from home, continue to be part of our daily lives. Managers and employees started to discover the benefits of working from home and chose to continue doing so. This observation raises the question if these changes would be accepted if COVID-19 was not present, especially when it is not effortless to change and is part of people's routine. Yet, changes occur on a daily basis like operating system updates like iOS, social media updates like Instagram, or even the layout of the local supermarket impact our lives.

Change is inevitable, whether the change takes place on a micro, macro, personal, or professional level. Change is not something new, however, the speed at which new technological, cultural, and strategical ideas evolve is increasing (Simmons, 2021). Change brings challenges since most change is received with resistance, which can have a range of explanations. As individuals and consumers, we might accept some changes and refuse others. Yet, organisations might not have this luxury; external factors like globalisation and developments in new digital solutions cannot be ignored anymore (Jankovich & Voskes, 2018). Industry leaders Blockbuster and Thomas Cook (Jankovich & Voskes, 2018) are examples of organisations that did not adapt to trends within their industry. This adaption might not be as prevalent in every industry, however, ignoring external factors within your industry is rarely beneficial.

Besides the external trends which pressure organisations to change, internal challenges could also be a reason for organisational change. Even though this change comes from a need within a company, aligning everyone inside the organisation is still challenging. Internal initiatives are precarious since people generally do not like change and often even undermine change (Satell, 2021). Change can come in many forms, from role adjustments to the entire restructuring of an organisation. Yet, the challenge of establishing an organisation where employees are willing and motivated to use new technologies is one of the most critical challenges, according to Tiersky (2017).

An organisation has its particular culture, values, and way of working, making every organisation unique. Amis, Slack, and Hinings (2002) conclude that support for a change depends on the similarity between organisational and proposed values. Moreover, a change management approach should align people within a specific organisation in order to introduce change successfully (Fountaine, McCarthy, & Saleh, 2019). Hence, the importance of a tailored change management approach for an organisation, its people and values. Different change management categorisations and approaches are explored in section 4.1.

## 1.2. Change within factories

A field that has seen several revolutions with significant changes is the production industry. The first industrial revolution showed the world that machines could mass-produce via power sources besides people and animals. The second industrial revolution introduced the world to assembly lines, innovative communication channels, and additional power sources. The third revolution demonstrated the possibilities to automate specific tasks and collect data through the use of embedded controllers. And now, the fourth industrial revolution presents the opportunity to collect even more data, increase automatisation, and adjust decision making through smart machines. On the factory floor, data is gathered through sensors, machines, and people to improve efficiency and production. The data can even be combined with other parts of the organisation's value chain to generate insights into the entire organisation (IBM, n.d.).

Industry 4.0 utilises different emerging technologies like cloud and edge computing, IoT devices, digital twins, cybersecurity, and artificial intelligence to create insights from the available data on the factory floor. These technologies have their specific strengths and challenges in the factory context. However, this thesis focuses on Artificial Intelligence (defined as AI). Essentially, AI technology analyses data sets, recognizes patterns within these sets, and makes predictions based on the provided data. The analysis can be done through a variety of models, which all have their strengths, weaknesses, and use case. However, the specific models will not be the focus of this thesis.

Yet, the capabilities of AI greatly depend on the model, data provided and the desired output. AI technology creates opportunities within industry 4.0 to automatically generate insights and decisions. These opportunities come with their own challenges as data collection, employee interaction and data evaluation are needed to successfully leverage AI systems.

## 1.3. COALA consortium

An example of AI technology in the production industry is the Digital Intelligent Assistant (defined as DIA) of the COALA consortium. This thesis is part of the COALA (**CO**gnitive **A**ssisted agile manufacturing for a **LA**bor force supported by trustworthy Artificial Intelligence) consortium, which is part of the European Union's Horizon 2020 Research and Innovation Programme.

**Figure 1** - *COALA's DIA mobile user interface*

The manufacturing industry is characterised by the need for consistent quality and production, complex production lines, and the convergence of different technologies. Consequently, operators' work on the production lines is defined by high-pressure situations and a high cognitive load. Therefore, the COALA consortium addresses these conditions through cognitive assistance. The cognitive assistance is defined as the DIA with trustworthy AI components and a voice-enabled and mobile user interface (see Figure 1).

The COALA consortium's vision is to develop a **human-centred digital assistant** which supports operators in production situations characterised by cognitive load, time pressure, and little or zero tolerance for quality issues (Bremer Institut für Produktion und Logistik GmbH, 2020). The consortium consists of 14 partners who aim to successfully implement the cognitive assistance solution for production operators in three business cases. The three production business cases are 1) textile, 2) white goods, and 3) detergent. This thesis focuses on the latter.

COALA's DIA comes from the growing demand for AI solutions, growing possibilities in AI, and the challenges of creating AI while adhering to Europe's requirements (Södergård, 2019). These elements, combined with labour force shortages (Wellener, Reyes, Ashton, & Moutray, 2021), loss of knowledge due to retirement or job change, and the digital skill gap in the manufacturing workforce (European Commission et al., 2017), form a strong desire among factory owners for a service like COALA's DIA.

In conclusion, COALA's human-centred DIA aims to support workers who need to use analytical tools, reduce the cost of retired operators' lost knowledge, and support on-the-job training for new operators.

## 1.4. The socio-technical context of Diversey

Diversey is one of the companies that provides a business case for the COALA project. Diversey is an international company that strives for a healthy and safe world (Diversey, n.d.). They aim to protect and care for people through leading hygiene, infection prevention, and cleaning solutions. Diversey has around 8500 employees worldwide in factories and offices with sales, manufacturing and R&D functions separated. Diversey supplies several solutions in the field of hygiene like all-in-one solutions for entrepreneurs, cleaning machines, E-shop, and consulting. Notably, in six industries: Facility management, Retail, Healthcare, Hospitality, Foodservice, and Facility services (Diversey, n.d.).

Yet, not all services are as relevant for the COALA program. The program focuses on the production of detergent products that differ per factory. Diversey has two sites with a factory in the Netherlands and Italy which provide a specific business case for COALA's DIA. The specific challenge within these factories is the stoppages on the production lines. A production line is composed of different machines or stations which manufacture a variety of detergent products. Due to multiple complex machines operating sequentially in one production line, stoppages occur frequently. The main purpose of COALA's DIA is to identify the bottlenecks through data provided by the operators and production line sensors. The factory in the Netherlands will be the context of this thesis as factory visits were possible. These visits are used to explore the existing dynamics and structures within the socio-technical context.

The socio-technical context refers to the interaction between the social and technical aspects of the organisational processes. The aim of the socio-technical focus is to optimise both aspects and the synergy between them. For the Diversey factory in the Netherlands, the social aspect refers to the employees, their responsibilities and needs, the interaction between employees and teams. The technical aspect refers to the business and production processes. Diversey's management has already experimented with introducing data collecting tools to identify the bottlenecks in the socio-technical context of their factory. Unfortunately, the engagement and adoption of these tools were relatively low. The challenge of adoption and engagement will also be prevalent for COALA's DIA.

## 1.5. The practical and theoretical gaps in implementing AI services

The challenge of implementing AI solutions is not only evident within the Diversey factory; the gap is also present in other organisations. It is estimated that 85% of AI projects will fail to meet expectations throughout 2022 (Engel, Ebel, & van Giffen, 2021). There could be a variety of reasons for not meeting expectations, yet Engel, Ebel, and van Giffen (2021) suggest that addressing interactions between AI systems and the socio-technical system can lower these rates. Additionally, many organisations perceive AI as a plug-and-play solution and expect instantaneous results (Fountaine, McCarthy, & Saleh, 2019). However, as organisations are experimenting with ad hoc pilots, they are likely to face cultural and organisational barriers. As mentioned before, change often results in resistance. How organisations deal with this resistance is essential. While these failed expectations can lead to disappointment, they can also be detrimental to future AI adoption and AI perception within the organisation.

In addition to the practical gap in ensuring expectation, there is also a theoretical gap in the literature regarding the social aspect of AI. The systematic literature review (SLR) of Cubric (2020) reviewed 30 systematic reviews regarding AI across different industries and fields. The most recommended focus across the SLRs was oriented toward people, organisational, and social aspects of AI (16 SLRs). Moreover, Engel et al. (2021) describe the research of AI implications in socio-technical systems as a 'nascent' field, further emphasising the early stages of literature regarding AI implications in socio-technical systems. Lastly, Engel et al. (2021) suggest that addressing these implications could limit AI projects' previously discussed failure rate.

To conclude, COALA's DIA could assist Diversey operators during situations with cognitive load, time pressure, and little or zero tolerance for quality issues to limit the production stoppages. However, previous data collecting tools were unsuccessful, and the AI model within the DIA needs data and output evaluation to perform. Therefore, it is crucial operators are willing to adopt the COALA's DIA and increase the Diversey factory production.

# 2. METHODOLOGY

## 2.1. Project aim

This thesis aims to demonstrate the importance of discovering and addressing underlying themes of previously unsuccessful digitalisation efforts within organisations before experimenting with AI services. This thesis explores the case study of a Diversey factory in the Netherlands that wants to integrate COALA's digital intelligent assistant (DIA) into its production lines. Within the case study, the need for a service like COALA, the motivation for COALA specifically, the previous attempts, the socio-technical context and stakeholders are analysed. Relevant organisational challenges in the field of change management, artificial intelligence, technology acceptance and sources of meaningful work are explored to formulate a strategy that addresses the stakeholders' concerns with regard to the integration of COALA's DIA in the context of the Diversey factory. In conclusion, the research question is:

*How to prepare AI service adoption in the socio-technical context of the Diversey factory through reframing?*

The research question is divided into four sub-questions that are addressed throughout the thesis:

1. How can an organisation prepare for internal change initiatives?
2. What aspects influence the adoption of change within an organisation, and how?
3. How do AI service changes differ from traditional organisational change?
4. What specific socio-technical system aspects within the factory lead to the resistance to change?

## 2.2. Project approach

### 2.2.1. Frame creation method

Management of the Diversey factory has already tried different tools to map bottlenecks in their production lines. However, these endeavours toward identifying these bottlenecks have been unsuccessful. The frame creation method excels at finding innovative solutions for problem definitions with previously unsuccessful attempts (Dorst, 2015) as the method applies a different form of reasoning. In order to explain these forms of reasoning, it is important to state the components of reasoning (see Figure 2):

- a 'what' (elements);
- a 'how' (pattern of relationships);
- and an 'outcome' (observed phenomenon).

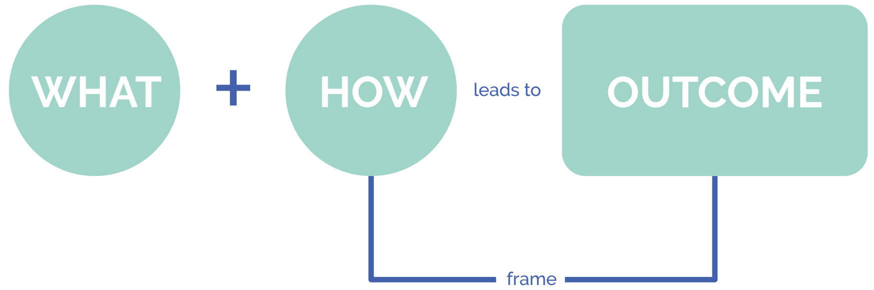



**Figure 2** - *Components of reasoning (Dorst, 2015)*

The deduction reasoning uses the 'what' and the 'how' to predict an 'outcome' like any engineering problem from calculating the speed of a falling object or insulation of a material. The induction reasoning uses the 'what' and the 'outcome' to form hypotheses of the 'how'. Lastly, the abduction reasoning looks at a fixed pattern of relationship (the 'how'), which will lead to a desired 'outcome', and the 'what' can be a product, service or system which will facilitate this pattern. For example, caffeine (the 'how') makes you feel awake (the 'outcome'), so the 'what' could be a coffee maker.

This combination of a 'how' and an 'outcome' is called a frame by Kees Dorst (2015). Instead of normal abduction, the frame creation method applies design abduction, which does not include a fixed 'how' (see Figure 3). The frame creation method explores different 'how's by finding the underlying themes within the current challenge and defining different frames. These frames lead to more creative and innovative solution spaces, which leads to different 'what's compared to the originally defined frame.


**Figure 3** - *Abduction reasoning (Dorst, 2015)*

An example could be the desired '*outcome*' of coming to work energised. The *'how'* can be defined through chemical stimulus, resulting in a solution space (the '*what*') that explores ways to make caffeinated drinks. However, by specifying the *'how'* in new ways like social interaction to feel energised, the solution space ('*what*') could be having an engaging conversation before work (Dorst, 2015).

In conclusion, the Diversey factory management has explored different 'whats' within an initial frame. However, it is considered necessary to explore different frames which address the underlying reasons for operators' resistance before introducing a new 'what' like COALA's DIA.

### 2.2.2. Research activities

As part of the TU Delft COALA team and the Diversey business case, I have had weekly interactions with the decision stakeholders of this project. The interactions consisted of a Diversey meeting, TU Delft general COALA meeting and a specific cognitive advisor meeting that focussed on the DIA. The site managers, production managers, EMEA (Europe, Middle East Asia) managers, and the TU Delft COALA team are invited to discuss current challenges within the Diversey meetings. However, the meetings also show the level of managers' involvement, the dynamic between stakeholders and their priorities, as some stakeholders were more involved than others. Moreover, I used the TU Delft meetings to gain insights into other relevant DIA barriers and facilitate creative sessions regarding the effects of COALA's DIA and its functionalities.

An additional way of collecting insights is through factory visits. During these visits, I interviewed and observed a variety of stakeholders with goals depending on the part of the frame creation process (see Appendix A for a complete overview).

In addition to Diversey's problem definition, third parties were involved throughout the steps of the frame creation framework in the form of experts, practitioners, and COALA partners to create an overview of the domains within the project.

Within the original nine steps, two iterations were made, which altered the order of the steps. The first iteration was made during the exploration of the Context. During the exploration, the importance of previous tools and current systems became apparent and were added to the Archaeology step. The second iteration is made during the co-evolution of the final frame during the Futures step. This iteration resulted in a second section of the Field step. The nine steps are listed below and visualized in Figure 4.

### 2.2.3. The nine steps of frame creation

**Archaeology -** The original problem is analysed in combination with earlier attempts to address the problem situation in Chapter 3. This step explores the dynamic within the organisation and sheds light on Diversey's boundaries that could limit possible solutions. This part consists of observations during an exploratory visit, analysis of the current solutions, previous change initiatives, management's priorities, the history of COALA and Diversey.

**Paradox -** The third Chapter ends with the central paradox of the problem. The paradox describes why this situation is so complex and challenging to solve. Normally, the paradox is only defined and assessed later in the frame steps. However, the 'what' is already partly determined as COALA's DIA, and therefore the paradox is followed by a short evaluation of the COALA's DIA service. The underlying themes of the paradox are explored in the Context and Field to reframe COALA's DIA.

**Context -** The Context and Field steps are combined in Chapter 4. The Context section explores stakeholders' experiences and expectations to examine which aspects influence their current behaviour. The context is explored through a creative session that maps the current and potential future stakeholders, through semi-structured interviews with Diversey management and support staff, and through structured interviews with operators. The insights from the context combined with processes, systems, and production lines discussed in archaeology are later used for generating themes.

**Field -** The next step is the field section, which is divided into two sections. The first section is described in Chapter 4 and explores the domains of Change management and Artificial Intelligent. In this section, the influence of these domains on the socio-technical system is examined. The second section in Chapter 5 explores the values, interactions, and 'currency' exchanged between stakeholders through an analysis of trust, behaviour change, and job satisfaction.

**Themes -** From the analysis within the Context and Field steps, encompassing themes are generated, which could explain the current challenge of implementing AI in the factory of Diversey. Themes describe the underlying reasons for the current resistance towards tools like the DIA. The themes are generated by findings patterns and clusters among the key stakeholders' needs, motivations, and experiences. The stakeholders' insights are extracted from 15 interviews and observations over five factory visits.

**Frames –** Frames are used to approach the problem situation from a different perspective and explore new solution spaces. Frames are formulated through the generated themes of the previous step. These frames can be concepts, metaphors, or relationships patterns that form these new solution spaces. The initial frame iteration resulted in three frames that were co-evolved with key stakeholders into the final frame.

**Futures –** The Future step assesses the fruitfulness of the solution space sparked by the proposed frames. The solution spaces of the initial frames were introduced to stakeholders in three parts; 1) a workshop with the supervisory team, COALA researcher, and the Operational Excellence (OpEx) director of Diversey, and 2) a structured interview with four operators, and 3) a presentation for the continuous improvement and production managers of the Diversey factory. These evaluation activities resulted in a co-evolution of the final frame.

**Transformation/ Integration -** In the last section, the overall strategy for the reframed DIA is developed. This strategy includes a concept of the DIA, which addresses the short term challenges and a roadmap that addresses the long-term challenge of integrating the new frame.

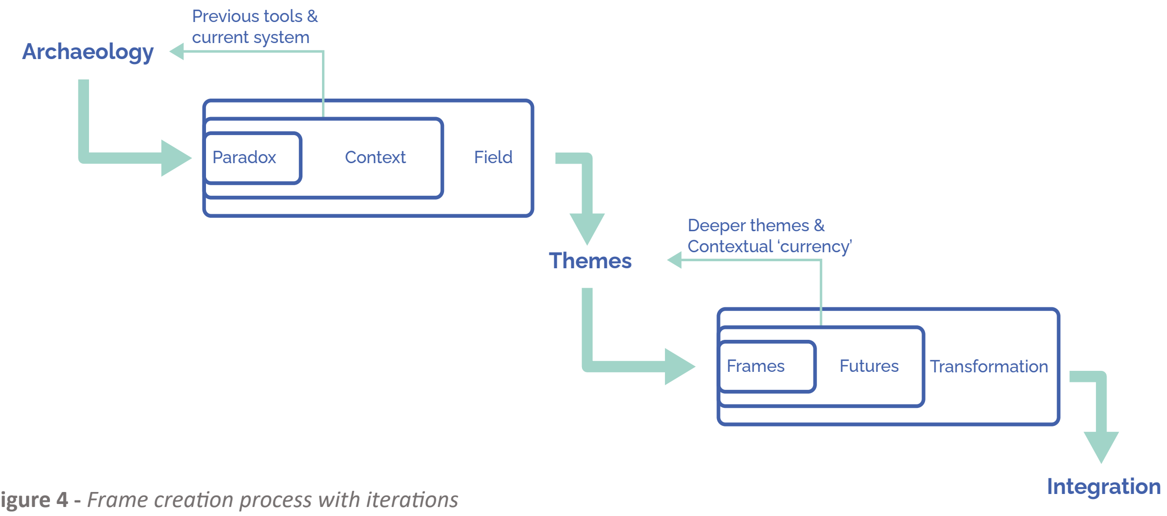



**Figure 4** - *Frame creation process with iterations*

# 3. ARCHAEOLOGY

Within the archaeology section, the problem definition is explored to discover past endeavours to gather bottleneck insights, the perspective of the problem owner, dynamics between the COALA program and Diversey, the dynamics within the Diversey factory, and the boundaries of possible solution spaces.



## 3.1. Diversey archaeology

This section explores Diversey's operating market, factory, processes, and systems to get a complete overview of the relevant components of the organisation.

### 1.1.1. The B2B detergent market

As Diversey is operational in different industries supplying cleaning solutions, their client's needs are diverse. Every industry has its standards and requirements, like handling food and sterilising surfaces in healthcare. These requirements result in specific demands in the factories (Diversey Quality, 2021; Occupational Safety and Health Administration, n.d.). Also, the global market needs influence the assortment of Diversey. For example, when the global demand for sanitation gels increased around the world and Diversey had to quickly adapt.

Besides the market industry effects, Diversey's business consists mainly of B2B orders. The B2B market has its own characteristics which influence the organisation. Within a B2B market, customer relationships are crucial due to the complexity of decision making and the longer purchasing cycles (SalesForce, n.d.). Moreover, the orders are larger and from limited buyers compared to a B2C business. Therefore, the quality of the product is crucial to maintain as it affects a large batch size and can damage the essential customer relationship. The production manager mentions during the exploratory visit that clients' demands put pressure on new products and production. The risks from stalled production or reduction in quality of a large batch are significant for Diversey.

Even though customer relationships, batch sizes, and extreme cases like COVID-19 affect the organisation in the sense of risks and changes, the complexity of these influences is relatively low. For example, chip manufacturers like ASML operate in more complex markets with regard to product implementation, customer relationships and service.

### 1.1.2. Process factory Diversey

The Diversey operators will be the main users of COALA's DIA, and the operators' main concern is the production of the detergent products. The Diversey factory's production process can be deduced into five main processes: 1) receiving chemical solutions and packaging, 2) mixing the chemical solutions, 3) quality control of the detergent solutions, 4) filling and packaging the detergent solutions, 5) storing and shipping the packaged detergents (see Figure 5).

The 5-10L production line is experiencing the most stoppage and is therefore chosen by Diversey as the focus. Moreover, the current COALA efforts like the ZED2 camera are already in place on the 5-10L, and therefore the operators on this line are the most up-to-date on the COALA development. Therefore, the scope of this thesis is also the 5-10L production line. Figure 5 gives an impression of this production line and the different stations. The 5-10L line produces, as the name suggests, both 5L and 10L products, which differ in labelling, detergent solution, and packaging. The line consists of stations or machines with their own functionalities and settings (see Figure 6). Every station has 3-5 different settings, which differ for every unique product

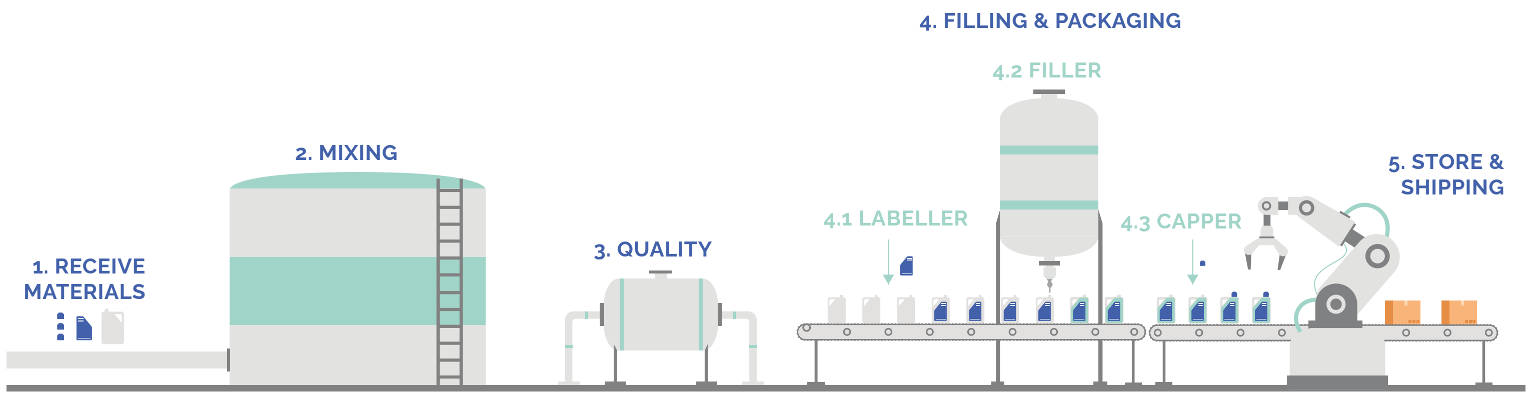



**Figure 5 -** *Main processes within the Diversey factory*

(defined as SKU). Moreover, the 5-10L line is one of eleven production lines within the Diversey factory.

Operators' activities are adjusting the settings of machines and washout procedures according to the SKU and preparing the changeover between shifts. Moreover, in a factory like Diversey's, there are various dependencies like the availability of chemicals, packaging (labels, caps, and containers), boxes to palletize, and available storage space. These dependences and the settings of the different machines can result in the interruption of the production process. When materials are missing during a shift, the operators will perform maintenance or cleaning, which was scheduled for another time. Yet, with the settings, the operators need to evaluate the settings through trial and error. Examples of some of the issues are overflowing canisters or labels getting stuck.

Previously, the operators were responsible for their shift yet not assessed on anything specific metric. Management is currently developing more awareness regarding the production line output, so operators are aware of their performance with respect to their peers. However, only assessing the output of the production line could result in a limited short term focus. For example, the team lead explained in an interview (Diversey interview, 2022) that operators often reset the machines, so the error disappears. This solution helps the individual operator; however, it limits the advancement of the factory.

In conclusion, the bottlenecks within the production process could be caused by various possibilities, making it a complex context to identify specific bottlenecks in the production system. Moreover, operators are not supported to identify these bottlenecks.

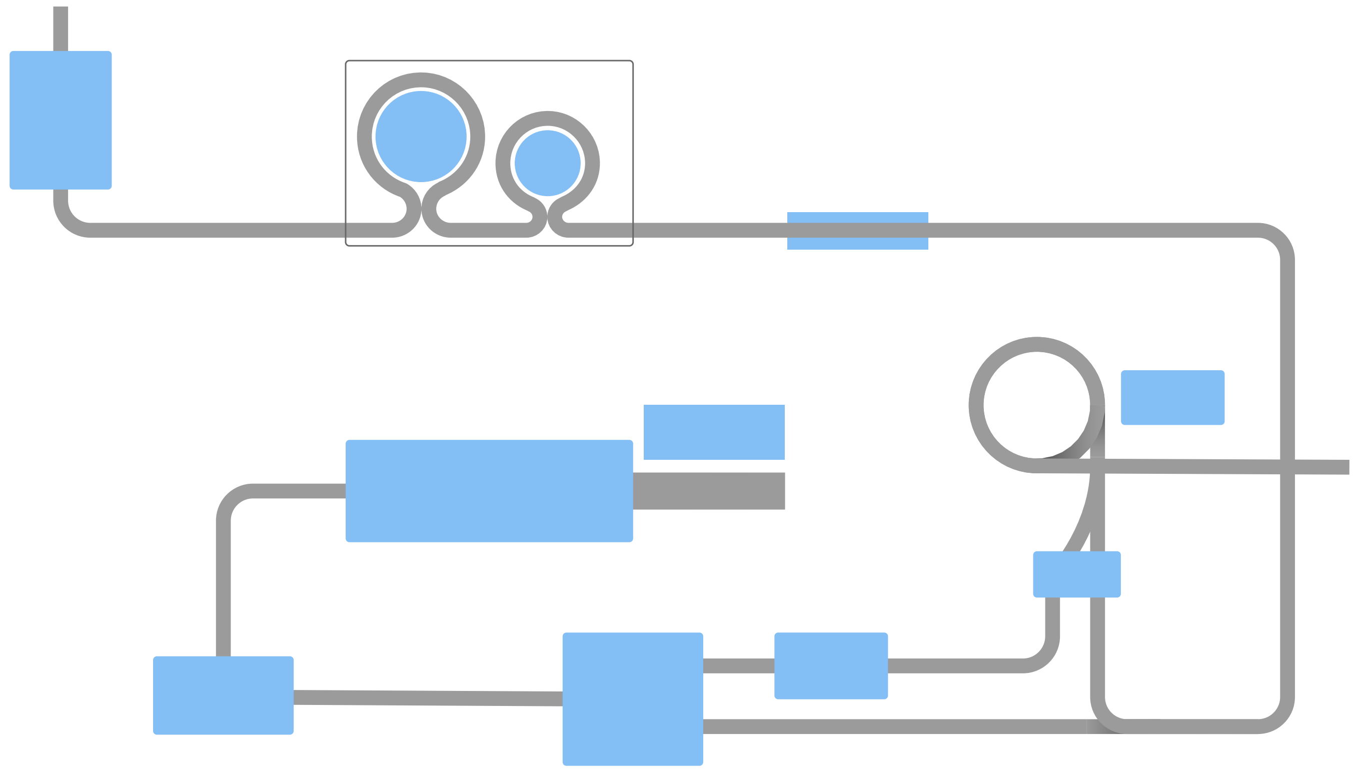


**Figure 6** - *The 5-10L production line with stations in blue*

### 3.1.1. Support staff Diversey factory

Besides the main activity of manufacturing detergent products, there are supporting departments like logistics, quality, and maintenance. There are other departments as well, which are explored in section 4.3.4. However, these three departments have the most influence on the operator process. Logistics are responsible for the required chemicals and semi-manufactured products like canisters and caps. Logistics also makes sure the products are stored appropriately and distributed to Diversey's clients. Quality is responsible for the quality of the chemical mixture, quality of the final product, new product engineering, production precautions, and customer complaints. The quality of the chemical mixtures is tested through micro biology, the quality of the final product and safety precautions undergoes sample analysis control. New product engineering is mainly performed by the global office, yet the local department assesses the viability and feasibility of potential new products. Lastly, quality handles customer complaints by analysing the root causes of the quality complaints. Maintenance is the direct support on the production lines for operators when the issue cannot be solved by the operators. If the issue cannot be solved through configuring the machine settings or takes longer than 10 minutes, the issue is escalated to maintenance. The maintenance department uses a digital ticketing system for issues and previous solutions. Other departments like quality use their Statistical Process Control called Alis. Alis and other tools that are used by operators are explained in section 3.2.

### 3.1.2. Safety, quality and then production

The primary challenge within the Diversey factory is the variance of production output between production lines and shifts, yet safety and quality cannot be compromised. The main priorities of the factory are safety, quality, and production in that order, as mentioned by the production manager (Diversey management interview, 2021). Even though the order of the priorities suggests a focus on safety or quality, this is not where the main challenge lies.

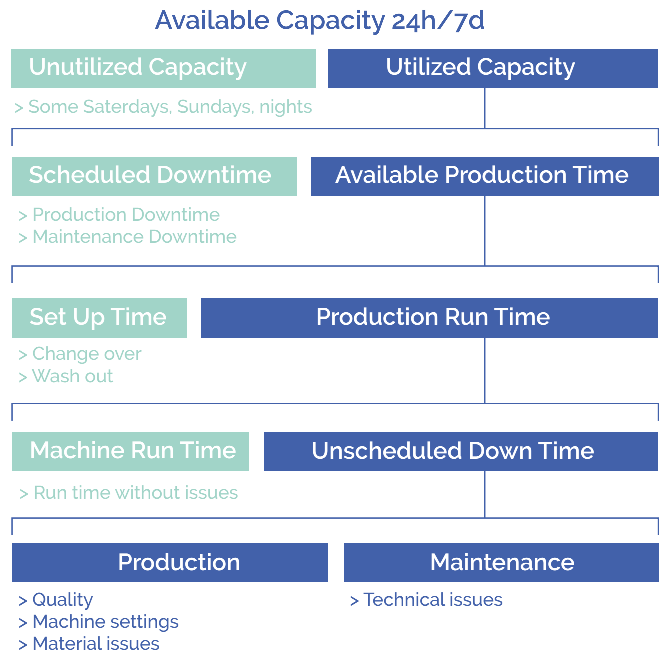



**Figure 7** - *The perfomance over availibility breakdown of 'OEE' KPI*

First, safety entails the working conditions of Diversey personnel which has top priority. These conditions are monitored and dependent on the specific chemical solutions. These conditions are determined and tracked through processes that ensure safety whenever a change in the process takes place. Since this aspect is under control through enforced processes, it is not the management's main challenge.

Second is the quality of the products, meaning the mixing and packaging of chemical detergent solutions. This is prioritised as quality is essential for industry standards like the food and health industry. Moreover, a quality issue in a batch can have a significant impact as Diversey operates within a B2B market which is characterized by larger decision cycles and exact product standards (Steinberg, 2009). Thus, a poor batch could lead to a decrease in customer relationships and can be costly due to the large batch sizes. However, the mixing requirements are already set by the global office, as mentioned in the interviews with the quality department (Diversey Quality department interview, 2021). Therefore, their main activities are to periodically check the quality, handle customer complaints, and test runs if changes are needed. Since the processes to test and ensure are stable, this aspect is also not the main challenge within the factory.

Lastly, production is the efficiency of the factory measured in produced SKUs in a given period. As mentioned before, the production lines differ in chemical detergent solutions and packaging. The settings for the production line are determined by the operators according to the SKU requirements. These settings also include the washout procedures, which can compromise the quality as well if guidelines are ignored. As their production process affects the production output and quality, the KPI 'OEE' is formulated to get insights into the specific areas that need improvements. The KPI is the product of Availability, Performance, and Quality; the complete breakdown of the KPI can be seen in Figure 7. Interestingly, the scheduled downtime is not included in the 'OEE' calculations as only the available production time is included in the calculations

Within the KPI, there could be various reasons for a reduction in measurement. These reasons range from the entered machine settings to missing materials. However, as output differs between shifts and production lines, the reason for the low KPI measurement is unclear. The complexity of some production lines leads to significant amounts of stoppages. These stoppages result in lowering the production line's production rate, which lowers the production output. The control over the last priority is significantly lower compared to the previously discussed aspects. Therefore, the eventual thesis strategy should focus on production yet not compromise quality and safety.

### 3.1.3. Risk oriented factory and engineering problem solving

The Diversey factory is an organisation that focuses on minimising risks and controlling variables to solve complex problems. This is not uncommon in factories. However, this emphasis on minimizing risk can limit the range of possible solution spaces for this thesis. The priority to maintain safety and quality is also understandable, and yet there should be a balance between rigid risk evasion and innovation. Moreover, as we explore in the later Chapters regarding change and artificial intelligence, it is important to have a test-and-learn mentality when dealing with AI.

As seen in the procedures and processes regarding safety, Diversey management's perception of change is to assess the risk and minimize this risk through strict processes. This emphasis on risk is also visible in the first interaction during the thesis kickoff. The suggested change management model was FMEA which focuses on what could go wrong with change by determining the severity, occurrence, and detectability of the failures (LeanSigmaSixPartners, 2021). This model also occurs in Diversey's Management of Change which serves as guidance for changes that pose risks regarding health, downtime and maintenance. Management of Change is crucial for risk assessment and safety within the factory and is suitable when specific machines or components are changed. Yet, this Management of Change does not account for the adoption among employees of a service like COALA's DIA and could therefore be less effective when the urgency of the change is unclear.

Moreover, the production manager views securing best practices as one of the most valuable features of COALA's DIA. As mentioned in section 3.1.2, the variance between operators and production line is a challenge within the Diversey factory. Therefore, the production manager aims to remove the variance between shifts and production line through best practices (Diversey management interview, 2021), hopefully resulting in a well-oiled machine. However, securing this process would be a challenge, yet through COALA's DIA, this would be possible. Dorst (2015) describes this as the core paradox of innovation management and raises the question: "How do we find a balance between routine operation and the need for novelty and change in an organization?".

## 3.2. Current tools and systems within Diversey

### 3.2.1. Previous tools and the role of management

In order to get an overview of the history of the problem situation, the previous tools are examined in an interview with the two IT representatives (Diversey IT interview, 2021) and the role of management. The employee in IT has been working for Diversey for 20 years and has seen the development of several digital tools. The digital tools were never fully adopted and are even currently being undermined, for example, by unplugging the power or scanner from their station, which prevents to software from working. The past tools lacked in giving operators responsibility, involvement, and feedback loops, as appeared in the interview with the IT representatives.

Currently, the internally developed tools consist of Qlikview, ODCE, and the recently added changeover form. Some production lines use Qlikview to detect if the mixed solutions are ready for filling. However, this tool is read-only for operators on the production lines and is not up to date for all production lines and is therefore not included in the following section; the ODCE tool and changeover form are addressed in the next sections.

Lastly, Diversey also uses externally developed tools like SAP's ERP, Manager+, and Alis to manage the business complexity within the factory.

### 3.2.2. ODCE tool

Since management desires insights into 'OEE' and specifically into the production line bottlenecks, information is needed. Therefore, the ODCE tool is developed by management and aims to identify bottlenecks through operators' input. The tool registers all stoppages above 30 seconds, and when the stoppage extends to 180 seconds or more, a pop-up appears that requests the operator to fill in the location or shift situation (see Figure 8). Yet, this tool is not retrieving as much valuable data as anticipated. Figure 9 displays the data from ODCE for a week, and four out of seven production lines have no data available. Even if enough data is retrieved on a production line, the data is of limited use as a significant part of the data is filled in as 'overig' (various) and 'onbekend' (unknown), which includes no information about the stoppage.

As Figure 9 only shows one week, it is not representative of the use of ODCE tool throughout the rest of the year. However, this data, combined with the interviews with operators, maintenance, and the production manager, shows that ODCE is not used as intended and has little added value.

The usage of the ODCE tool demonstrates an absence of quality data entries about the stoppage in this form. In the interview with IT, it became apparent that some operators fill in a few quality entries, others fill in low-quality entries with little to no information, and a few operators even undermine the tool by unplugging the scanner. Yet, data is needed to train and evaluate COALA's DIA. Therefore, it is essential to discover the underlying reason for this unwillingness and ineffective entries among operators. Some known issues extracted from interviews are listed below.

- Not adapted to every production line resulting in missing locations for issues
- Availability for 'easy' reason entries
- Technical malfunctions in the tool
- No direct data is available for users

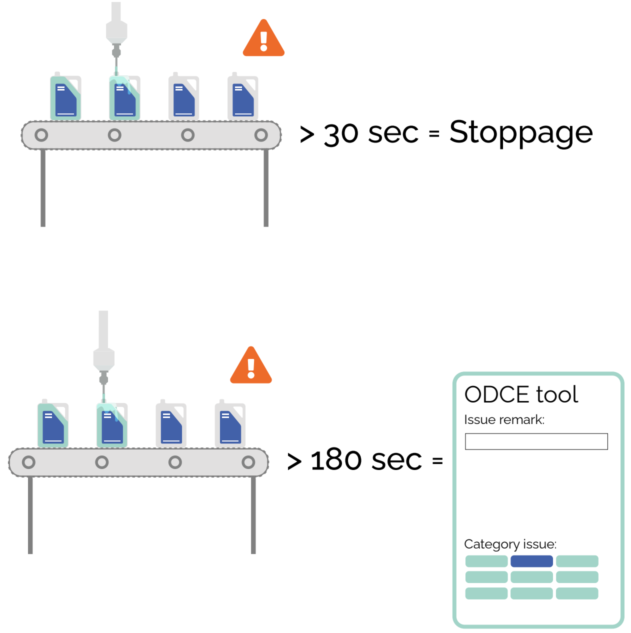



**Figure 8** - *Visualisation of the ODCE tool process*


**Figure 9** - *Data visualisation of ODCE on the different production lines*

- No follow-ups on their actions (no governance)
- Asked to leave remarks without guidance
- No operator involvement during the development

Moreover, the ODCE tool allowed ambiguous labels like 'unknown' and 'various', which make it easy to select these options without elaboration. Most of these issues are resolved in the recently introduced Change over form.

### 3.2.3. Alis

Alis is the Statistical Process Control program of Diversey, which includes most of their forms, primary, supporting and strategic processes. The program provides an overview of the processes, performed activities, and required follow-ups. Previously, the ODCE data was also stored in Alis. However, one of the initiative takers of Alis explained that the data started to clutter the program. This initiative taker explained how nobody followed up on the entries, and this resulted in the deterioration of entry quality.

One successful process within Alis is the Management of Change. This process serves as guidance for changes that can compromise the safety, quality, runtime, maintenance, and organisation personnel. The review committee assesses whether or not follow-up actions need to be taken. The review commission asses the change to see which follow-ups need to take place and why. Certain follow-up processes could be:

- **Common sense study**
  For a common-sense study, a multidisciplinary team is formed that goes over a checklist and uses common sense to form a list of necessary actions
- **What-if study**
  The aim of a what-if study is to make a risk assessment for both the implementation and operational phase to determine which technical and organizational control measures are necessary—using the Risk = Probability * Effect model.
- **PSR study**
  The PSR study is an established checklist document. Through this document, a number of specific machines or process-related aspects are extensively tested for completeness. This applies to both the implementation and operational phases.

### 3.2.4. Change over form

In this course of the thesis, Diversey chose to tackle some of these known issues by introducing a new process as a form in Alis. One of the new value stream engineers developed this process which is one of his first projects. The new changeover form deals with known ODCE issues in the following way:

- **Not adapted to every production line resulting in missing locations for issues**
  Talking with operators on the specific line about the most relevant issues and adding these issues to the options in the form.
- **Labelling unaccounted hours with ambiguous labels like unknown and various**
  No ambiguous labels are available in the form to corrupt the data.
- **Technical malfunctions in the tool**
  It is simply a form integrated into Diversey's central process dashboard, making it easy to fill it in throughout the shift.
- **No direct data is available for users**
  It is available in Alis, making it easy to generate quick overviews.
- **No follow-ups on their actions**
  The overviews from Alis are being used in the daily day start.
- **No operator involvement during the development**
  Operators were involved in discussing the most common issues on the production line

Yet, during an interview with the value stream engineer responsible for this form, he mentioned the operators are still not fully satisfied with the process (Diversey Interview, 2021), showing that the underlying reason is more profound than just the tool experience.

## 3.3. COALA program and its DIA

### 3.3.1. the COALA consortium

Within the EU program COALA, there are four main objectives:

1. Reduce the number of quality incidents in manufacturing
2. Reduce the time needed for on-the-job training of workers in manufacturing
3. Overcome barriers and reduce scepticism regarding the use of a voice-enabled DIA in manufacturing environments; and
4. Improve the competencies of blue-collar workers for managing AI opportunities, challenges, and risks on the factory floor.

As part of the COALA consortium, this thesis will focus on the third and fourth objectives. Even though these objectives focus on the change management of the COALA service, COALA's DIA will be a TRL 6 innovation level at the end of the program. The definition from the Horizon 2020 annexe states a "technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)" (European Commission, 2014). This definition suggests a gap between the DIA innovation and implementation and integration into the specific context of the Dutch Diversey factory.

Therefore, the thesis focuses on specific needs within the context and explores various interpretations of COALA's DIA service. As the exact definition of the COALA service is only ambiguously defined as the service needs to address all three business cases, the interpretation of the COALA service is still open to exploration.

The partners within this program are categorised into; 1) Research, 2) Technology, 3) Industry, 4) Innovation, and 5) Advisors. The relevant stakeholders for this project are the TU Delft COALA team, Diversey, and MEWS management consultancy. The TU Delft team provides the development for research purposes, Diversey provides the business use case, and MEWS focuses on change management within the COALA program.

As mentioned before, Diversey's aim is to identify bottlenecks in the production lines and manage more proactively instead of reactively. The business case of detergent products at Diversey focuses on the cognitive advisor aspect of DIA, which includes the issue descriptions, root cause analysis, recommendations, and on-the-job training for novice operators. Excluding the first feature, all features require AI models and training data for development. The current form of COALA's DIA is a tablet with a chatbot and the choice between voice to text interface or direct text input.

As mentioned in section 1.4, Diversey has two sites (Italy and the Netherlands) that are part of the COALA consortium. This distinction between sites is essential for two reasons 1) the local management and 2) the local language. Firstly, the level of involvement and commitment differs between local management. Unfortunately, the Dutch Diversey management is not present at the weekly COALA meetings and is hesitant to provide access to operators on the factory floor. The reason for this difference can partly be explained by the history of establishing the consortium (see Figure 10). The EMEA director of OpEx suggested the Dutch and Italian factories as suited business cases. However, the Dutch Diversey factory had a change in management. This new management is more concerned about the short term challenges and is hesitant in involving operators during production.

Furthermore, the factories also use different languages, which resulted in the requirement for an English, Italian, and Dutch DIA.

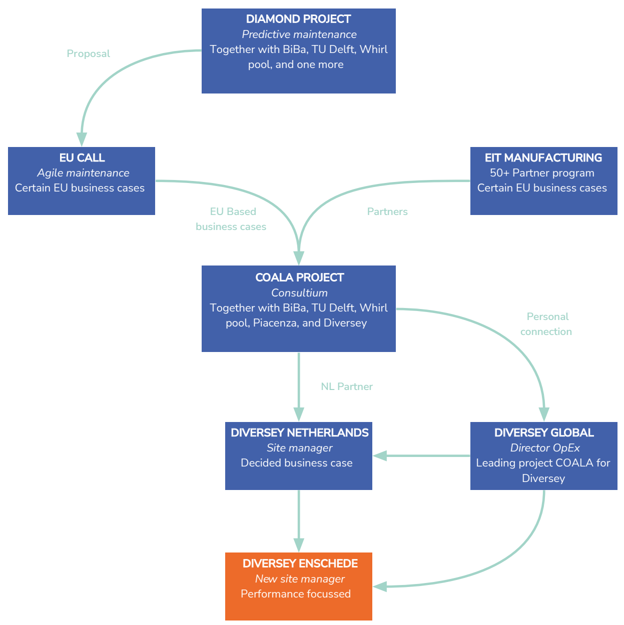



**Figure 10** - *history of COALA in relation to new Dutch management*



### 3.3.2. The DIA interface and interpretation

As mentioned in the introduction, COALA's DIA will be a cognitive assistant for operators to tackle the main objectives stated in the section above. The interface of COALA's DIA is demonstrated in Figure 11, a mobile user interface that is also voice-enabled. However, only the Italian and English language are available in the current DIA prototype and can therefore not be used as a prototype in the Dutch factory.

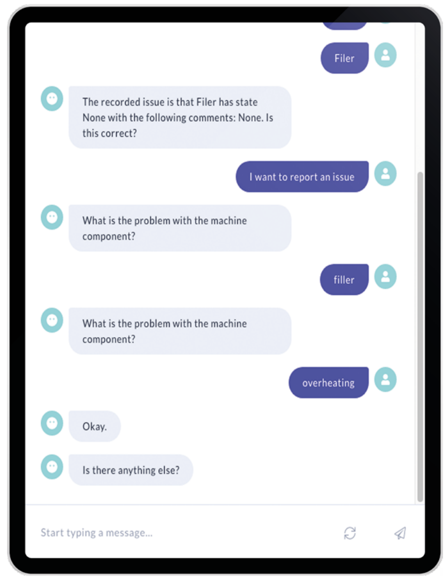



**Figure 11** - *Rasa chatbot interface*

The prototype which can be used is a chatbot prototype that is developed through the use of the open-source software Rasa. This Rasa chatbot was tested during the exploratory visit at Diversey's factory facilitated by a fellow master's graduate. The aim of the session was to determine the interaction barriers between the Rasa chatbot and operators and test whether the AI recognized the contextual terminology. Unfortunately, we were not able to speak to operators, yet we could speak with support staff who had experience with the terminology. The aim of the experiment was for the chatbot to recognize the operator terminology and extract the components of an issue description (see Figure 12). The interactions with the DIA chatbot proved to be challenging as there was a lot of variation between participants in describing issues on the production line. The overall sentiment among participants was excitement with regard to the exploration of new technology. However, the Rasa chatbot did not recognize the issues enough to be effective. Oddly enough, some participants even thought it was their fault when the chatbot did not recognize their issue description.

Even though the positive interaction with support staff shows willingness, this willingness cannot be generalised to the context of operators who deal with high-pressure situations on the production line itself. As learned from the prototyping session, the chatbot needs to improve further to be effective on the production lines. One way of doing so is the train with contextual data; however, not many data issue description entries are available, which include all relevant components.

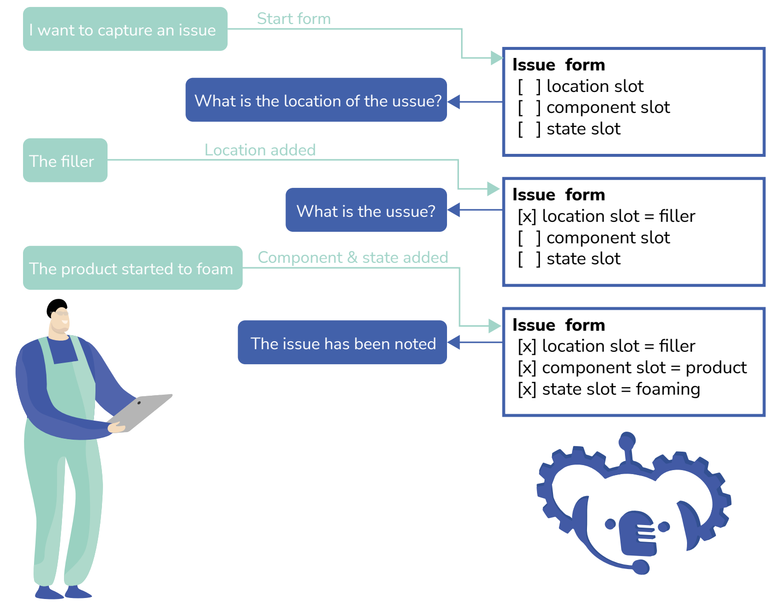



**Figure 12** - *Rasa chatbot flow factory visit tests*

## 3.4. Paradox

After the analysis of the initial problem definition, the central paradox is introduced, which explains the difficulty of the present situation. The paradox step of the frame creation method demonstrates how logically a choice needs to be made between two options as the combination is logically impossible.

An example of one of the paradoxes within this context is the balance between routine and novelty. The paradox can be described as follows:

***Because efficiency is key in the manufacturing industry, management wants to standardize the solutions***

***Because practices are standardized, operators act out of routine instead of creative problem-solving***

***Because operators are not using their problem-solving skills, novelty and improvement are therefore difficult to reach***

However, this paradox is too general and is applicable to a variety of contexts. The paradox that is specific to this context is the paradox of the ODCE tool:

***Because*** *there are many stoppages on the production lines, operators try to solve them through their experience and knowledge.*

***Because*** *of the stoppages and operators solving them through their experience and knowledge, there is variance in production output between operators.*

***Because*** *there is variance in production output between operators, management wants information about the issues and solutions*

***Because*** *operators are so busy with the stoppages, they just want to solve the current stoppage instead of providing data*

Unfortunately, the paradox is not solved by introducing COALA's DIA as it still requires data to formulate the required knowledge, as seen in this paradox:

***Because*** *the operators are in high cognitive and pressure situations, they need assistance to improve their production output.*

***Because*** *AI has the ability to learn from input data and interactions, the technology could help operators deal with complex situations.*

***Because*** *AI learns from input data and interactions, input from operators is necessary to develop an effective AI feature.*

With the current interpretation of COALA's DIA, the paradox will still be applicable as there is no alternative strategy for gathering the required data. The only difference between the current tools and COALA's DIA is the voice-enabled interface in which operators can provide data. However, it is unknown if the voice-enabled interface is preferred over a mobile user interface.

The core paradox will be revisited in the concept evaluation section to confirm if the concept is addressing the paradox accordingly.

## 3.5. Initial design constraints

During analysing the current problem situation through the current tools and systems, an exploratory visit, and the COALA program, some limitations emerged which could influence the possible solution space. These limitations are formulated into initial design constraints, which protect the viability of the suggested strategy for COALA's DIA in this thesis

After the initial analysis of the problem definition, I concluded the initial design constraints which influence the possible solutions spaces.

**Cognitive assistance, not load**

The primary aim of COALA's DIA is to cognitively assist operators in a manufacturing environment in high-pressure situations. Therefore, operators' involvement is essential to provide the appropriate assistance. As seen in the previous tools, the data entries can be perceived as an additional load during a demanding situation. This task should, therefore, not outweigh the assistance as this would be illogical.

**Production improvement**

Even though the DIA's primary aim is operator assistance, there should also be added value for management to allocate resources to the cooperation with COALA researchers. Therefore, the eventual strategy should address the impact on production output without compromising operator safety and product quality.

**Business complexity**

The stations with 3-5 possible settings per station, the dependencies on the production line, and the variety of SKUs result in a complex production process. This process, combined with the processes between departments, results in high internal complexity. However, the market Diversey operates in is low in complexity resulting in overall moderate business complexity.

**Aligning management and operators**

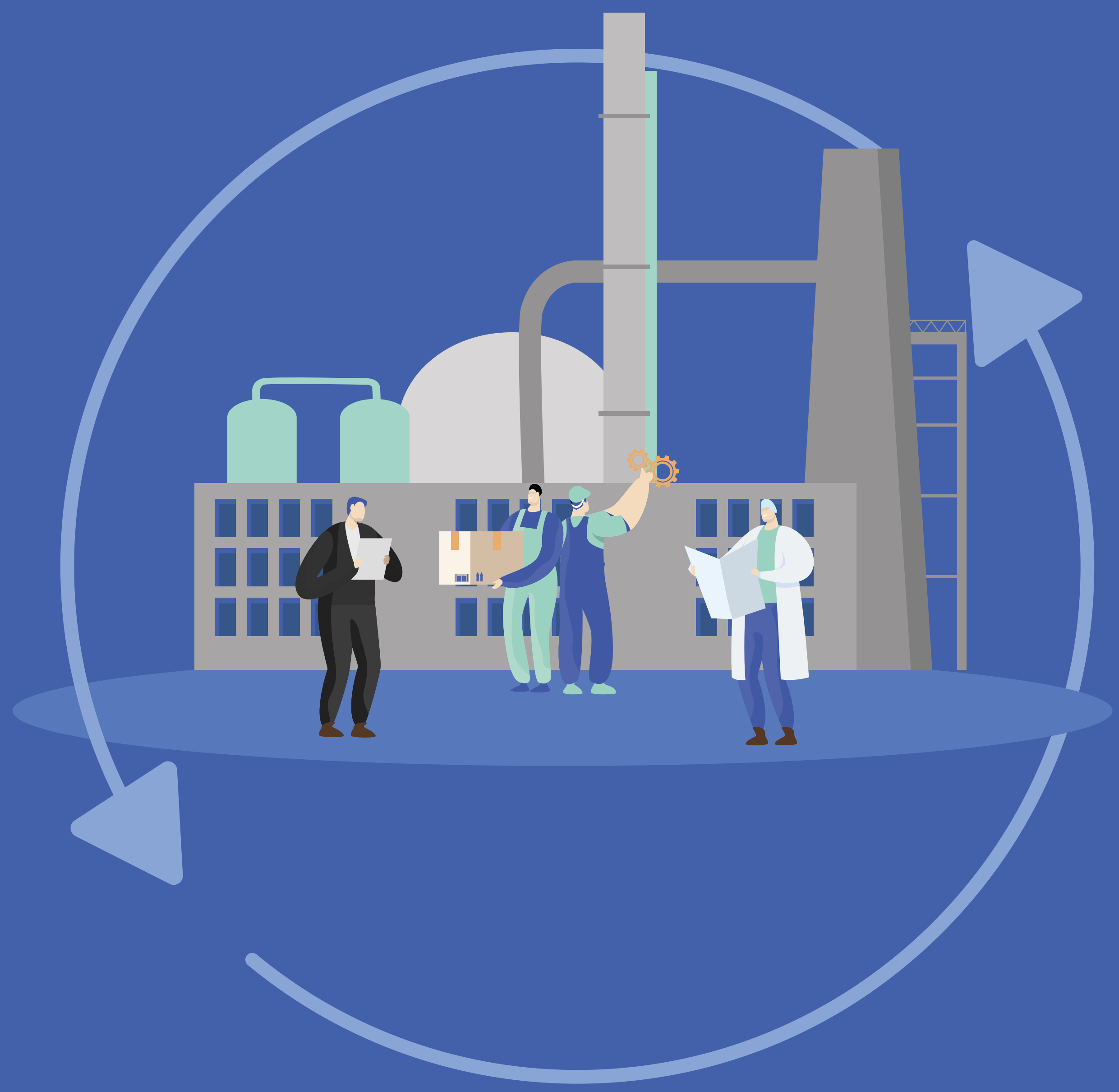
The two main stakeholders of the problem definition could both benefit from the current tools and COALA's DIA. However, management and operators are not aligned toward the same goal. Therefore, alignment between management and operators is crucial to integrating COALA's DIA.

**Approach change for DIA integration**

The current approach to innovation and improvement is mostly aimed at minimizing mistakes and streamlining the process. Even though focusing on minimizing risk and variables will help with variance between operators, it will most likely limit further innovation. Thus, a change in approach is needed allowing flexibility and novelty.

**Novelty in a risk-oriented context**

Dorst (2015) describes one of the differences between frame creation and innovation management as the difference in finding novelty. Innovation management searches for novelty in innovative solutions like COALA's DIA. However, frame creation is searching for a new approach to the problem situation. Solving the problem by replacing one tool for another without acknowledging the deeper themes is a shot in the dark. Therefore, the frame creation method is needed to discover the deeper themes and search for a new approach to address them.



# 4. EXPLORATORY STUDY

Within this Chapter, the frame creation steps 'context' and 'field' are combined in an exploratory study of the domains of change management, AI characteristics, the organisation of the Diversey factory, their employees, the interaction between management and operators. The Chapter will conclude with the chosen change management approach in line with the business context and the proposed change.



## 4.1. Deep dive into change management

In this first section of the exploratory study, I explore the frameworks that guide decision-makers in managing change within their organisation. The book "Making sense of change management" (Cameron & Green, 2019) and the research of Joseph Galli (2018) together describe 14 of the most used organisational change models (see Appendix B for an overview). This section summarizes the differences and similarities between the frameworks, the influential aspects described within the frameworks, different change management categories, and nuances within change management literature.

### 4.1.1. How existing change management frameworks differ

The 14 analysed frameworks differentiate in their process, focus area, and framework definition (see Figure 12). Cameran and Green (2019) discuss how all change management models differ in their view of organisations. While analysing the 14 frameworks, other differentiating factors emerged as well. First of all, the overall **process** can be linear with a clear beginning and end, or the process is iterative. An example of a linear model would be Lewin's change management model with three clear steps; unfreeze, transitioning, and refreeze. In comparison, the cycle of change is an iterative process with seven steps with no clear end, which is derived from Kotter's theory.

Secondly, the **focus area** of the framework can lie at the individual level or look at the organisation level. ADKAR is a framework that focuses on the needs of the individuals in an organisation by looking at the perceived presence of five elements. Contrastingly, other frameworks like Kotter's theory focus on the organisation by suggesting steps for a specific business department or team within the organisation.

Lastly, the models differ in the **framework's definition** as frameworks can be either descriptive or prescriptive. Descriptive frameworks only describe certain phenomena, as Kübler-Ross's model describes employees' stages throughout the change without specific guidance. Prescriptive frameworks like Lewin and Kotter have specific steps in chronological order; however, these frameworks can still lack specificness within the actions (Kang, 2015). These differentiating elements serve only as exploratory research to find gaps and overlapping themes within the existing frameworks *as it is solely based on personal interpretation*. Moreover, the list of frameworks is not exhaustive; however, most frameworks are similar to or originate from one of the analysed frameworks (Kang, 2015).

In conclusion, there is a gap in change management models in the prescriptive and individual needs focussed frameworks (see Figure 13). The frame creation model could fill in this gap; however, it is still unclear what change management strategy is needed in this context. In the

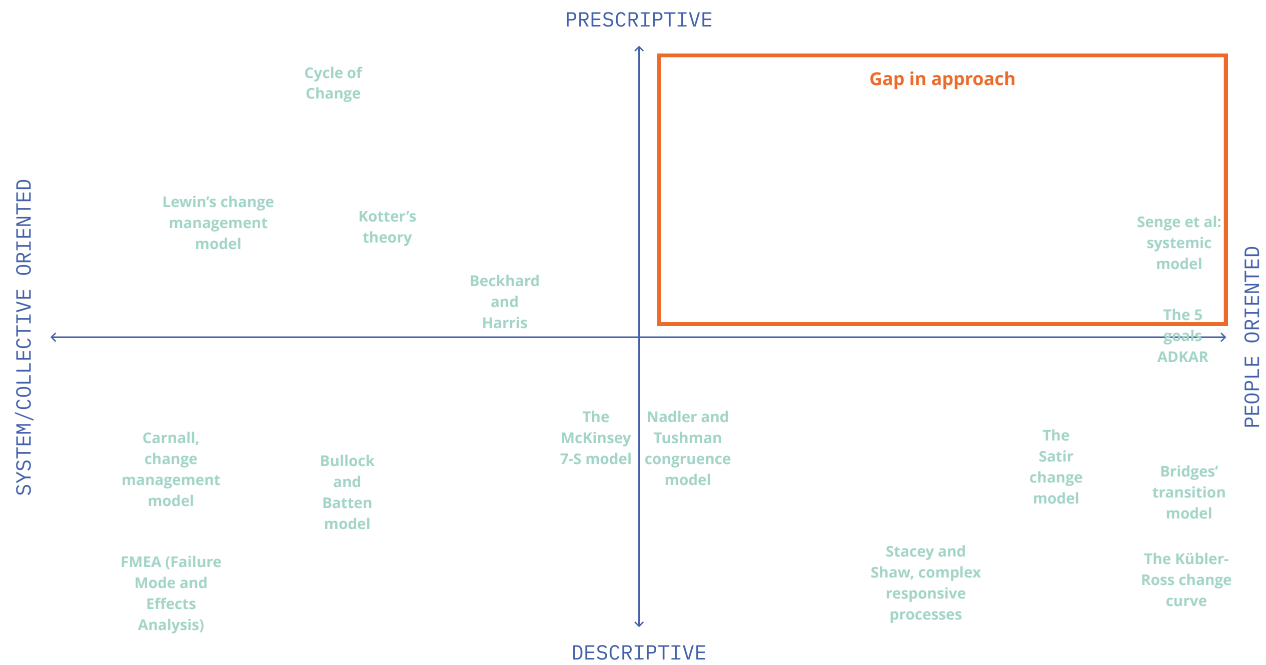



**Figure 13 -** *Potential gap in change management models*

following sections, the process and the focus area are explored further.

### 4.1.2. Overlapping themes and influencing factors

Even though the frameworks differ from each other in the process, focus and definition, the frameworks also have overlapping themes with regard to essential influencing factors. An influential factor is a component within a change management model that needs to be addressed or analysed. For example, the 7-S model refers to *staff* as one of the dependent components in an organisation when dealing with change. Together with other models, this component resulted in the influential factor of employees.

All 14 frameworks are used to gather a complete picture of all influential factors. The analysis consists of 5 steps (see Appendix C for a comprehensive overview of the analysis):

1. Brief description of the frameworks
2. Influential factors extracted from the descriptions
3. The first iteration of clustering
4. The second iteration of clustering
5. Flowchart of clusters and their likely relationship

The analysis demonstrates three main influencing categories 1) the characteristics of the proposed change, 2) the characteristics of the organisation where the change takes place, and 3) the interaction and support between users and the change (see Figure 15). This overview of the influential factors is used to structure further research throughout the exploratory study; Artificial Intelligence as proposed change, the organisation of the Diversey factory and the stakeholders within.

### 4.1.3. Categorisation within change management frameworks

As mentioned in section 4.1.1, change management models can differ in process. However, the process can differ beyond iterative or linear. Kerber and Buono (2004) suggest three change management categories that also differ in the way change manifests itself. Kerber and Buono state that the change process should align with the organisation's culture and the change that will be implemented. Consequently, the preferred category can be determined by the **socio-technical uncertainty** of the change and the organisation's **business complexity**, according to Kerber and Buono (2004).

**Socio-technical uncertainty** refers to the character and amount of information management and decision-making that is needed for the change in the organisation. **Business complexity** refers to the level of complexity of the organisation like size, interdependencies, amount of critical stakeholders, their products and services, and other relevant characteristics of the organisation. Within this framework, Kerber and Buono have determined three categories of change management; directed, planned, and guided change (see Figure 14).

**Directed change** is a top-down change that depends on authority and compliance. This approach focuses on persuasive communication to convey business necessity, logical arguments and addresses emotions to reach acceptance. Secondly, **planned change** can emerge anywhere within the organisation and is ultimately backed from the top. Leaders use proven actions that mitigate common resistance and loss in productivity

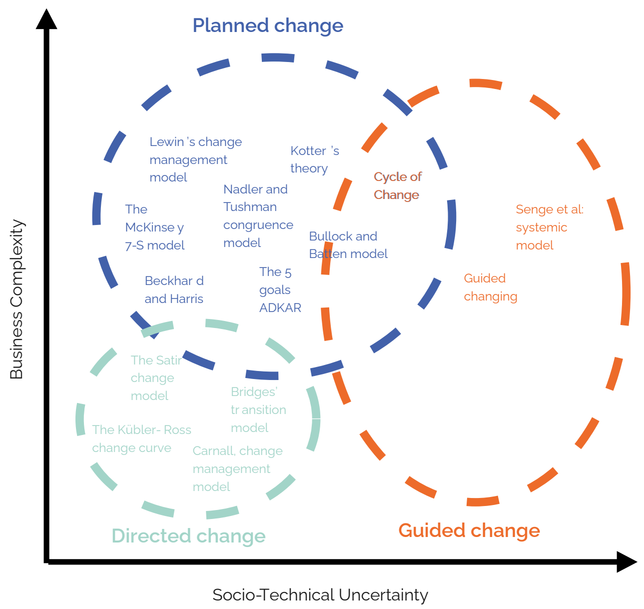



**Figure 14** - *Categorised change management methods on the axis of Kerber and Buono (2004)*



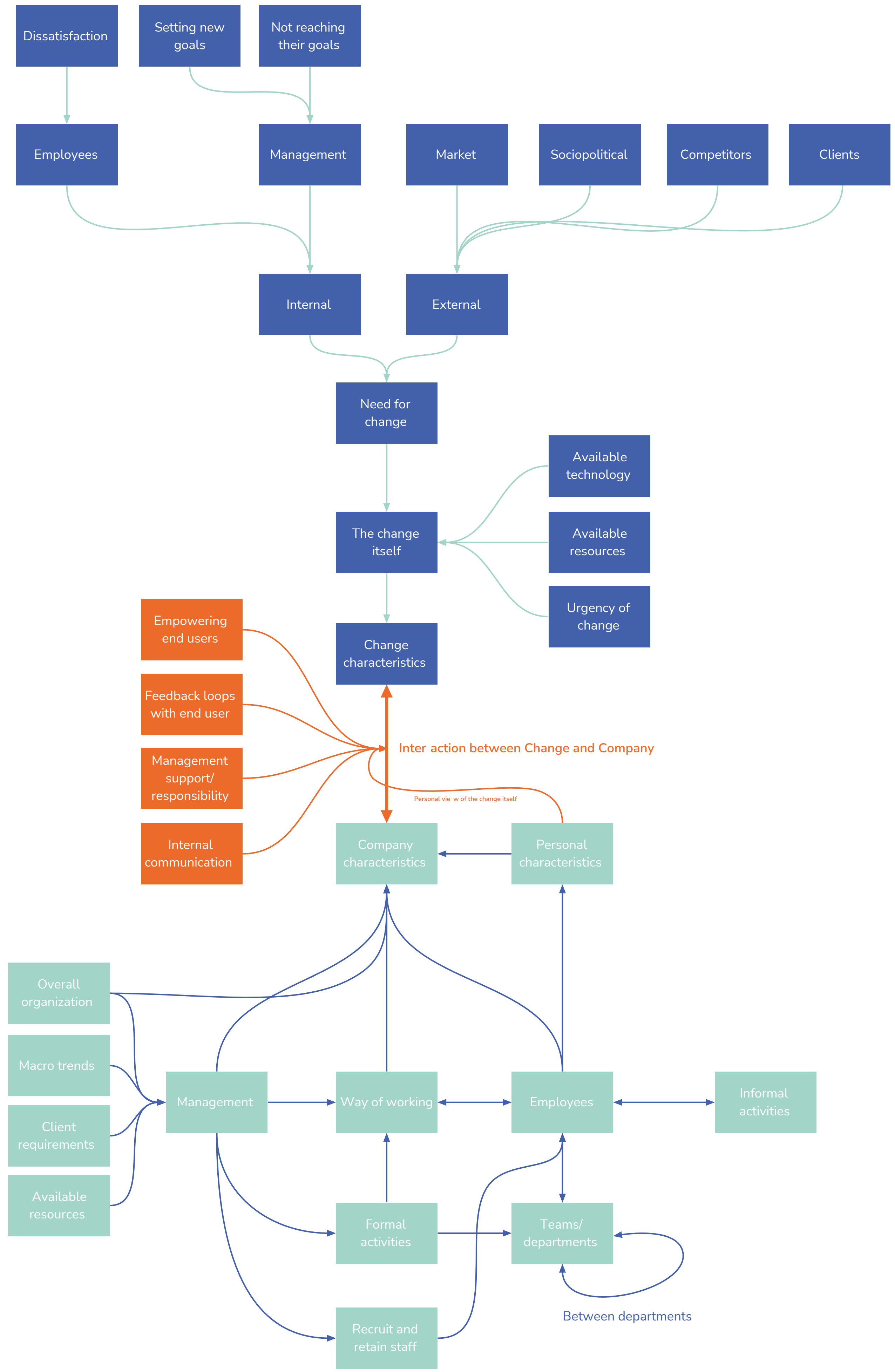



**Figure 15** - *Collected by analysing the 14 change management models (see Appendix C)*

that is correlated with directed change. Lastly, **guided changing** emerges from the commitment and contribution of the people to the organisation. Within guided changing, there is a better understanding of what is going on within the organisation, and instead of telling people what to do, they inspire the people within the organisation. Additionally, this approach is an iterative process consisting of interpreting, designing, implementing, improvising, learning, and sharing insights.

Besides the different processes, Kerber and Buono also determine two moderating factors. The first factor is *change capacity*; this entails the willingness and ability of the change-makers, existing infrastructure within the organisation that facilitates change, and resources. The capacity influences how likely the organisation can handle guided changing. However, the primary consideration should still be business complexity and socio-technical uncertainty. The second factor is *urgency*. If there are high risks by introducing no to little change, then the organisation needs short-term change, which is best achieved through directed change. The preferred category of change management model to be used in this thesis will be determined by analysing the socio-technical uncertainty of COALA and the business complexity of Diversey.

### 4.1.4. Distinction in change management focus

The term change management is an umbrella notion with various interpretations. These differences are making it hard to define what someone means when using change management. As in various other fields, there can be miscommunication when using the same terms and concepts and assuming someone else's understanding is the same (Kang, 2015). For example, in the first conversation regarding change management with Diversey management, they referred to risk assessment. This miscommunication is why Kang (2015) suggests a differentiation between macro and micro change management.

Macro change management focuses on the process and initiative for organisational changes and, as the name suggests, is more strategic. The holistic view indicates a higher probability of strategic alignment of the change and the organisation itself. However, the process and models lack details, making it challenging to implement organisational changes successfully on an individual level.

Micro change management focuses on eliminating people's concerns through open communication, guidance and empathy on the individual level. However, this individual focus can cause maximisation of a part of the organisation, often causing harm to the entire organisation, also known as suboptimisation. On the contrary, as previously perceived, this distinction does not conclude choosing either an individual or an organisation model. The lack of details and guidance within the macro change management models can be strengthened by combining it with a micro change management strategy.

### 4.1.5. Change management in practice

MEWS is one of the partners of COALA, and they have practical experience in applied change management. So, to gain practical knowledge, I interviewed one of the consultants at MEWS (MEWS, interview 2021). The main takeaway is that change management is fluid. It can change over time, and it does not even have to be consistent across the organisation, as the needs can differ between teams. Yet, the needs and habits are universally essential within change management. One good place to start is the end-users' needs and how to provide value. Focus groups are crucial to discovering needs, gaining feedback, and identifying the team's dynamic. Within a team's dynamic, there will always be habits that are hard to change and focussing on changing these strong habits can result in failed change management.

### 4.1.6. Takeaways from change management

After the exploration of the change management field, there are insights that help define the eventual strategy for COALA's DIA in this thesis. These insights also provide guidance towards the next knowledge gaps for further exploration.

**Balance between organisation and individual**

The direction of the organisation is critical for overall consistency and limiting sub-optimalisation. However, without addressing individual concerns, it is unlikely people within the organisation will adopt the proposed change.

**Move away from directed**

As seen in the Archaeology section, the previous attempts were mostly aimed at initiatives at the management level and directed to the operators. However, involving the production team as focus groups could help with identifying needs and strong habits, which could act as drivers or barriers during the change introduction.

**Dependent on change and organisation**

Planned or guided change could be a better approach to change management dependent on the socio-technical uncertainty through the proposed change and the business complexity of the organisation. In section 3.1, the business complexity is already determined as moderate. However, the current socio-technical uncertainty and the change in socio-technical uncertainty need to be explored together with the change capacity of Diversey and the urgency of the change.

## 4.2. Artificial Intelligence as proposed change

In this second section of the exploratory study, the proposed change of COALA's DIA is analysed. This section includes the exploration of the specific AI elements of the DIA and interactions with the DIA, the characteristics of AI technology, and their potential effect on socio-technical systems like the Diversey factory, drivers and barriers of AI.

### 4.2.1. The AI aspect of COALA

Even though the 'what' should remain open in a design abductive reasoning approach (Dorst, 2015), COALA's DIA is this project's *'what'* as mentioned in section 2.2. However, the only concrete aspect of the DIA is the AI technology and its need for training data and output evaluation. Even though this open definition of the COALA service allows for the exploration of new solution spaces, it also produces a required interaction to gather and evaluate the data.

Figure 16 shows the two required interactions; 1) operators' sharing their experiences and knowledge and 2) evaluating the DIA's output (suggestions). These interactions are dependent on the willingness and adoption of operators and also the DIA's output. So, characteristics and their possible effects, barriers and drivers of the AI technology are explored in the next sections to form requirements for the DIA's behaviour and to facilitate the desired operator interactions.

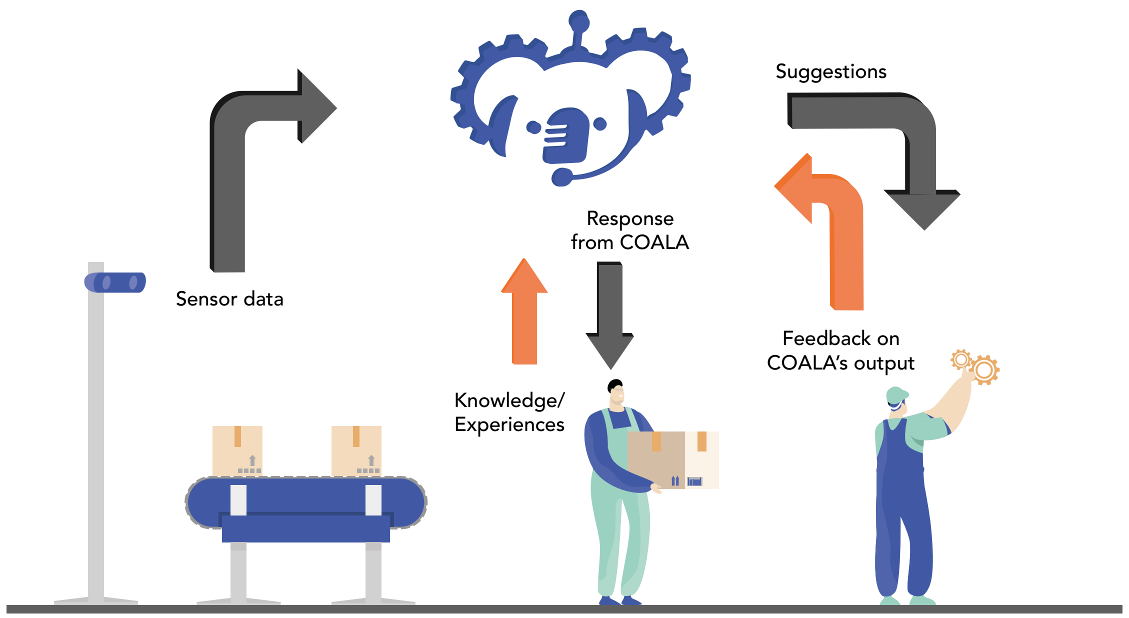



**Figure 16 -** *The two required interaction with COALA's DIA (left =1, right=2)*

### 4.2.2. The characteristics of AI technology and their barriers

The relevant characteristics of AI are its output complexity, output uncertainty, and context sensitivity, which pose a variety of challenges when designing for future interactions and adoption within the Diversey context. The effects of the characteristics can be categorised into 1) economic, 2) technological, and 3) social barriers. The characteristics and barriers are gathered from three studies; the effects within socio-technical systems (Engel, Ebel, & van Giffen, 2021), the challenges among designers to anticipate (Yang, Steinfeld, Rosé, & Zimmerman, 2020), and a systematic literature review of 30 systematic reviews (Cubric, 2020). The characteristics that Engel, Ebel, and van Giffen mention are black box, context-sensitivity, experimental, and learning requirement, the framework of Yang et al. uses output complexity and capability uncertainty, and Cubric categorises the found barriers into economic, technical and social. The overview of characteristics categorised by barriers can be seen in table 1.

*Table 1 – AI characteristics overview and categorized barriers*

| | Output complexity (black box) | Capability uncertainty (experimental) | Context-sensitivity (learning requirement) |
|---|---|---|---|
| | • Governance needed | • Investment of resources<br>• Risk in data | • Continuous monitoring<br>• Difficult scalability<br>• Data infrastructures |
| Technical | • Anticipate interactions/ prototype<br>• 'Right' problem selection | • Ambiguous design requirements<br>• Experimental with data<br>• Probabilistic testing | • Continuous AI model tuning and track changes<br>• Track stability<br>• Quality and volume of data needed |
| Social | • Explainability/ transparency<br>• Trust<br>• Ethical and cultural bias | • Communication of expectations and capabilities<br>• Lack of data<br>• Possible safety risks in data | • Expectation management<br>• Ownership in the operating context needed<br>• User interaction is required for quality data and AI output evaluation |
| | Barriers, regardless of the AI characteristics, are **job security** and the **dependence on non-humans** | | |

**Output complexity**

This characteristic refers to the output the AI system can produce. The output can be relatively simple when the answers are just 'yes' and 'no'. However, in the business case of Diversey, the output could be rather complex. This complexity can affect the interactions in two ways; 1) this makes it virtually impossible to anticipate all possible interactions, and 2) the explainability of the output is increasingly more difficult. The challenge of anticipating human-AI interactions depends on the complexity of the eventual AI system, and it is, therefore, important to select the 'right' problem to solve and start with.

The second challenge of output complexity refers to the reasoning and the sources to produce the specific AI output. The COALA consortium aims to tackle this challenge through its WHY engine and knowledge graph. The WHY engine could limit the possible AI output as the more complex the AI model is, the harder it is to explain the decision's origin. It is, therefore, essential to be aware of the trade-off between performance and transparency (Engel, Ebel, & van Giffen, 2021).

One of Engel, Ebel, and van Giffen's case studies showed an instance where the output of the AI was not in line with the expected outcome of the human actors. This disagreement could be relatively harmless if the human actor is doubtful of its own outcome. However, in this instance, the expected outcome seemed trivial to the human actor resulting in distrusting the AI system. Even though the AI system had a higher accuracy, the disagreement between human actors and AI systems could harm trust. Engel, Ebel, and van Giffen suggest involving end-users early in the ideation and development phase of AI to minimize this barrier.

Lastly, AI is constantly changing according to the provided data. So, when the data input changes due to a change in the human-AI interaction or data from sensors, the output could change as well. Moreover, user biases in the provided data by the users will also be present in the AI output. These aspects raise the need for governance for AI output as well as human-AI interactions.

**Capability uncertainty**

The second characteristic is defined as to what extent the AI system can produce valuable results. As the data input does not guarantee certainty of valuable output, capability uncertainty results in ambiguous requirements with regard to data volume and quality, and model tuning (Engel, Ebel, & van Giffen, 2021; Yang et al., 2020 ). This aspect creates a challenge for the designers, the organisation, and the end-users. The specific challenge for design makes the desired interactions challenging as the requirements for data collection are unknown. If done incorrectly, low-quality data could result in undesired outcomes and perhaps even compromise safety. Moreover, organisations are careful with their resource investment decisions for AI projects if results are uncertain, according to Engel et al. (2021). Additionally, organisations could also experience barriers trying to clearly communicate the added benefits and expectations when output is still uncertain. Therefore, Fountaine, McCarthy, and Saleh (2019) suggest focusing on what was learned and adopting the test-and-learn mentality to reframe these experimentations of probabilistic testing into discoveries.

**Context sensitivity**

Lastly, the characteristic of context-sensitivity refers to the dependency of data to generate reliable output. The context-awareness of the AI system is dependent on the different data sources. This aspect poses three main challenges 1) the requirement of retraining after context change, 2) the scalability challenges of AI systems and 3) the difference in context-awareness between the AI system and human actors.

Firstly, when changes occur in the context, it is essential to retrain the AI models to align the AI output with the new context. If not, the output of the AI could be incompatible with the new context, which can cause unexpected outcomes and interactions. This incompatibility raises the aspect of governance as evaluation of AI output is needed when change occurs.

Moreover, due to this context-sensitivity, the scalability of AI solutions cannot be applied to the different contexts within an organisation without certain adjustments like tuning and retraining the AI model. If AI systems scale, structures and teams are needed to address and resolve AI problem as each AI systems depend on different contexts and expertise.

Lastly, the context-awareness of an AI is dependent on the provided data, as mentioned before; however, human users experience the context in more detail. These experiences can be conscious or latent, making users more aware of the context. However, AI can manage large amounts of data and recognize patterns that would be impossible for humans.

The framework of Stoimenova and Kleinsmann (2020) demonstrates how to continuously identify values through prototyping and could be a useful model.

**AI characteristics combined with context**

Even though all these barriers are essential for AI adoption, some aspects are less relevant for the scope of this thesis, such as the scalability of COALA's DIA and the anticipation of future interactions between the DIA and end-users. Moreover, structured interviews among five operators regarding the concern of job security, dependence on non-humans, lack of knowledge, trust, and personal safety showed little to no concern regarding these aspects (Diversey operators interviews, 2021; Appendix D). However, the structured interviews were an inquiry on operators' imagination instead of experiences.  Thus, these concerns should be revisited after experiencing COALA's DIA.  The remaining relevant barriers result in the following requirements for COALA's DIA:

- Early involvement of end-users
- Manage expectations for end-users and management
- Focus on what is learned instead of concrete capabilities
- Governance of the AI output and context changes
- Facilitate quality data collection and output evaluation

The aspects which fall out of the scope of this thesis are the scalability and interaction anticipation challenges with AI. The determination of scalability needs technical knowledge and experience from working with AI systems which perhaps fall outside of the scope of the design field. However, the interaction anticipation can be explored through the framework of Stoimenova and Kleinsmann (2020). Their paper addresses the concerns regarding unintended consequences that come with AI systems. The framework is used to discover the different values that occur (negative or positive) while interacting with an AI system by using prototypes. These prototypes assume a purpose based on gathered insights to form a frame. The framework combines the frame with a mode of action resulting in the prototype.

***Purpose + data -> frame***

***Frame + mode of action -> prototype***

***prototype + actuation -> values***

(Stoimenova & Kleinsmann, 2020)

### 4.2.3. The strengths of AI technology and their drivers

Even though addressing the barriers is essential, it is also essential to highlight the strengths and potential drivers for AI. The strength of AI is briefly mentioned in the previous section; it can process a vast amount of data and recognize patterns. Technologies like the cloud and IoT create a continuous flow of data that can be used by AI technology to be trained. This loop of continuous data used for continuous improvement by training the AI system is defined as a problem-solving loop by Verganti, Vendraminelli, and Iansiti (2020). These adjustments to the system or service can be instantaneous, resulting in a system or service that is constantly changing. These problem-solving loops can be applied system-wide but also on a personal level. The instant personalisation based on personal decisions and interaction is a strength of AI technology.

The drivers of AI gathered by Cubric (2020) through 30 literature reviews are mainly economic drivers. However, there are also two social drivers, which are sustainability and well-being. Even though the context is a manufacturing factory, the well-being driver could be interesting and is explored in the meaningful work section 5.3.2.

### 4.2.4. Take away from artificial intelligence as change

The analysis of COALA's DIA AI aspect generated insights into characteristics, barriers, strengths, and drivers. These insights provide a variety of requirements that need to be implemented in this thesis' final strategy. Additionally, the analysis also provides several opportunities for COALA's DIA. Both the requirements and opportunities are listed below.

**Learning and data necessity**

The context-sensitivity characteristic of AI technology describes the need for AI to adjust to the operating context through learning data. This data is partly gathered by sensors, yet the sensor cannot capture the experiences and actions of operators. So, next to sensors, the operators are needed to provide data. The exact quality and volume of data can only be assessed through testing and evaluation.

**The two required interactions**

The need for learning and testing results in two interactions between operators and COALA's DIA, 1) operators elaborating on experiences, activities, and their knowledge so COALA's DIA can learn about the context and 2) evaluate the AI output on relevance and accuracy, and adjust the DIA accordingly. The primary focus will be on the first interaction; however, this thesis should also address the current challenges regarding the second interaction.

**Testing and evaluating output**

The capabilities of AI's output are uncertain, and therefore, concrete goals are challenging to integrate into existing processes. Instead, the users should focus on what is learned and develop a test-and-learn mentality. Moreover, the expectations of AI's output should be managed in such a way that it mitigates unrealistic expectations.

**Governance needed**

As AI technology is context-sensitive, retraining is needed when changes are made in the context which is not embedded in the data. Moreover, AI develops over time by processing the provided data, and the AI output could therefore also change over time. These two aspects require governance which monitors the AI output and tunes the model accordingly.

**Well-being as an AI driver**

Besides the possible barriers and requirements for AI, there are also drivers to implement AI. Most drivers are economical, which also could improve management's involvement. However, are also social drivers like 'well-being'. This driver stands out as it fits with the DIA's premise to cognitively assist operators. In the second field section, well-being on the factory floor is explored through job satisfaction.



## 4.3. The organisation of the Diversey factory

Within the third section of the exploratory study, the Diversey factory stakeholders are explored through semi-structured interviews with management and support staff, structured interviews with operators, and a creative session to map present and future stakeholders. The section concludes with the preferred change management approach based on Diversey's business complexity and change capacity.

### 4.3.1. Stakeholder overview of problem definition

The inner circle of stakeholders is determined through a creative facilitation session with the TU Delft COALA team and the EMEA director of OpEx of Diversey, resulting in an overview of current and future stakeholders (see Appendix E). The stakeholders are categorised into 1) core team, 2) involved, and 3) informed. The Diversey stakeholder from the core team who are interviewed are:

- Operators (N=6)
- Team lead
- Value stream engineer
- Production manager
- Continuous improvement manager
- Operational Excellence director EMEA

Unfortunately, not all stakeholders could be interviewed throughout the frame creation steps. Therefore, also Diversey employees from the support staff are interviewed to comprehend experiences and interactions within the factory. The interviewed support staff are:

- Maintenance engineer
- Logistic team lead
- Quality manager
- Micro quality control employee
- Quality control employee

For the overview of employees interviewed and their relationships, see Figure 17. The interviews are analysed by extracting statements from the interviews. Next, these statements are organised by motivation, needs and experiences. The first stakeholder is management, as this stakeholder decides the course of the COALA business case within the Diversey factory and grants access to operators and other personnel. Next, the operator's perspective is analysed as their contribution is needed in data collection and evaluation. Lastly, supporting staff are interviewed to gain a better understanding of change and employee dynamics within the context.

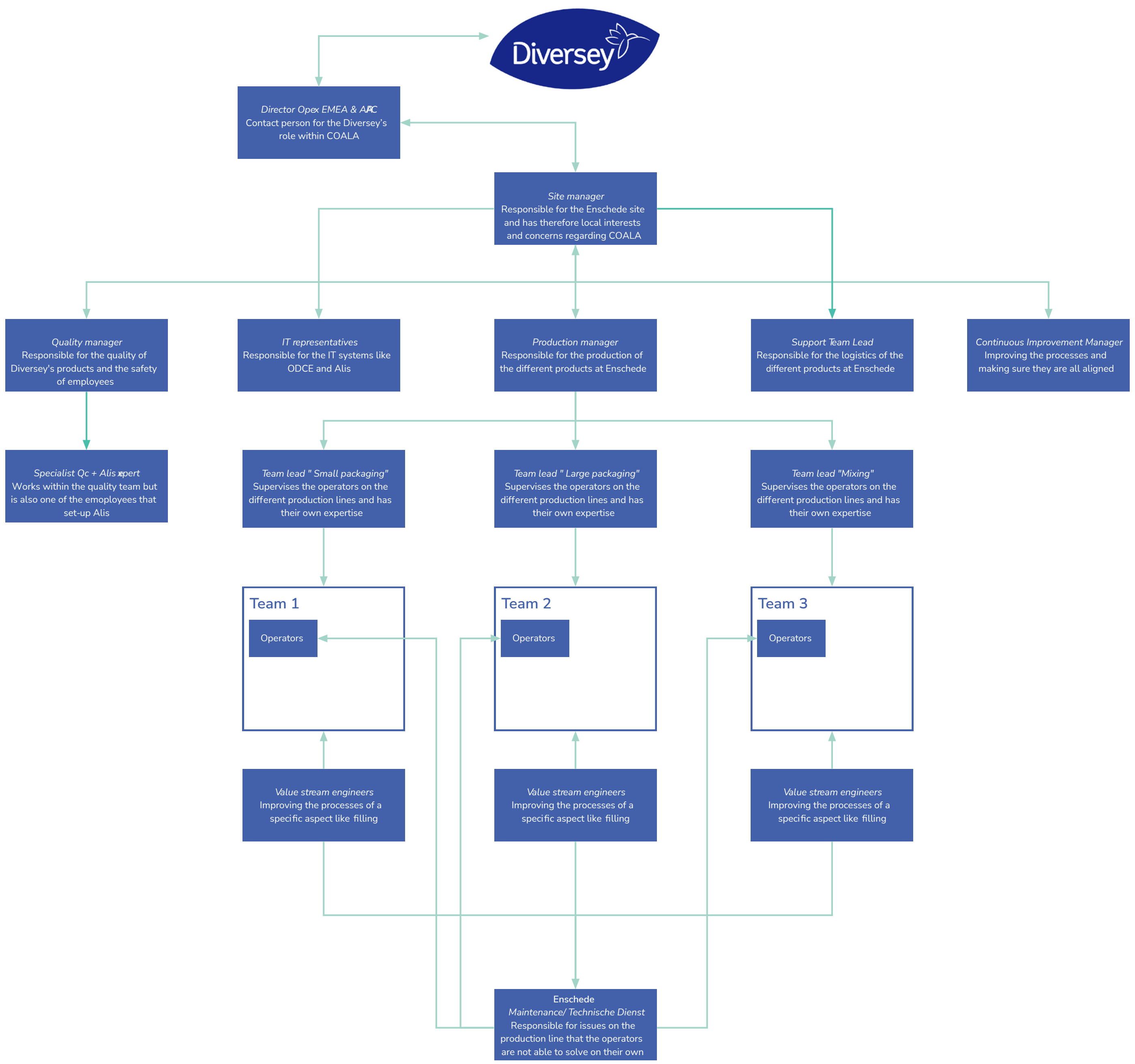



**Figure 17 -** *The wider field of stakeholders within the Diversey Factory*

### 4.3.2. Management perspective

The management insights in this section are based on the two interviews with the production manager and are divided into concerns, DIA value and his vision. As mentioned in the archaeology section, the main motivator for management is to manage the production proactively instead of reactively (Diversey management interview, 2021). In order to manage proactively, insights from the production lines are necessary.

**Primary concern** — The primary concern of the production manager is the variance between operators. This variance includes their solutions and settings on the production lines, and their data input into the current tools.

**DIA value** — The added value for production management is to maintain the best practices for operators through the DIA. In this scenario, the DIA would tell the order of the practices and help the operators along the way.

**Vision** — The future vision for the DIA would be in the form of AR glasses which require minimal interaction of the operators. These AR glasses would proactively manage the production line and display tangible results of the operator's actions, perhaps even gamifying them among operators.

Even though the best practice feature of the DIA would be valuable in some scenarios like on-the-job training, it would also limit the flexibility of experienced operators. Additionally, the best practices have to come from data gathered by machines and operators or insights directly from operators. The latter would imply management needs to choose the operators responsible. Data as a source for best practices would be objective and grounded in context; however, the challenge still remains how to collect the practices. Management does acknowledge the importance of operators' knowledge and expertise. However, tools to collect production line insights like ODCE are not adopted. Would a tool that prescribes practices and limits operators' flexibility be adopted?

Besides the concern for variance, the production managers also show concern for implementing and securing improvements as this was a challenge with previous management. Recently, value stream engineers have been hired to identify and implement improvements. However, these value stream engineers work on projects, meaning they finalize projects and need to move on to the next project. Perhaps COALA's DIA could be of value in securing improvements.

### 4.3.3. Operator perspective

The operators will be the main users of COALA's DIA, and as mentioned in Chapter 3, it is important to involve end-users and focus on their needs. Operators were not involved in previous attempts to gain data from operators. However, this is changing with the integration of the change over form. Yet, operators' needs and the added value of services like COALA's DIA are still not clear. Therefore, I interviewed five operators on the 5/10L line, a theme lead, and one maintenance support to discover the needs and underlying reason for adoption resistance. As with management, the interview insights are divided into concerns, DIA value, and vision.

**Primary concerns** — The primary concern for operators is their perception of not being heard, as they get no follow-ups regarding their feedback on the production line. The primary concern of the team lead is that operators get more and more work from support staff.

**Potential DIA value** — Just wanting to do their jobs is something operators keep saying. However, it is unclear what they exactly mean.

**Interpretation vision** — The interpretation of just doing their job is working on a production line without continuous stoppages.

One of the common themes from the interview analysis is the lack of trust in the tools. Operators have tried to explain their experiences and communicate the perceived bottleneck through various channels (Alis, whiteboard, meeting etc.). However, operators do not receive any follow-ups regarding these bottlenecks and therefore make assumptions about why bottlenecks are not addressed. For example, operators assumed the ZED2 AI camera, which is part of COALA's DIA, was installed to get a second opinion on the bottlenecks. The operators saw this as a sign that management was not listening to them and the ZED2 camera was a plan B. Therefore, operators propose it is time for management to show commitment.

Since their feedback did not result in any changes and operators, assume this is due to financial restrictions. So, if their feedback does not result in change, operators do not trust other services will. The team lead perceives support staff is demanding too much from operators who should be focussing on production as this is where the products are made. So, either the requests from support staff do not benefit the production process, or the results from these requests are not clear to the theme lead and operators.

### 4.3.4. Support staff perspectives

In order to assess the broader field of the Diversey factory and the dynamics within, I interviewed six support staff employees from quality, logistics, and maintenance regarding change processes, previous innovations, and the ODCE tool. Comparable to the previous stakeholder analysis, interview insights were gathered and clustered into themes. Overlapping themes were 1) the need for change, 2) willingness towards technology, and 3) the importance of operators' knowledge. Yet, there is a divide between support staff who work with operators and who work with operators' output. The maintenance employee, who works with operators, suggests operators and maintenance need a "solid foundation" instead of a new tool. This remark is interesting as it implies the problem definition is larger than just the tool itself and likely deeper reasons for adoption resistance. These deeper reasons are explored in the theme section 5.1.1. Quality support staff is more on the side of management, and constraining operators' flexibility to operate as operators' flexibility has led to contaminated quality of the product in the past.

### 4.3.5. Change management within the Diversey factory

One of the deciding aspects of change management is business complexity (see section 4.3), with a moderating factor of change capacity and urgency. Kerber and Buono (2004) define what business complexity entails; however, they do not specify what constitutes as high or low. Reeves, Levin, Fink, and Levina (2020) look at the complexity of organisations and define complex as a large number of different elements. These elements can be technologies, raw materials, production, people, and business units. The Diversey factory has 11 production lines that manufacture over 300 different SKUs. These production lines are composed of different machines, and these machines depend on different software. Besides the production lines, Diversey's factory has interdependencies within their SAP ERP and custom processes in their Statistical Process Control Alis. Even though these dependencies suggest an internal complexity, the market in which Diversey operates is mostly straightforward and predictable. To conclude, Diversey has a relatively high internal complexity, yet has a low external complexity resulting in a moderate business complexity overall.

Even though the moderating factors of change capacity and urgency should not be the main drivers behind a change approach (Kerber & Buono, 2004), these moderators are still relevant to assess. Diversey's change capacity is evident in its processes to minimize risk focusses, which is crucial in a factory with dangerous equipment. Yet, as seen with the previous tools, these processes do not facilitate change in behaviour or increase willingness among employees. Moreover, most of the change examples in previous attempts and interviews show a directed approach to change management. This limited experience within Diversey with change approaches could hinder the needed capabilities for the other change management categories like guided and planned.

Second is the urgency for the required change. The challenge of minimizing the variance between operators is the focus of the current value stream engineers. A new initiative to tackle this challenge is currently being developed, suggesting a high urgency. However, the urgency applies mainly to the current challenge of variance and not the overall project of COALA's DIA, which tackles a broader scope of challenges.

To conclude, Diversey has a moderate business complexity with change capacity, which addresses the technical aspect of the factory. The urgency is not severe enough to dictate the final change approach as it only applies to a fraction of the DIA's capabilities. These insights, combined with the concluded high socio-technical uncertainty in Chapter 4.2, suggest a guided or planned approach as the preferred change management category. However, the lack of experience with these change approaches should be addressed in the final strategy of this thesis.

### 4.3.6. Take away Diversey factory and its stakeholders

The analysis of the stakeholders and the preferred change management approach is formulated in the insights listed below. These insights are used for the second section of the frame creation field step and to formulate themes in the next chapter.

**Concern variance and data input**

Even though frame creation as an approach does not focus on problem-solving in an engineering way like minimizing variables, management's concern for the variance between operators and their data input should be still addressed. A way to do so is through the best practice feature of the DIA and to find the balance between routine and novelty.

**Importance of knowledge and expertise**

All stakeholders involved agree on the importance of operators' knowledge and expertise. The operators play a crucial part in root cause analysis and production line maintenance. Moreover, management views expertise as vital for employees, as demonstrated by the introduced expertise of team leads. However, this expertise could also have negative effects as common ground between employees diminishes and communication between departments becomes challenging.

**Contribution to operators' work**

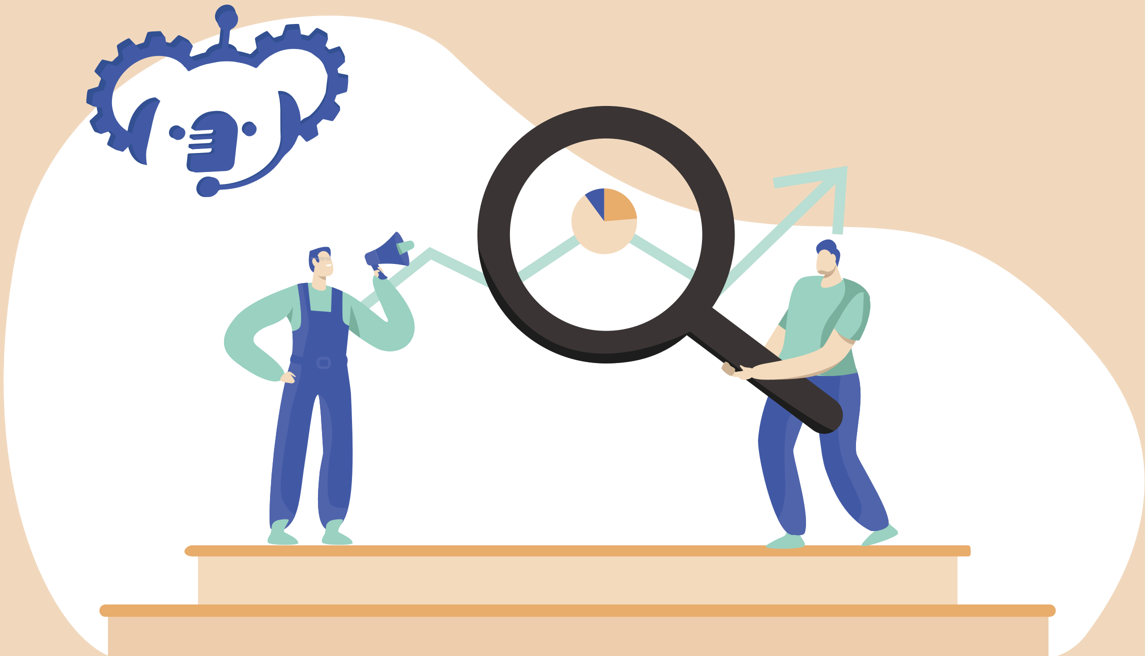
As mentioned by MEWS, the need and added value of end-users are important during change management. Currently, the tools' added value is minimal for operators and should be enhanced and highlighted. Operators revealed the desire for a smooth production line with minimal stoppages, yet operators do not perceive the tools as a way to achieve this.

**Communication and metric change**

The communication between operators and management is troublesome as operators are not informed about their suggested improvements. The lack of follow-ups leads operators to assume reasons for the lack of follow-ups, which leads to miscommunications. Moreover, management expresses the importance of the production output. However, only focussing on a production output metric could limit future improvements as short term gains trump long term actions for operators.

**Change approach**

As mentioned in section 3.1.3, Diversey's focus on change is minimizing risk through a mostly directed approach. As seen in the AI section, the socio-technical uncertainty of the proposed change is relatively high. Combining these insights with the moderate business complexity of the Diversey factory suggests a planned or even guided change approach. However, the lack of experience with other change management approaches could present a challenge.



# 5. FRAME CREATION

This section looks at the results of the Field and Context steps during the exploratory study. Next, these results are transformed into themes, and these themes are used to form three frames that are co-evolved with the stakeholders. Lastly, the takeaways from the co-evolution result in the exploration of the additional field of behaviour change, trust and social contracts, and work motivation. The essential elements from the first iteration frames and the additional field findings result in a frame that includes all relevant themes.



## 5.1. Frame creation

### 5.1.1. Theme analysis from factory visits

As described by Kees Dorst in Frame creation (2015), by generating themes, one tries to identify and understand the deeper factors underneath the current problem definition by examining the context and broader field. The current problem definition is further specified as the first interaction with COALA's DIA demonstrated in Figure 16. These themes are synthesized from the interviews with management, interviews with operators, and interviews with support staff (maintenance, quality, and logistics) over five Enschede site visits. The analysis includes four steps (see appendix F) 1) dividing the insights per stakeholder in needs, motivations, and experiences, 2) clustering the insights per stakeholder, 3) bundling overlapping clustering between stakeholders, and 4) defining "universals" from clusters. Dorst explains "universals" as universal themes relevant to the problem situation on a deeper level that take exceptional circumstances to be expressed. The themes are described below.

These organised statements are grouped per stakeholder group (support staff, production team, and management) into overlapping themes. Lastly, the themes are clustered across the stakeholder groups into common themes.

**Trust**

The theme of trust represents the absence of trust between management and operators to provide improvements. Management is concerned about the data input and variance among operators on the production lines. Operators do not believe their data input will result in tangible improvements on the production line as their previous attempts did not result in considerable improvements.

**Acknowledgement**

Operators have tried various channels to communicate bottlenecks without receiving follow-ups or recognition for their efforts. Some operators feel like management is taking advantage of their willingness. Thus, operators experience the difficulty of being heard and a lack of acknowledgement regarding their role and involvement in improvement initiatives.

**Clarity**

There is no clear contribution of previous and current tools to operators' work. Additionally, the reasoning for certain activities on the production lines is not communicated clearly. As such, assumptions are made by the operators for these activities resulting in miscommunications, demonstrating the need for clarity.

**Expertise**

This theme describes the challenge around process ownership on the production lines as the operators act out of their own experience and expertise. All stakeholders agree on the importance of operator knowledge and expertise on the production lines. However, operators only have their own experiences and expertise to act on, resulting in variance among operators.

Secondary themes:

**Goodwill**

The goodwill theme is an indirect theme from the previously mentioned themes. Operator responsibilities are increasing through tools like ODCE without a clear contribution to their work. Moreover, after multiple attempts to communicate their perspective on the bottlenecks, some operators believe it is management's turn to show commitment resulting in the absence of goodwill.

**Consistency**

The theme of consistency is present in both key stakeholders. For management, this theme represents the desired consistency between shifts and across production lines. Yet, for operators, this theme indicates consistency within the changes from management and their commitment to them.

### 5.1.2. Created frames

As mentioned in the method section, frames are used to explore new solutions by approaching the problem situation from the constructed themes. The frames are described through metaphors that embody the same pattern of relationships of the constructed themes. The first iteration of frames are COALA as a guardian angel, COALA as a translator, and COALA as a scrummaster


**Figure 18** - *The first iteration of created frames*

(see Figure 18).

**Guardian angel**

The guardian angel protects the operators from the cognitive load and ensures operators are not overwhelmed by additional tasks like the ODCE tool. The guardian angel values the individual and guides them to express their concerns in a trusted manner. Moreover, a guardian angel could assist in personal goals in the workplace. The frame addresses the themes of *acknowledgement, trust and clarity*. Moreover, the frame builds on these design requirements from the exploratory study:

- **Balance between organisation and individual**
- **Well-being as an AI driver**
- **Importance of knowledge and expertise**
- **Contribution to operators' work**

**Translator**

The translator translates the needs and concerns of operators and management to the other party. This frame provides the communication bridge between operators and management. Management cannot act on every improvement suggested by operators. However, the translator could assist the operators in gathering the needed argumentation. The translator also works the other way around by clarifying why a certain improvement is not possible, providing the needed follow-ups. The frame addresses the themes of acknowledgement, clarity, and consistency. Moreover, the frame builds on these design requirements from the exploratory study:

- **Balance between organisation and individual**
- **Testing and evaluating output**
- **Communication and metric change**

**Scrummaster**

Lastly, the scrummaster frame provides transparency through a clear overview of responsibilities. The scrummaster facilitates iterations and creates a test-and-learn mentality. Moreover, scrummaster is a permanent position that secures the processes and facilitates new behaviours needed for proposed changes like the DIA itself. The frame addresses the themes of clarity, consistency, and ownership. Moreover, the frame builds on these design requirements from the exploratory study:

- **Testing and evaluating output**
- **Governance needed**
- **Concern variance and data input**

## 5.2. Co-evolution

Coevolution entails the evolution of the problem definition and shaping the solution space by using frames to open the discussion with stakeholders. The discussion with stakeholders and investigations into the context will increase the viability and feasibility of the solution. The fruitfulness of a frame is explored with the relevant stakeholders to examine whether the frame generates ideas that stimulate engagement and commitment.

### 5.2.1. Co-evolution workshop

In this workshop, the Frame creation steps are demonstrated to the Director of OpEx, the head of COALA, my thesis mentor, and a COALA PhD'er. The workshop aims to examine if the stakeholders envisioned the same solution spaces from the three frames (see Figure 18). Explaining the frame creation method proved challenging as this model deviates from the traditional problem-solving approaches. According to the present participants, the individual frame formulations did not depict all the relevant themes. This feedback resulted in the need to find an umbrella frame representing all relevant themes without creating a Frankenstein solution space.

### 5.2.2. Coevolution survey/ structured interviews

As the added benefit for operators is crucial, it is essential to validate these found themes and frames with the operators. Initially, the validation would be through a survey sent out by management. This survey would demonstrate management's commitment and access to a larger group of operators. The survey's aim is to assess their needs based on the themes from the analysis. Lastly, this survey was intended to find champions within the company that are willing to contribute to the development of the DIA, as mentioned by MEWS (see section 4.1.4). Eventually, this survey was used to interview operators in the vicinity of the production line as there was a miscommunication with management.

As mentioned in the Archaeology section, COALA's DIA is only defined in a conceptional form that appeals to stakeholders' imagination instead of experiences. This appeal to their imagination makes it difficult to gather feedback. Combining the ambiguous conceptualisation of COALA's DIA with the abstract frames proved to be challenging as the operators were not willing or able to envision futures based on these frames. The operators point out that they just want to do their job and not bother with other aspects.

### 5.2.3. Co-evolution takeaways

The co-evolution workshop, in combination with the themes, provided three takeaways that led to making a pivot. First, the Human-AI interaction aspect should not be the initial focus as the adoption resistance is rooted in the new behaviour of providing data. The challenges and influential aspects of the request to change employees' behaviour are unknown. Therefore, the domain of general technology acceptance and behaviour change are analysed. Moreover, the 'currency' within the workplace of operators is still unknown, which is crucial to understanding the importance and impact of the generated themes. Thus, trust and social contracts within an organisation, work motivation and sources of meaningful work are further explored to grasp the themes within the Diversey context. Lastly, following the exploration, a new frame is crafted to embody the essence of the central themes.

## 5.3. Deep dive into the 'currency' of the Diversey factory

The generated themes exist in a socio-technical system where people and technology influence each other's expectations, agreements, and actions. These social, symbolic, and sometimes economic interactions between stakeholders can be viewed as the 'currency' of the context. During the co-evolution of the themes and frames, the importance of this 'currency' became evident. The 'currency' is explored through the fields of trust and social contracts, behaviour change and technology acceptance, and job satisfaction. As a result of this deep dive, the deep-rooted themes within the Diversey context can be better understood.

### 5.3.1. The trust wobbles in Diversey

The most reoccurring theme within the contextual operator interviews (Diversey operators, 2021) is trust. Trust, in this context, is the trust in management and tools to provide tangible results and contributions to operators' work. Additionally, trust is one of the influencing factors of technology acceptance which is explained in section 5.3.2. Hence, trust is an important aspect of frame creation in this context. The trust triangle of Frei and Morriss (2020) is used to obtain a better understanding of trust. Frei and Morriss describe the trust triangle as the three main drivers of trust: authenticity, logic, and empathy (see Figure 19).

The relationships between themes illustrated in Figure 20 could explain the 'wobble' inside Diversey. Frei and Morris (2020) describe the 'wobble' as the explanatory driver(s) for the absence of trust. The lack of acknowledgement (empathy) and clarity (logic) would likely be the 'wobble' for Diversey. Restored trust could lead to restored goodwill between stakeholders, and Clarity in work contribution could invoke consistent behaviour. Moreover, the lack of goodwill can be detrimental in a working environment as many exchanges are quid pro quo. Additionally, the lack of goodwill can be hard to notice. For example, a pocket veto demonstrates employees do not disagree with a given task yet do not execute the required action (Gag, 2017).

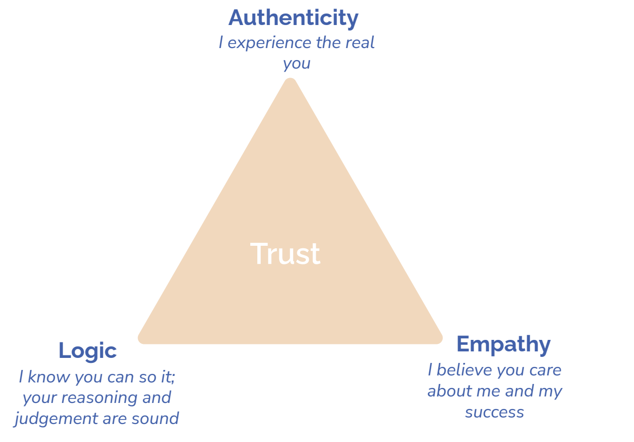



**Figure 19** - *The trust triangle describes by Frei and Morris (2020)*

Another description of the quid pro quo exchanges is 'social contracts'. In a conversation with Snelder (2021, October 27), who is a service design expert at the TU Delft, the notion of social contracts was explained. Social contracts are implied contracts that can be actual or hypothetical agreements between people or organisations (Fogel & Nehmad, 2009). Social contract theory is common in service design and is related to trust (Pan & Zinkhan, 2006). The service design expert also explained the importance of relative value within a socio-technical system. For example, when a change requires effort from the users, this effort benefits some users more than others. The notion of relative value can lead to discontent among the users as the added value is not evenly distributed. Relative value could be a driver behind the need for the acknowledgement theme.

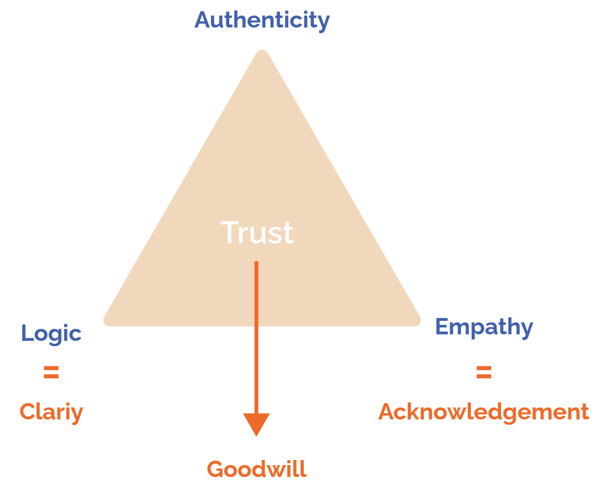



**Figure 20** - *The trust triangle compared to the generated themes*

## 5.3.2. Behaviour and technology acceptance

### Behaviour requested from operators

The two required interactions from operators are 1) operators sharing their experiences and knowledge and 2) evaluating the DIA's output (suggestions), as seen in Figure 16. The first interaction is similar to the current ODCE tool and the change over form. This interaction requires a new behaviour of operators, which calls for elaboration on their experiences and actions. This new behaviour is needed before the DIA can produce relevant or accurate output. Therefore, the primary focus of this thesis lies in the first interaction. Even though the second interaction is essential for the integration of COALA's DIA, some prototypes are necessary to assess this interaction which is not the scope of this thesis. An approach for the second interaction will be addressed in the recommendations sections.

### Ability vs motivation

In order to facilitate the behaviour of describing their experiences and clarify their actions, the operators need the *ability*, *motivation*, and *trigger* to do so, according to Fogg (2009). Fogg maps these aspects in his Fogg behaviour model (FBM) and concludes the requirement of adequate motivation, adequate ability, and an effective trigger. A preconception of AI is that the technology is easier to use as it has its own intelligence. However, as demonstrated before, the knowledge has to come from somewhere before AI can be effectively applied. Even if AI would lower the effort required for the behaviour, there should also be sufficient motivation to perform the behaviour see Figure 21.

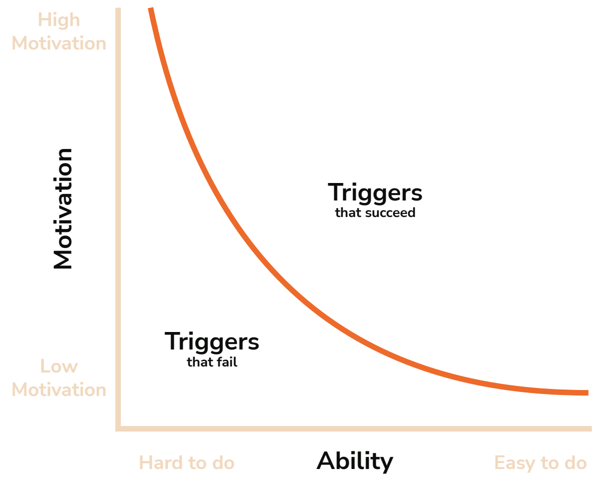



**Figure 21** - *The FBM graph (Fogg, 2009)*

Counterintuitively, lowering effort could even lower motivation for the target behaviour as well. Inzlicht, Shenhav, and Olivola (2017) conclude in their research that effort can also add value as the outcome can be more rewarding. Take, for example, the IKEA effect, where people value their successfully build furniture more than comparable products (Mochon et al., 2012). However, the experienced value depends on the when, why and how of the required effort and the perceived outcome. In the structured interviews, five operators perceived minimal value from the ODCE tool while the effort was relatively high. The value or anticipated value of an outcome is categorized as a Hope motivator by Fogg (2009). Besides the *Hope/Fear* motivator, there is *Pleasure/pain* and *Social acceptance/rejection* motivation. The first motivator of *Pleasure/pain* is the most effective and primal motivator. Even though pleasure can be present in the gamification of a service, pain should not be a design component used in service design. Lastly, the motivator of social acceptance/rejection can be an effective motivator in the socio-technical context of an organisation.

After motivation comes the behaviour ability, other components besides the cognitive and physical effort need to be addressed to satisfy the ability component. Fogg (2009) specifies the time, money, social deviance, and non-routine as the remaining components of ability. The description of these components can be found in table 2.

*Table 2 - Ability factors of the FBM (Fogg, 2009)*

| Component | Description |
|---|---|
| Time | When a behaviour costs time and this time needs to be spent on other activities, the behaviour is less likely to become a reality. |
| Money | When a behaviour requires people to spend money, the behaviour becomes more complex as people have to evaluate the cost and behaviour. |
| Social deviance | The further the target behaviour is from the norm and rules within the social context of the behaviour, the less likely users will pursue the behaviour. |
| Non-routine | People experience behaviour as accessible when the behaviour consists of routine actions which people frequently perform. |



Lasty, Fogg (2009) concludes three types of triggers that announce people to perform the behaviour at that moment. The first trigger is *Spark* which sparks motivation in people who lack the motivation to perform the target behaviour. Secondly, the trigger *Facilitator* simplifies the behaviour by increasing the ability of the behaviour. Finally, the *Signal* trigger simply acts as a reminder for people who have the ability and motivation to perform the behaviour

In conclusion, only focussing on lowering effort will not be sufficient to reach the target behaviour, and therefore COALA's DIA should also address motivation with an effective trigger.

### Routine through habits

As mentioned by Fogg (2009), the ability to perform a target behaviour is lower if it requires non-routine actions. Fogg (2019) and Clear's book Atomic habits (2018) describe the power of small and incremental changes and habits. Clear agrees with Fogg regarding the need for motivation, ability, and trigger. However, Clear (2018) divides behaviour change into three layers 1) outcomes, 2) process and 3) identity. The first layer is about the desired results or goals, yet many people have goals and never reach them. The second layer addresses these issues by changing habits into a system by anchoring them into a routine. Lastly, the third layer is about changing the identity, which refers to the beliefs and values regarding oneself.

However, this approach to behaviour change is primarily based on intrinsic motivation and could perhaps not be expected from every operator on the production line. Therefore, the approach should address the different personal ambitions and goals among operators. Moreover, organisations like Diversey cannot expect employees to change their identities based on the work requirements.

### Technology acceptance model

A model which describes user motivation is the well-established technology acceptance model (TAM, Figure 22) (Marangunić & Granić, 2014). In this thesis, I apply the extended technology acceptance model to explore the broader field of technology acceptance. The original TAM maps out the perceived usefulness and ease of use which affect the attitude towards using the technology. However, the extended TAM includes 1) external variables which influence the perceived usefulness and ease of use, 2) Additional belief factors which influence the attitude, and 3) factors from related models which influence the intention to use (see Figure 22). These factors and variables are used for the sense-making of the interview insights and exploratory study results. For example, Marangunić & Granić (2014) conclude output quality is one of the

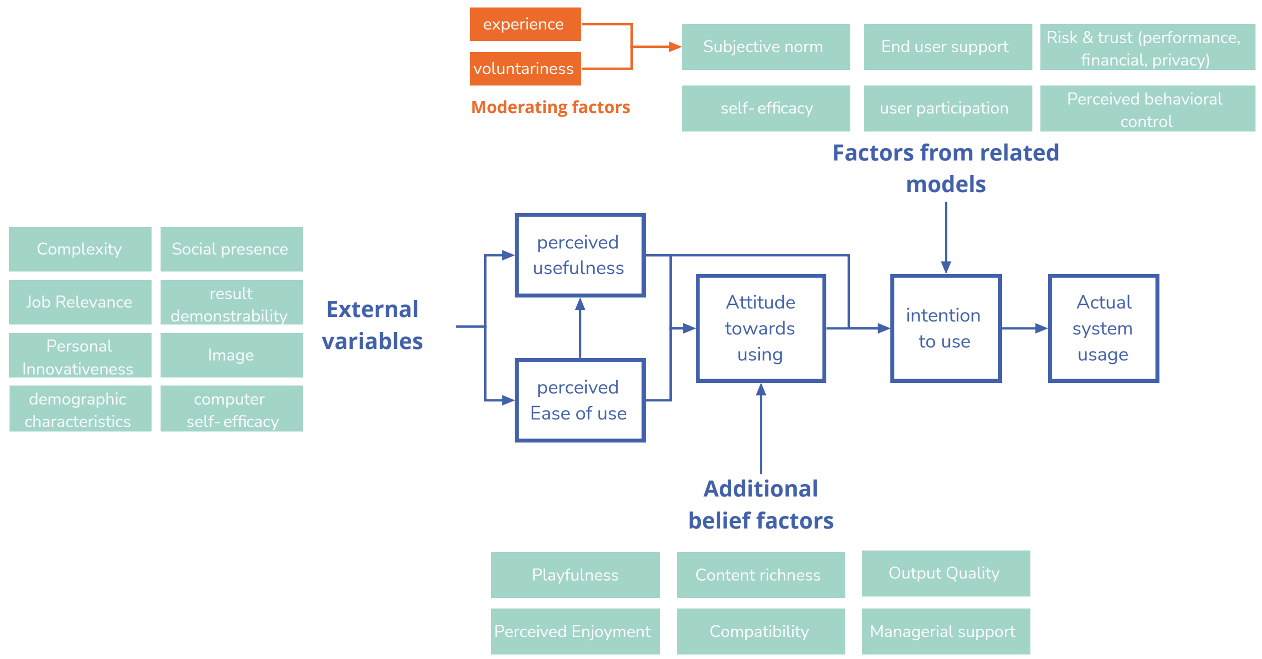



**Figure 22** - *The TAM diagram with the relevant factors and variables*

variables which could be compromised due to the capability uncertainty of AI. See Appendix G for the full TAM diagram, including the descriptions from the research by Lee, Kozar, and Larsen (2003) and Marangunić and Granić (2014).

Factors that did not emerge out of the context analysis in section 4.3 but that are present in TAM are the social and personal factors. As the context is a socio-technical system, the social aspect of technology acceptance should be addressed. Moreover, the personalisation possibilities of AI could also address personal factors.

### 5.3.3. Job motivation

As operators emphasise their desire to 'just' do their job, it is important to explore the field of job motivation. Therefore, the two-factor theory of Herzberg (1959) and the self-determination theory of Ryan and Deci (1985) are analysed. Even though these theories are relatively old, the theories are still relevant to job satisfaction and human motivation respectively (Alshmemri, Shahwan-Akl, & Maude, 2017; Adams, Little, & Ryan, 2017).

**Motivation factors of the two-factor theory**

Human Relationships management (HRM) is essential for every working environment to ensure an enjoyable work environment and satisfying job, so also for factory workers. The importance of HR on factory floors is already known since the Hawthorne studies when the Hawthorne effect became apparent (Wickström & Bendix, 2000). Since the Hawthorne studies, many motivation theories have been developed. The Two Factor Theory is a theory that contains several themes from the contextual interviews. Herzberg (Alshmemri, Shahwan-Akl & Maude, 2017) suggest two categories of factors that cause (dis)satisfaction. These categories are called the **motivators** and **hygiene factors**; improving the motivators induce satisfaction, and decreasing the hygiene factors decreases dissatisfaction. In Figure 23, some of the motivators and hygiene factors are similar to the themes found in section 5.1.1; relationship with supervisor & trust, and recognition & need for follow-ups. Moreover, the work itself and operators whom 'just' want to do their jobs are also similar. Perhaps other factors could also be of importance among operators. Unfortunately, the survey did not confirm or deny the presence of other motivator factors as operators did not elaborate on their answers of 'just' doing their jobs.

| Job Dissatisfaction<br>Hygiene Factors | Job Satisfaction<br>Motivation Factors |
|---|---|
| > Working conditions | > Achievement |
| > Coworker relations | > Recognition |
| > Policies and rules | > Responsibility |
| > Supervisor quality | > Work itself |
| > Base wage & salary | > Advancement |
| > Status | > Personal growth |

**Figure 23** - *The Two-Factory theory of Herzeberg (1959)*

**Self-determination within Diversey**

Another well-established theory is the self-determination theory (SDT). This theory describes the circumstance of three psychological needs: 1) competence, 2) autonomy, and 3) relatedness. The satisfaction of these needs has a crucial role in motivating self-initiated behaviour (Adams, Little, & Ryan, 2017). Adams, Little, and Ryan (2017) describe the needs as follows in their Chapter:

- **Competence** as feeling effective and self-confident following and achieving a task,
- **Autonomy** as the freedom to make own choices
- **Relatedness** as experiencing connected and social belonging

However, SDT is a macro theory and should therefore also be evaluated in a similar context. Saari, Leinonen, and Tapanila (2021) evaluated the SDT through a theory-driven content analysis of blue-collar workers through survey responses and semi-structured interviews. Saari, Leinonen, and Tapanila's findings conclude the presence of autonomy, competence, relatedness, and beneficence among blue-collar workers (see Figure 24). Moreover, the presence of these needs occurs as a source of meaningfulness. Even though the findings confirm the presence of these needs, this does not conclude a necessity to satisfy these needs in the Diversey context. However, these needs are used for probing the concept development.



| Autonomy | Competence | Relatedness | Beneficience |
|---|---|---|---|
| > Autonomy refers to the independence or flexibility at work amidst the preconditions and restrictions | > Competence refers to realizing their own competencies, gain recoignition for them, and adapting to work demands | > Relatedness refers to colleague relationships, flat hierarchies, and when applicable client relations | > Beneficience refers to helping colleague, helping the user through the product, and how the product contributes to society |
| > Also defined by the quality of supervisor-employee relationship | > Meaningful work emerged when blue-collar workers were given the opportunity to develop skills, daily use of competencies, and their role in the organisation | > A satisfying work community could reduce negative aspects of work | > Presenting the added value of the end product for users and workers could increase beneficience within work |
| > Organisational supervisory practices could represent feedback channels and generalise independence | | > Positive experiences with reducing hierarchies builds up the sense of working towards a common goal | |
| > Blue-collar workers enjoyed taking responsibility, expand influence in organisation, and manage without supervisory control | | > Blue-collar workers which see themselves as important part of the organisation experience more relatedness | |

**Figure 24** - *The self-determination theory applied to blue-collar workers (Saari, Leinonen & Tapanila, 2021)*

### 5.3.4. Takeaways context 'currency'

The deep dive into the contextual 'currency' showed the importance of social contracts, trust, and the components of behaviour change. The themes show a lack of motivation and ability in the current situation to perform the requested behaviour. The insights from the deep listed below are used in the second iteration of frame creation to address this shift.

**Limiting ability**

Besides the physical and mental effort, there are other factors that affect the ability to perform a behaviour. The factors of social deviance, non-routine, and time should not limit the target behaviour. If these factors limit the behaviour, usage of the DIA could be perceived as risky for operators. This could present a challenge as TAM shows a negative relationship between the perceived risk of using the technology and the technology acceptance.

**Trust through logic and empathy**

In order to restore trust in management, the trust triangle of Frei and Morriss (2020) suggests improving logic and empathy while maintaining authenticity. This insight aligns with the themes of unclear contribution to work and lack of acknowledgement of operator roles in improvements.

**Ability through habit routine and measurement**

The ability to perform the target behaviour should be facilitated by management. This facilitation could be executed by adding other measurements for operators' work besides production output. Moreover, designing a system of small incremental habits could facilitate a habit routine, which could improve the ability. This process-based behaviour change could be strengthened by identity-based behaviour change when the behaviour is perceived as part of someone's identity.

**Participation and job satisfaction as motivation**

Previously, management focussed on lowering the effort for the required change through new tools. However, effort can even be a positive element of behaviour change. Additionally, TAM demonstrates how user participation can have a positive effect on system usage. For example, by involving operators during the development phase, their preference is included. Moreover, satisfying the motivation factors and self-determination needs could also increase motivation for the target behaviour.

**Personal preferences between operators**

The degree of satisfaction among motivation and ability could vary per operator. Participation and job satisfaction as motivators could differ in effectiveness across employees, and the intrinsic motivation for the routine is also dependent on the individual. However, by leveraging AI's strength of personalisation and the need for an effective trigger, a personalized trigger could be developed, which increases the likelihood of adopting the target behaviour.

**Operator social relatedness and deviance**

COALA's DIA will be introduced within a socio-technical system with the corresponding communities and relationships. Moreover, TAM demonstrates the potential importance of this aspect through the factors of image, result demonstrability, social presence, and subjective norm. Moreover, the desire for community and social belonging at work emerges in the job satisfaction section through relatedness and co-workers relations. Thus, the DIA should include and address the social components of the context.

**Protect flexibility**

Autonomy is in contrast with management's interpretation of the DIA for best practices process as the best practices would dictate the operators' actions. The limited autonomy can be experienced as demotivating and eliminates the advantage of people with diverse knowledge and perspectives over robots. Even though consistency and safety are essential within factories, a balance needs to be found between autonomy and best practices dependency.

## 5.4. Frame fusion

The frame fusion Chapter describes the second iteration of creating a suitable frame for COALA's DIA in the context of Diversey's factory. The second iteration is performed by fusing the essential elements and themes from the first iteration and the takeaways from the contextual 'currency' into the final frame.

### 5.4.1. Essential elements from previous frames

During the stakeholder workshop, the participants confirmed the themes and the essential elements within the frames. So, the essential elements of the frames are extracted to form requirements.

**COALA's DIA as a guardian angel**

This frame primarily aims to protect the operators from being overwhelmed, involve operators in the process of developing production line improvements, and guarantee added value for operators.

**COALA's DIA as a translator**

The primary aim of this frame is to align the key stakeholders, management and operators through the communication of both perspectives.

**COALA's DIA as a scrummaster**

The scrummaster frame is aimed to address the need for governance and structure. This frame focuses on the best practices, quality and volume of data, and structure for testing and evaluating AI output.

The frames individually address all relevant themes. However, only one frame can be chosen to reframe the solution space, and individually the frames do not address all relevant themes. Moreover, the frames also do not include the takeaways from the second field iteration.

### 5.4.2. Missing elements from field

The takeaways from the contextual 'currency' are the second iteration of frame creation's field step. The missing elements from these takeaways are:

- **Ability through routine and measurement**
- **Participation and job satisfaction as motivation**
- **The social aspect of operator relatedness and deviance**
- **Protect flexibility and expertise in operators' work**
- **Personal preferences between operators**

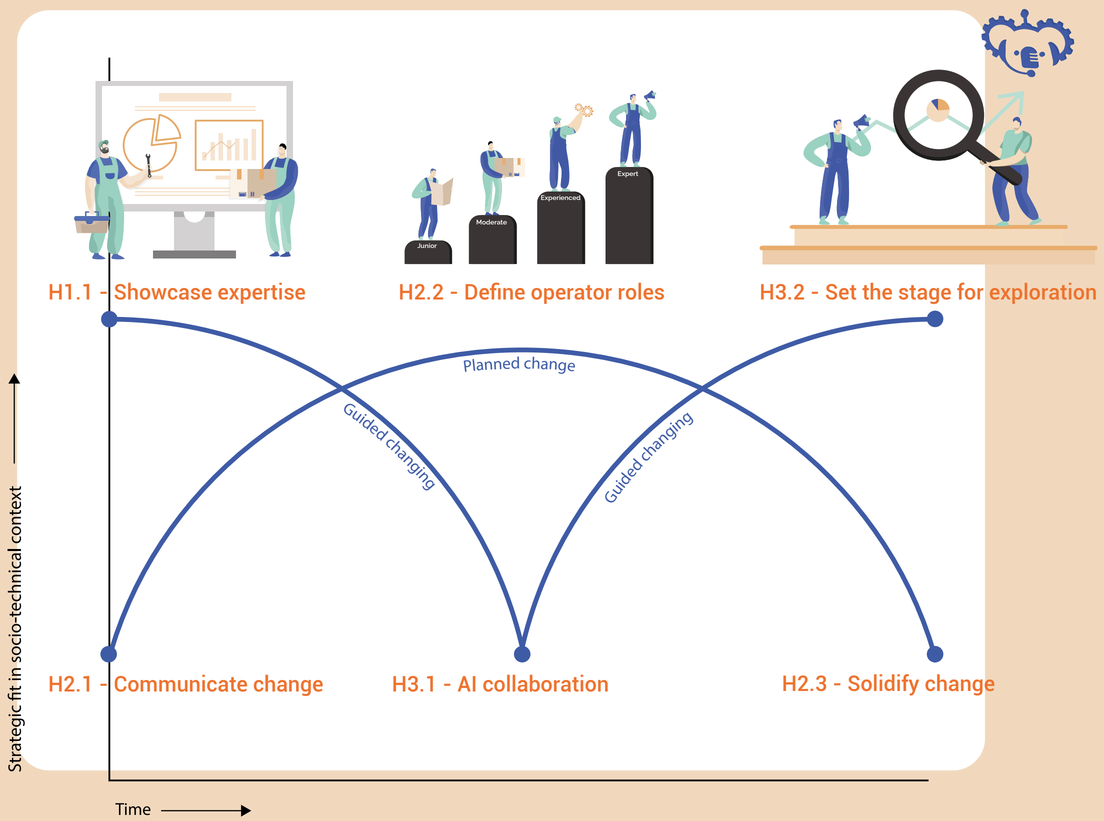
### 5.4.3. The DIA as a stage for expertise and exploration

The final frame combines the need for protection and involvement (Guardian angel), communication and alignment (Translator), structure and governance (Scrummaster). Moreover, this frame addresses the missing elements of the ability and motivation of operators to perform the required behaviour, the social aspect of relatedness and social deviance, protecting the flexibility and expertise of operators' work, and the personal differences between operators. All these components come together in the frame

*COALA as a stage for expertise and exploration*

The frame consists of four elements 1) showcase expertise, 2) setting the stage, 3) auditions for different roles and 4) taking centre stage. The first element addresses the empathy wobble of trust and motivation through involvement, achievement, and acknowledgement of expertise. Setting the stage refers to designing the system and feedback loop for behaviour change through routine and a second dimension for operator assessment. Next, the auditions for different operator roles address the concern for data input and determine the balance between best practices and autonomy depending on the operators' expertise and ambition. These auditions also address the desire for advancement, personal growth, and responsibility from the job satisfaction section. Lastly, the collaboration between operators and COALA's DIA takes centre stage as the DIA's insights are used to explore future improvement, which could even extend beyond production line improvements.

In conclusion, the frame as a stage for expertise and exploration is used as a solution space for collecting learning data and production line improvement (first interaction, Figure 16). The concept solution is further developed in the next Chapter with the Transformation and Integration steps of frame creation.




# 6. CONCEPT TRANSFORMATION AND INTEGRATION

The final two steps, transformation and integration of the frame creation method, are described within this section. Transformation focuses on the idea's within the new solution space, which could be implemented without making impossible changes to the organisation. Moreover, the transformation step ends with the proposed strategy for COALA's DIA in the Diversey factory. Lastly, integration focuses on integrating the frame and the accompanying mindset in the context of the organisation through the evaluation of the frame and concept.



## 6.1. Concept elements

As mentioned in the description of the final frame, the frame consists of four elements. The interpretation of these elements and the accompanying strategy form the concept of this thesis. The strategy consists of the change management approach and the three horizons, which result in the final concept.

### 6.1.1. Chosen change management approach

The change management approach is chosen using the model of Kerber and Buono (2004), which suggests guided change due to the high socio-technical uncertainty of COALA's DIA AI component and the moderate business complexity of the Diversey factory. However, Diversey's management has minimal experience with change led by employees. Therefore, the guided change will be accompanied by a long term planned change approach that provides clarity throughout the development and implementation of COALA's DIA.

The systemic model (Senge et al., 2014) is chosen as the preferred guided change approach. The systemic model focuses on the individual's concerns making it a micro change management approach. The systemic model views organisations as living and adaptive systems like organisms which matches MEWS' view of fluid change. Senge et al. also state that the issue in change management is that managers tackle symptoms yet avoid the deeper systematic issue, which is similar to frame creation. The systemic model is characterised by starting small, growing steadily, and expecting challenges (Cameron & Green, 2019).

However, as Diversey's management has minimal experience with change emerging among employees, guided change will be accompanied by a long term planned change approach. The combination provides guidance and clarity for management and operators in the direction of the change. Additionally, the planned change approach needs to address the macro change management aspect to minimize sub-optimization, as mentioned in section 4.1.6. The chosen method for the planned approach is Kotter's model, as it focuses on the vision, inspired action, agility, and celebration within the organisation (Cameron & Green, 2019). The eight steps of Kotter's model are:

1. Create a sense of urgency
2. Build and maintain a guiding coalition
3. Formulate a strategic vision and accompanying change initiatives
4. Communicate the vision
5. Empower others to act on this vision
6. Plan and create short term wins for celebration
7. Promote and reward advancing change and initiatives
8. Institutionalise strategic changes in an organisation's culture

### 6.1.2. The three horizons

These change management approaches and frame elements are divided over three horizons. The most prominent themes are addressed in the first horizon as these themes have a higher strategic fit in the socio-technical context. The first horizon will be guided change through small changes, which will build the routine required for the DIA's data input. In parallel, the first four steps of the planned change approach are performed. When the first horizon ends, the third horizon will start. The third horizon will also be achieved through guided change, where the operators are empowered and facilitated to explore new change initiatives through DIA's insights. In Figure 25, the three horizons are displayed over the eight steps of Kotter's model.

**Horizon 1** – Setting the stage and showcasing operator expertise will be the focus of the first six months

**Horizon 2** – Establish Diversey's identity and vision to facilitate and empower operators to explore production improvements through different operator roles, which will take two years.

**Horizon 3** – Exploration will take centre stage as new change initiatives will be introduced through operators and collaboration with COALA's DIA. This horizon has no particular end as it is an iterative guided change approach.

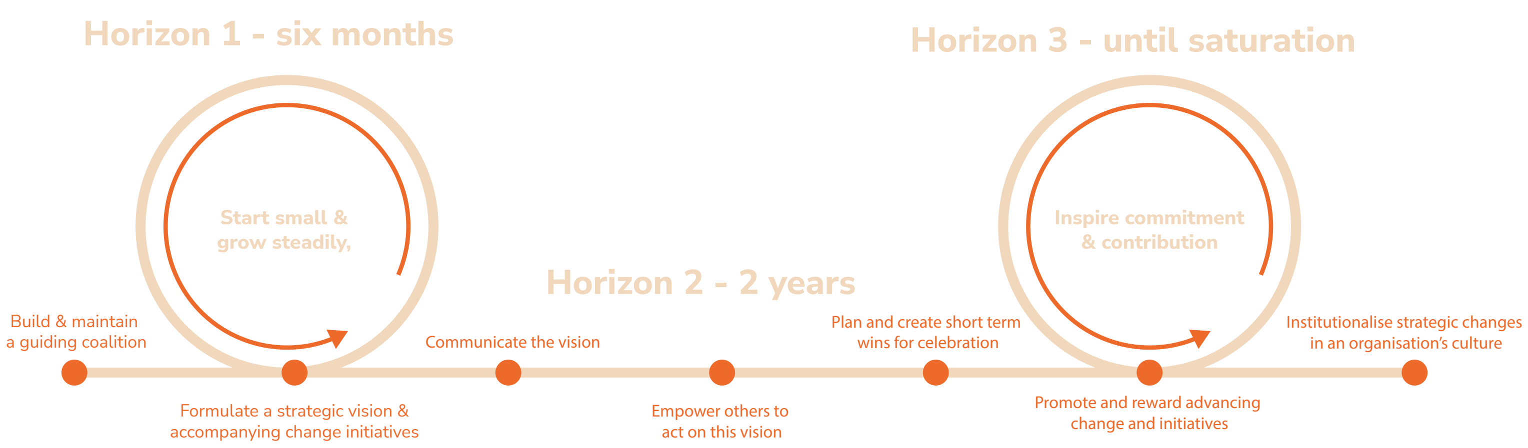



**Figure 25** - *The three components of the reframed DIA's strategic roadmap (Kerber & Buono, 2004; Senge et al, 2014; Cameron & Green, 2019)*

## 6.2. Concept transformation

In this section, the elements and horizon of COALA as a stage for expertise and exploration are elaborated. The transformation step addresses the short component of setting the stage and the long term component of exploration taking centre stage. The concept looks at the three layers of behaviour change and the motivation, ability, and trigger to perform the requested behaviour. This step will close with the detailed roadmap, which describes the complete strategy for COALA's DIA.

### 6.2.1. Short term component – setting the stage

The short term component revolves around settings the stage for the desired behaviour of operators sharing their knowledge and experiences. Setting the stage refers to designing a system (process) behind the desired outcomes described by Clear (2018). The desired outcome for operators is visible through the generated themes of Acknowledgment, Trust, and Clarity. Operators and management both want to reduce the stoppages on the line and improve production, which would be possible through COALA's DIA. However, operators do not trust tools or management to provide tangible results. Demonstrating tangible results directly through the DIA is impossible as it requires knowledge before it can produce relevant output. However, the notion behind COALA's DIA can be communicated, which is production improvements through operator expertise and addressing the themes generated from the context.

The first three steps of Kotter's theory are 1) creating a sense of urgency, 2) building and maintaining a guiding coalition, 3) formulating a strategic vision and accompanying change initiatives. These steps will be realized at the beginning of horizon 2. Unfortunately, the guiding coalition could not be established within this thesis. However, the vision will most likely be in line with production improvements through operator expertise as the themes are grounded in the context. For the process-based behaviour change, it is important to monitor the motivation, ability, and trigger of the requested behaviour. Moreover, the behaviour should start small and grow from habits into a routine, as mentioned by Senge et al. (2014), Clear (2018), and Fogg (2019). These habits should address the Acknowledgement and Trust theme. More specifically, addressing Trust by dividing Trust into logic and empathy, as seen in the trust triangle 19. Logic will be addressed through the Clarity in work contribution and empathy through the Acknowledgement of the operators' role and expertise.

As a result of these requirements, the first short term component consists of a mobile user interface combined with displays across the factory floor, which is part of the first horizon. The second component consists of a dashboard on the production line itself, which is part of the second horizon. These components are separated as they refer to two different interactions, as demonstrated in Figure 16.

**Stage for expertise**

The second environment should be associated with the end of operators' shifts; this could be a cafeteria, an office, or at the back of the production line. This environment can become the area free of cognitive load and reflect on the shift itself. Operators are asked to fill in please solutions or actions from the shifts into the DIA. These solutions and insights could be used by other operators. If operators are unwilling to fill in insights from their shift, the DIA will ask about the ability, motivation, and trigger regarding the sharing expertise and experience behaviour. This feedback loop is used as the foundation for the guided change within the first horizon. Examples of expertise showcase features are:

1. Displaying operator achievements (see Figure 26 for display example)
2. Sharing and voting on the most useful operator tips

The showcase of expertise, knowledge, and tips encourages operators to assist each other. Moreover, this aspect could stimulate to development of communities and colleague relationships.

The separation of these environments is important as environments play a crucial part in behaviour change (Clear, 2018). These features address the generated themes from the context and easy operators into the habit of sharing data through experiences and expertise.

**Figure 26** - *Example of a production line display*

**Production line stage**

The production line is an environment of high cognitive load and pressure. Therefore, this environment should be reduced of cognitive load, as expressed in the Archaeology section. Therefore, the interaction with COALA's DIA in this environment only includes features that directly contribute to operators' work on the production line and reduce cognitive load. Example features (see Figure 27) that contribute to operators' work are:

1. History of SKU settings
2. File a direct improvement suggestion to management

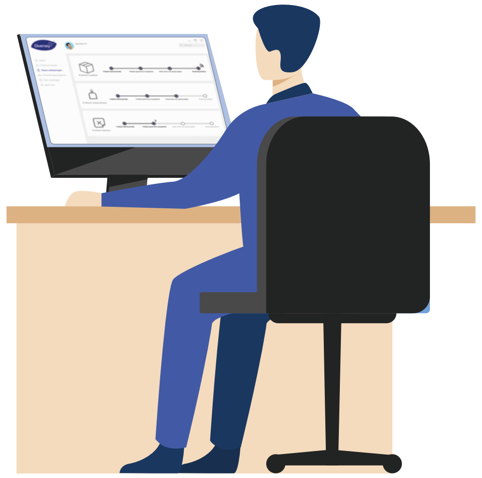


**Figure 27** - *Mock up of possible features for the production line 'stage'*

**Step by step**

Through the systemic model, the DIA can slowly and steadily grow in the context. When the habit of sharing data is turned into a routine, features can be elaborated or added. The following feature could be filing an improvement suggestion for management, which provides real-time insights into the status of the suggested improvements (see Figure 27). Within the dashboard, operators could remind management after a certain amount of time and can read the argumentation why the improvement will (not) be implemented. Eventually, the feature can be elaborated by adding issues to the suggested improvement. This feature could allow operators to draw up a technical dossier regarding a specific machine to convince management of the required improvement. The Rasa functionality in section 3.3.2 can even be used to help draft complete issues. This additional feature, among others, emerged during a creative session with the TU Delft COALA group (see Appendix E for an overview) and is just an example of a use case that can emerge from a guided change approach. Even though relevant features are beneficial for COALA's DIA, inspiring and empowering commitment is crucial to the guided approach and can provide features that are supported by the users.

## 6.2.2. Long term component – exploration takes centre stage

The long term component refers to the vision of the organisation and the identifying layer of behaviour change. An example of a personal identity change that resulted in behaviour change is believing I was not a morning person at the beginning of my thesis. By not identifying as a morning person, I felt like I was not in control of my behaviour. However, after a good morning routine with some stretching and exercise. This insight led me to identify as more of a morning person, and this insight has solidified my morning routine throughout my thesis.

Even though employees' identity will not completely change through a change initiative of their organisation, employees' job and the corresponding organisation is a significant part of the employees' life. Therefore, the organisation is part of the employee's identity. How much an employee's identity is part of the organisation might be dependent on their personality, their position, and the company's brand. Nevertheless, the organisation and its vision are some part of the employee's identity. It is therefore crucial that the organisation, including management, believes and acts on this identity. When this identity is not present and communicated by management, the authenticity is at risk. This, as seen in section 5.3.1, could result in further loss of trust among operators.

As a result, Kotter's eight steps change model should be applied with guided change initiatives. The first three steps are already mentioned in the short term component of setting the stage. After the short term component, the foundation of the required behaviour of providing data is set. The next step of Kotter's model is to empower others to act on this vision, which will be realized through the first AI feature and role auditions. The first AI feature will be to assist operators towards higher quality data entry as with the Rasa chatbot (see Figure 12).

During the first interactions with COALA's DIA, it is important to plan and create short term wins for celebration. After the momentum of success, new AI features can be added, like extracting best practices from the provided data and personalising the human-AI interaction based on personal preferences and motivational factors.

The different roles (see Figure 28) are determined to guide and structure the first interactions between operators and AI features. The roles are based on the expertise and ambition of the operator, as intrinsic motivation is important for the active roles regarding the DIA. As mentioned in section 4.2.2, the capability uncertainty and output complexity aspects of AI cause the challenge of governance, expectation management, and evaluation. These challenges are addressed within the roles:

- The expert provides governance over the AI output
- The experienced and expert roles provide an evaluation of the AI capabilities and focus on best practice outliers
- The experienced and expert roles are only available for operators with a test-and-learn mentality.
- AI features for the moderate and junior roles are only available after extensive testing from the experienced and expert roles, and the DIA will focus on on-the-job training

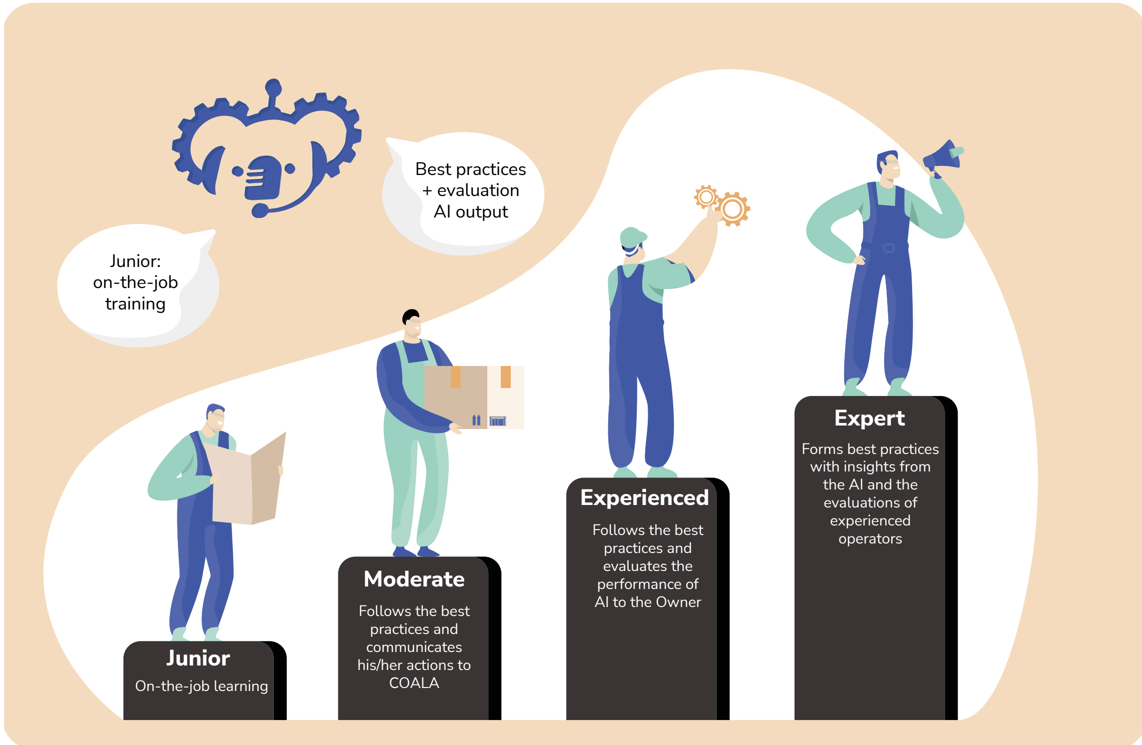



**Figure 28** - *Horizon 2's operator roles that influence the interaction level with the DIA*

The roles also provide motivation as the roles create opportunities for advancement, increased responsibility, and autonomy. The roles also provide a form of well-being as the roles protect inexperienced operators from high-pressure situations. Additionally, the roles address management's concern for data input as data input is limited for inexperienced operators.

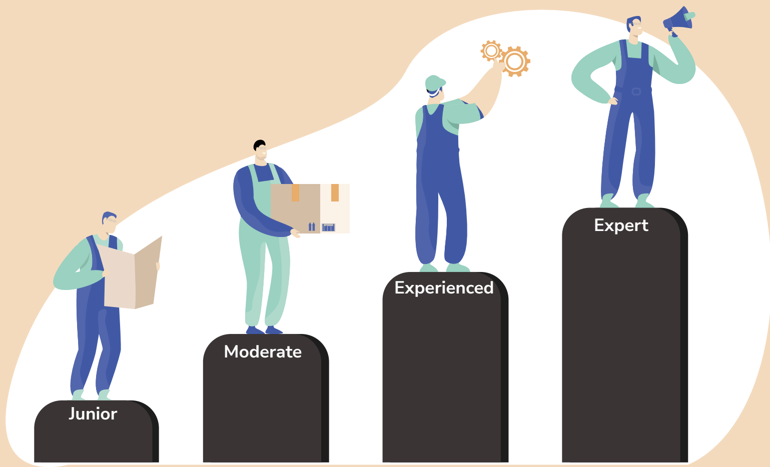
The following step of Kotter is to promote and reward advancing change and other initiatives. This step is the third horizon of the roadmap. During this guided change, exploration takes centre stage. Operators with expert and experienced roles are empowered to provide improvement initiatives through an additional metric of engagement besides the production output. This exploration can emerge or be planned. The exploration can emerge as the pattern visualisation of the DIA is used for serendipity, where operators connect the dots between patterns and context. Additionally, the exploration can be planned through a monthly creative session with a multidisciplinary team where patterns are explored to find an explanation and solution.

The last step is to institutionalise strategic changes in the organisation's culture. COALA's DIA can elaborate on the personalized interaction making the behaviour associated with the change more accessible.

### 6.2.3. Detailed Roadmap of the DIA as a stage for expertise and exploration

The detailed roadmap consists of seven columns that represent the insights throughout this thesis. The first column represents the chosen change approach for the given horizon. Second is the theme focus within the horizon, the three focus aspects (ability, motivations, and exploration) that are not themes yet are a crucial part of the horizons. Moreover, a column with collected data is visible as the reframed DIA focuses on the behaviour of data gathering. The next columns represent features that could prove the be valuable for the DIA in that specific horizon. The change activities represent the physical aspects that are required besides the DIA. Lastly, the relevant factors of AI, ability, and motivation are addressed within the last column. See Figure 29 for the complete roadmap of the DIA as a stage for expertise and exploration.

| | H1 Showcase operator expertise | H2 Set the stage with operator roles | H3 Exploration takes centre stage |
|---|---|---|---|
| **Change approach** | Guided change - System model<br>Planned change - Kotter's theory | Guided change - Guided changing spiral | |
| **Theme focus** | Restore trust<br>Acknowledgement<br>Expertise<br>Clarity | Ability and Motivation<br>Consistency | Exploration |
| **Horizon's aim** | Restore operators' trust by showcasing their expertise and importance towards production line improvements. Displaying their achievements and results, demonstrates their contribution through data and knowledge sharing, which creates the foundation of a data sharing process among operators. | Diversey demonstrates its commitment to the new vision by providing structure and incentive through operator roles. These roles reflects the ambition and expertise of operators, and inspire to share insights beyond the standarised processes within the factory. | Building on the foundation provided by the previous two horizons to share knowledge and experiences. This horizon explores future improvements on the production lines. The duties of the expert roles extend production and include connecting the dots between the DIA insights and suggestion, and the context. |
| **Data collected** | High level issues<br>Issue desciption<br>Service interaction<br>Expertise and achievements of operators<br>Opt out reason (ability, motivation, trigger) | Opt out reason (ability, motivation, trigger)<br>Best practices<br>COALA's DIA interaction<br>SKU settings<br>Issue description | Opt out reason (ability, motivation, trigger) |
| **Feature focus** | Track progress of issues<br>Rasa issue reporting help<br>Operator tips spotlight<br>Profile with interests<br>Demonstrate expertise<br>Opt out form issue report | Best practices for on-the-job training<br>Operator path from junior to expert<br>Flagging outliers best practice<br>Community sharing | Visualisation and export features for COALA's DIA<br>Emerging features from employees |
| **Change activities** (Approach dependent) | Create shared vision<br>Collect and address feedback<br>Form guiding coalition<br>Bi-weekly results meeting | Test-and-learn workshops<br>Facilitate experiments<br>Data capabilities training<br>Share learnings | Multidisciplinary production team meetings to discuss results<br>Workshops data presentation and visualisation |
| **Relevant factors:** Artificial Intelligence | Capability uncertainty<br>Context sensitivity | Output complexity<br>Monitor all three | |
| Ability | Sharing expertise form<br>Separating routines | Provinding role structures<br>Time for secondary tasks | Time for exploration |
| Motivation | Recognition<br>Achievement<br>Involvement<br>Competence | Personal growth<br>Advancement<br>Responsibility<br>Relatedness | Autonomy<br>Beneficience |



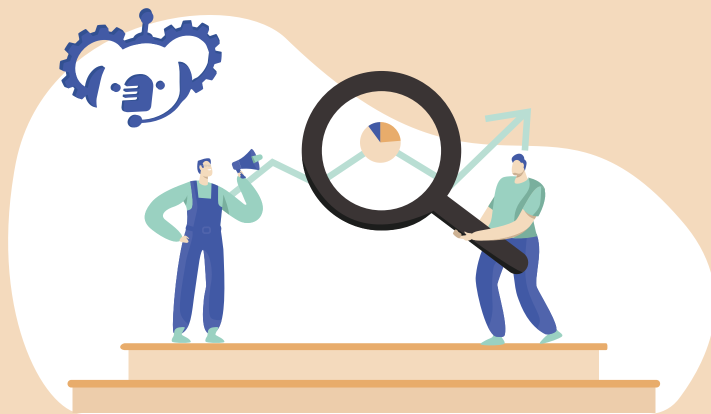



**Figure 29** - *The reframed DIA's strategic roadmap*

## 6.3. Concept integration & evaluation

The last step of the frame creation method revolves around integrating the frame into the broader context so Diversey's management can shift from reactive to proactive. The integration is performed through an evaluation session with the continuous improvement manager, production manager, and value stream engineer. Additionally, the concept is evaluated on the strategic aspects of desirability, viability, and feasibility defined by Calabretta, Gemser, and Karpen (2016).

### 6.3.1. Changes within Diversey

During the last factory visit, I could introduce the reframing of the DIA to the continuous improvement manager, production manager, and value stream engineer. The production manager demonstrated several overlapping aspects between the suggested frame and current changes within the factory. Management is introducing a friendly competition between team leads by showing production output results on the displays in the factory. Additionally, the information on the displays showcases operators who performed above average, similar to the proposed frame. Moreover, by showing these differences, the production manager anticipates interaction between operators to help each other reach the same output. Currently, many operators believe their way of working is the preferred way. However, there are no measures in place to objectively assess the best practice.

In addition, operators of the 5-10L line and management have collaborated to construct a report which describes 20+ required improvements. These improvements will be executed on the premise the production output increases as well. This initiative shows commitment from management and could reduce the trust challenge stated in the themes. However, this initiative is a reactive approach and a temporary solution. There is still a system missing that structurally facilitates the engagement and involvement of operators' knowledge and experience.

Lastly, during the visit, the continuous improvement manager explained the presence of latent knowledge, yet this is not always top of mind among operators. Therefore, he agreed with the aspect of giving operators more responsibility and flexibility to contribute. Moreover, the idea of concrete roles was well-received as Diversey already has a skill matrix for the operators. However, management only uses this to determine whether an operator can train a novice.

### 6.3.2. Desirability

The desirability of the concept is assessed by the strategic fit with the wishes and needs of stakeholders. As mentioned in the previous section, management is enthusiastic regarding this perspective on COALA's DIA. However, as there are no prototypes available, there are still some unknown factors that need to be tested. Unfortunately, the operators were not available for an evaluation of the final frame. Still, the confirmation of operators regarding the specific themes and motivation for this frame is crucial. Even if the operators are not enthusiastic about the frame, the introduction of guided change should develop a frame or interpretation of the DIA, which is endorsed by the operators. Moreover, the concept incorporated a feedback loop within the dashboard that should ensure a continuous alignment between operators and the DIA. Even though the 'what' is still the same (the DIA), the reframing of the DIA addresses themes that were unknown before the research and increases the desirability of a new tool.

### 6.3.3. Feasibility

The feasibility of the concept is assessed by looking at the operational capabilities of the COALA consortium and the Diversey factory. As mentioned in section 4.2.2, it is hard to assess whether an AI will have the capabilities to deliver the expected outcome. However, the suggested AI features are proven to be successful in other services. Moreover, Diversey is not required to develop the DIA as the DIA task force will introduce a TRL 6 innovation level of the DIA. However, the new features suggested in the concept section are not part of the innovation. Moreover, the Diversey factory does not have its own IT department, which makes it unlikely the Diversey factory can develop these features themselves.

Yet the factory management could still develop a proof of concept within their Alis program. This proof of concept will not have the same capabilities. However, the notion behind the frame can still be tested and used. This simplified version could assess whether guided change and empowering operators to share their expertise works in this context. Throughout the interviews, several employees asked to be involved in the further development of this project., which demonstrates the willingness among employees.

### 6.3.4. Viability

The viability of the concept regards the match between the Diversey factory's goals and objectives, and the concept's goals and objectives. The factory management mentioned in section 4.3.2 would like to go from reactive to proactive management. Currently, management is drawing up a report on the 5-10L to address the current issues. This report takes time, so when new issues emerge on other production lines, the whole process starts over again. The concept with COALA's DIA as a stage of expertise and exploration builds a foundation for gathering knowledge and data regarding potential improvements and issues. This system is scalable for other production lines and other issues, which could shift management from reactive to proactive managing. This potential shift confirms the match between the objectives of this frame and the management of the Diversey factory.

Additionally, the new identity for Diversey could also improve operator churn and improve recruitment options as the new identity might not be limited to the operators within Diversey.

### 6.3.5. Revisiting the paradox

The last section of the concept evaluation reflects on the main paradox defined in Chapter 3:

***Because*** *there are many stoppages on the production lines, operators try to solve them through their experience and knowledge.*

***Because*** *of the stoppages and operators solving them through their experience and knowledge, there is variance in production output between operators.*

***Because*** *there is variance in production output between operators, management wants information about the issues and solutions*

***Because*** *operators are so busy with the stoppages, they just want to solve the current stoppage instead of providing data*

And COALA's DIA specific paradox:

***Because the operators are in high cognitive and pressure situations, they need assistance to improve their production output.***

***Because AI has the ability to learn from input data and interactions, the technology could help operators deal with complex situations.***

***Because AI learns from input data and interactions, input from operators is necessary to develop an effective AI feature.***

The new frame addresses the data collection challenge through the motivation of operators to share their knowledge and experience. The acknowledgement of their role and clarity in contribution to their work improves trust between operators and management. Moreover, by separating the interaction of sharing data from the production environment, which is characterised by high cognitive load and pressure, operators have the ability to share their knowledge without being preoccupied.

# 7. DISCUSSION & RECOMMENDATIONS

This chapter will delve into the relevance, meaning and importance of my results. Additionally, I will recommend further research into three areas and address the limitations the of results.



## 7.1. Discussion

As mentioned in the introduction of this thesis, there is little known about the social aspect of AI implementation. This thesis tries to shed light on this aspect by viewing AI as a powerful and valuable tool yet not a magical solution. The technology of AI provides ample opportunities and strengths like real-time adjustments and uncovering hidden patterns. However, before these use-cases, the knowledge within AI has to come from somewhere and in this context, that source is the operators.

The research showed the difference between change management models (micro and macro) and change management approaches (directed, planned and guided). Additionally, the research uncovered the output complexity, capability uncertainty, context-sensitivity characteristics of COALA's DIA, and concluded Diversey's risk-oriented perspective on change management.

Additionally, the context analysis of the current situation on the production lines demonstrated friction between management and operators. Management shows concern with regard to the quality of operators' data input and variance in production output between operators and production lines. Operators experience an absence of acknowledgement of operators' role in improvements, trust that management provides tangible results, and clear contributions to operators' work. The absence of these aspects led to a decrease in trust and consequently goodwill. Even though the different stakeholders have different perspectives, management, support staff, and operators agree on the importance of expertise with regard to improvements on the production line.

The agreements, expectations and interaction between stakeholders are all part of the social contracts within the socio-technical context. Therefore, within a socio-technical context, trust is crucial and can be comprised through incoherent logic, lack of authenticity and empathy. Within the context results, the logic aspect and empathy aspects are most evident. The lack of acknowledgement of the operators' role could indicate a lack of empathy. Additionally, the different tools and unclear contributions to operators' work contribute to incoherent logic. These challenges might be indicating a shift in the manufacturing domain.

Manufacturing is a field that is known for the regulations and rules to protect the safety of employees and the quality of the product. However, in the Diversey factory, a shift is visible from improving machines and product quality to collecting knowledge and improving processes. The model of Kerber and Buono (2004) shows how an increase in socio-technical uncertainty can alter the preferred change management approach. Previously, Diversey applied a directed change approach when machines were altered, or new products were introduced. In this scenario, the logic and empathy were clear as the change had to occur; otherwise, operators' safety would be at risk. However, with the new scenario, the change solution and the urgency is not as clear as with physical alterations. Instead of the extrinsic motivation of clear rules to follow, the change depends on intrinsic motivation for a change initiative to emerge and be adopted.

With the shift towards more socio-technical uncertain change, the acceptance of the desired behaviour becomes apparent. Technology acceptance and the performance of a desired behaviour is dependent on the motivation, ability, and trigger aspects for this behaviour. The context analysis shows a lack of work contribution that can result in insufficient motivation. Additionally, management only assesses the production output, which can result in insufficient ability. Lastly, the trigger can also be insufficient as the tool is digitally requesting a behaviour while operators need to physically alter the production line at the same time.

Additionally, the behaviour change can occur in three layers 1) outcome-based, 2) process-based, and 3) identity-based. The desired outcome for this context is clear; reducing the variance of production output between operators and production lines. The previous process was requesting operator knowledge and experiences through a digital tool. Now, this process has changed to COALA's DIA as a stage for expertise and exploration. Lastly, for behaviour to really sink in, it has to become part of the user's identity. Organisations cannot expect employees to change their identity based on a suggested change. However, an organisation can facilitate this development by embodying this identity within the organisation itself.

Lastly, the results and interpretations are facilitated by the frame creation method demonstrating its use case as a change management model. Moreover, the change management models analysis showed limited guided change models and a gap in the people and prescriptive section of the change management model analysis. The frame creation method would fit in this section. Additionally, one of the challenges of frame creation is to assess the "ripeness" (Dorst, 2015) of a problem that regards to the readiness of stakeholders and a problem situation to apply frame creation. In change management, previously failed attempts are common and result in problem situations ready for frame creation. However, the frame creation method can be hard to explain to non-designers. Personally, I view myself as a designer and assessing the "fruitfulness" of a frame was extremely challenging. Even though the method was challenging as a designer, the method leverages several strengths of designers and could therefore provide designers opportunities within the change management field.

## 7.2. Recommendations and limitations

The main research question addresses the preparation stage of AI adoption. However, the stages of evaluating, improving, and governing AI systems also need to be addressed for AI implementation. The frame of COALA's DIA as a stage of expertise and exploration addresses the first required interaction (see Figure 16). However, the thesis does not specifically address the second interaction of evaluation AI's output and the preferred human-AI interaction. Even though the thesis strategy addresses the potential barriers of AI and facilitates continuous alignment between COALA's DIA and its users, not all interactions can be anticipated. Therefore, research is needed with regard to how the interaction of operators and the AI output evolves over time. The framework of Stoimenova and Kleinsmann (2020), briefly discussed in section 4.2.2, can be applied to explore specific AI interactions and the corresponding output. This framework explores how AI systems are being used and how the AI system itself behaves by monitoring (un)intended values. The framework starts with an initial frame based on the intended purpose and qualitative and quantitative data. This frame and how the AI system influences its environment are combined into a prototype. The (un)intended values are explored by analysing the interactions with this prototype. Their framework is an iterative approach as insights of the prototype interactions can be used for the next frame.

In addition to the specific interaction, future research should be critical regarding the preferred interface for the DIA. Currently, the suggested frame uses a dashboard with a mobile user interface with an optional voice-enabled feature. The choice for this interface was already made in the COALA proposal. However, in the interviews, operators expressed their dislike toward a voice-enabled interface. This dislike has two reasons 1) operators work in a loud environment, and 2) they do not want to be distracted by a talking AI. The voice-enabled interface allows operators to use their hands while interacting with the DIA. However, there are other interfaces that could provide the same flexibility, like wearables and AR glasses. Therefore, I recommend further research on other user interfaces to analyse which interactions and interface facilitate sharing of knowledge and exploration.

Additionally, the environment is a crucial part of behaviour change as the environment can act as a trigger or as an anchor of a routine. However, the DIA is invisible and can therefore be easily overlooked. Perhaps, an interesting aspect of the DIA interface could be a connection to the physical environment. For example, when an operator is frustrated with a stoppage. In this case, there could be little punching bags at every station, the operator could hit a small punching bag to indicate the location of the stoppage. This interaction could reduce the frustration, increase the empathy and playfulness of the DIA service. Therefore, I recommend exploring possibilities to incorporate the environment in the DIA service.

The results from this thesis are extracted from the 5-10L production line within the Diversey factory, which had top priority because of its complexity and number of stoppages. The operators of the morning and afternoon shifts were interviewed (n=6). However, the visiting hours limited the access to the night shift, who perhaps have different concerns. Even though the results are grounded in literature, the results cannot be applied to the remaining production lines in the factory without additional research. Thus, it is recommended to observe the application of DIA on the initial production line, and explore and evaluate themes among other production lines with other operators.

# 8. CONCLUSIONS

This initial research question formulated in the method section is:

*"How to prepare AI service adoption in the socio-technical context of the Diversey factory through reframing?"*

In order to answer this question, the question is divided into four sub-questions. The first three sub-questions are answered during the exploratory study, and the fourth question is answered through the last iteration of the frame creation's theme step. The four sub-questions are:

1. How can an organisation prepare for internal change initiatives?
2. What aspects influence the adoption of change within an organisation, and how?
3. How do AI service changes differ from traditional organisational change?
4. What specific socio-technical system aspects within the factory lead to the resistance to change?

Firstly, Kerber and Buono (2004) conclude three change management categories 1) directed, 2) planned, and 3) guided. The change initiative's source of directed change is management which relies on authority and focuses on employees' reactions to implement the change. The change initiative's source of planned change can be from any level within the organisation and is ultimately sponsored at the top. This approach focuses on a roadmap with planned activities which reduce productivity loss and resistance. The last change category is guided change which emerges from employees' commitment and contribution to the organisation's vision. Lastly, within these categories, there are micro and macro change management models. The macro change management models address the process of change and focus on the strategic aspect of the organisation. As with micromanagement, the models focus on individual concerns and how to address these concerns.

The second sub-question is more challenging to answer as change is applied to socio-technical systems, which refers to social, cognitive, informational, and technical systems within the context. The three overarching categories of influential aspects are 1) the change itself, 2) the organisational context, and 3) the interaction between the two. The categories can be divided into smaller categories that characterise the change or organisation, as seen in Figure 15. The relationship between the aspects depends on congruence with the other aspects and is therefore difficult to map out. However, the frame creation method proved to be an effictive tool for uncovering this interaction.

Next up is the third sub-questions that refer to the change itself; COALA's DIA. AI systems' strength lies in the ability to recognize patterns in large volumes of data. However, this strength also includes the characteristics of context-sensitivity, output complexity, and capability uncertainty which pose the challenges of trust, governance, expectation management, data requirements and collection. The human-AI interaction of the DIA can be divided into operators sharing their knowledge and experiences and the evaluation of the DIA's output. The first interaction is the requested behaviour from operators, as knowledge is required to develop an AI system with relevant output.

The last sub-question revolves around the organisation context of the change, which is the Diversey factory in the Netherlands. The primary focus of the factory is safety, quality, and production, and in that order. Therefore, management is mainly risk-focused and strives for a factory as a well-oiled machine by focussing on the variance between operators and production lines. In order to identify the bottlenecks resulting in this variance, management has introduced two tools; the ODCE tool and the changeover form. Both tools aim to collect operator knowledge and experiences which eventually could lead to the variance causes.

Management aims to address these identified causes for variance through best practices. Even though this strategy could reduce the variance between operators, it does not facilitate improvements that enhance the overall production. Moreover, by introducing best practices, the problem-solving skills and knowledge of operators could be reduced as operators no longer has autonomy in their work.

Additionally, the tools are not generating quality insights as the tools are not fully adopted by the operators. Operators express an absence of contribution to their work and acknowledgement of their expertise and role in production improvement. These themes and management's concern for variance results in diminishing trust between operators and management.

Therefore, the thesis concludes with reframing COALA's DIA as a stage for expertise and exploration. The frame ensures the ability towards data providing behaviour by adding an assessment dimension, separating the production aspect and sharing the knowledge aspect of an operator. The motivation aspect is satisfied through the ability to advance, acknowledgement of expertise, be involved in the improvement process, ensure operation flexibility and exploration. Lastly, the trigger towards the sharing behaviour is provided by the stage aspect of the frame, which entails visibility of operators' expertise and exploration initiatives throughout the factory.


# 9. PERSONAL REFLECTION

As expected, this thesis had its twists and turns, and even though the project has changed so much since the original project brief, it still fits with my original goal. The original goal was formed throughout my Master where I was amazed at the possibilities of AI technologies. However, most projects only scratched the surface and made the technology appear like an all-in-one solution. To my limited personal knowledge, I knew that the implementation of AI could not be as easy as it is presented in projects. Therefore, my original goal for the thesis was to explore the different barriers to AI adoption and raise awareness regarding realistic expectations.

Unfortunately, I was not able to directly explore human-AI interactions with AI prototypes. However, the frame creation method allowed me to explore and understand the deeply rooted themes within the context. In previous projects, I thought I applied the frame creation method with project groups and already was amazed by the results. However, little did I know that this version of the frame creation was only a small part of the whole method. Throughout the thesis, I have learned what the different steps mean and why they are applied. Especially, the perception of the field step has changed. Previously, I thought field entailed the different fields of studies, and now I know that it regards the interplay between players connected to the problem situation, their actions, and used ‘currency’. This assumption of the field step was not the fault of a poor explanation. If I had read my own description at the beginning of my thesis, I would not have understood its meaning. This thesis has shown me the cliché of experiencing something versus just reading about it. When I reread the frame innovation book, the text had not changed, yet the meaning behind it had for me.

Even though applying the frame creation method was quite challenging, doing this thesis on my own was so much harder. I learned from myself that I reflect on my though by expressing them within the project team. Still, I did have meetings with the TU Delft COALA team, supervisory team, and Diversey. However, these interactions are different when you work in a group on the project and together work towards a solution. So, I had to learn how to actively reflect on my own work. I had three different approaches for this towards the end. First, whenever I felt lost, I sketched my entire thesis and tried to answer why this aspect was necessary and to which other aspects it connected. Second, I am better with presentations, so I imagined having a presentation for a specific stakeholder and prepared the presentation. Third, I just started writing and assessed whether it made sense or not. Lastly, I experienced the importance to schedule in time to reflect on gained insights and let them sink in.

To conclude, this graduation project has taught me a lot and also showed there is still a lot to learn. Besides the behaviour accompanying AI implementation, I have also learned a lot about my own behaviour in a complex, dynamic, open and networked problem situation.

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# APPENDICES

## Appendix A - Factory visit overview

### 1st Factory visit - 16-09-2021

> Exploration and orientation
>
> Rasa chatbot test (N=5)

### 2nd Factory visit - 17-10-2021

> Interviews support staff (N=2)
>
> Interview Production manager (N=1)

### 3rd Factory visit - 28-10-2021

> Interviews with quality team (N=3)
>
> Structured interviews with operators (N=4) (survey)
>
> ZED2 perception 5-10L production line

### 4th Factory visit - 16-11-2021

> Interview about communication (operator and maintenance, N=2)
>
> Interview IT representatives (N=2)
>
> Interview value stream engineer (N=1)

### 5th Factory visit - 06-01-2022

> Interview maintenance added value DIA (N=1) (survey)
>
> Interview operators added value DIA (N=3) (survey)
>
> Interview value stream engineer change over form(N=1)
>
> Interview production manager future vision factory (N=1)

### 6th Factory visit - 15-03-2022

> Frame evaluation - value stream engineer & continuous improvement manager
>
> Frame evalution - Production manager

# Appendix B - Change management models overview

Planned change

## Lewin's change management model

**Three stages of change management:**
Change must happen only when there is a strong motivation for it

**Unfreeze**

A change agent needed and identifying the need for change**. Communicate** the nature and likely **impact** of the proposed change(s) before introducing the new technology moreover create a **sense of urgency** for the change(s). People support what they **help to create**, so mobilize others.

**Transitioning**

Create a detailled plan for the change and treat it as a process instead of an event. Engage people to try out, overcome fear through coaching, and clear communication to focus on the target impact

**Refreezing**

Stabilize the change and embed it into existing systems. Locking in the change is crucial for the sustainability over time.

**Strengths**

One of the oldest and easy to use. Best used during top-down changes and it needs champions to successfully drive change

**Limitations**

The method is quite linear and simpel. Change is generally complex and erratic making the method too static.

## FMEA (Failure Mode and Effects Analysis)

**Identify** and **prevent** known and potential **problems** from reaching the consumer FMEA focuses on four aspects of potential failure: what could go wrong? How serious is it? How often could it go wrong? And what is the probability of timely discovery?

**Indentify phase**

Brainstorm with team and find opportunities of improvement. Then sketches out the process in a block diagram or flowchart.

**Analyse phase**

Start the analyse phase by prioritizing the known or potential failures. Following by gather data about these specific failures and fill in the FMEA form. From the analysis fill in the results for **Severity, Occurance, and Detection**

**Control phase**

Confirm/ measure/ evaluate the success or fail, so is the situation better, the same or worse than before?

**Strengths**

It focusses on preventing instead of fire fighting when a problem occurs

**Limitations**

FMEA is a more a potential failure analyses method than change management

Directed Change

## The Kübler-Ross change curve

Kübler-Ross is known for the five stages of grief. This seems excessive, however, is the change management is a directed change (meaning top-down) then there is little interaction from users/employees that need to deal with change. Meaning that there will be some kind of loss during change.

**Denial**

**Anger**

**Bargaining**

**Depression**

**Acceptance**

The update is released and users respond with surprise, shock, theories it may be a glitch or some other temporary change. - Denial

Some very vocal users take to social media to protest the change and criticize the company. - Anger

These angry users will lodge complaints and/or start petitions in the hopes of pressuring the company to revert to the old setup. - Bargaining

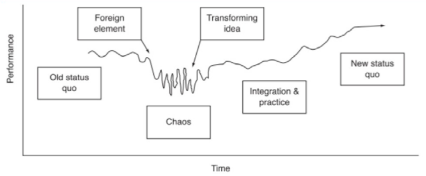
When the company doesn't respond those previously angry users experience a sort of sadness and rejection. Their app isn't the same anymore. - Despression

While typically continuing to use the app throughout this process, those same users have slowly gotten used to the new (imptoved) UI. - Acceptance

## The Satir change model

The Satir model originates from the family therapy background. The model has several stages and two primary events.

**Foreign element**




The first event is that a foreign element enters a mostly stable situation, this being change. This is followed by a period of choas with emtions like panic, disbelief or denial.

**Transforming idea**

After the choas phase with different emotional stages, the individual create a form of acceptance. There is still work to do before really accepting the new reality. However, this transforming idea helps form the new status quo. This is not a given, since there has to be planned with clear communication and intergration.

## Bullock and Batten model

This model describes theid planned change phases. The four phases are exploration, planning, action, and integration

**Exploration**

In the exploration phase a need for change is established. Moreover, additional resources for this change will be obtained.

**Planning**

In the planning phase, the key decision makers and the required technical expert will be involved. The change activities are planned within the change plan.

**Action**

Before any action can take place, the plan needs to be signed off by management. Within this phase the plan will move forward with feedback loops in place to allow replanning to take place if plans do not go according to plan.

**Integration**

After completing the change plan, the integration phase will take place. In this pahse the change will be integration throughout the organisation and structure are put in place to cement the change in place (policies, rewards etc)

**Limitations**

Sees change management as a technical problem that only holds up in isolated instances of change management

## Kotter's theory

**Establish a sense of urgency**

Consider today's challenges and envision potential future scenario's

**Form a powerful guiding coalition**

This coalition needs to work well together

**Create a vision**

A vision to guide the change and how to achieve this change through strategies

**Communicate the vision**

Communicate at least 10 times more than you think in a variety of ways including the corresponding vision and strategies

**Empower others to act on the vision**

Allow people to experiment and minimize barriers for the change

**Plan for and create short-term wins**

Look for low hanging fruit ,advertise and reward these short-term wins

**Consolidate improvements and produce still more change**

Promote and reward advancing change, and add new aspects to the change like projects & resources to motive continue the change and

**Institutionalize new approaches**

At this point everybody should understand the new behaviours

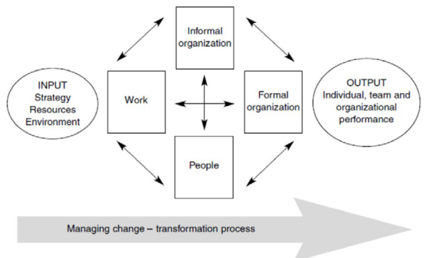
## Beckhard and Harris

$$C = [ABD] > X$$

C = Change
A = Level of dissatisfaction with the status quo
B = Desirability of the proposed change or end state
D = Practicality of the change (minimal risk and disruption)
X = 'Cost' of changing

The formula is also written as A*B*D>X, this implies that the seperate components can't be near zero. If so, the left side of the equation would be near zero as well. These aspects need to become aware within the organisation and this can be done through designing interventions.

## Nadler and Tushman congruence model




All components are dependen on each other.
**Informal organization**: unplanned and unwritten activities overtime
**Formal organization:** the structures and systems within the organization
**People:** The skills and characteristics of the people
**Work:** The day-to day activities that are carried out

Because these componenets are dependent, changing one aspect means check up on the remaining three. If not, this can cause low congruence, which can cause resistance, control and power issues.

## Cycle of Change

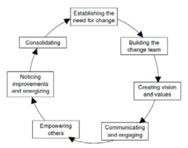



**Figure 3.3** Cycle of change
*Source:* Cameron Change Consultancy Ltd

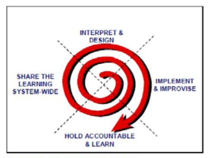



**Figure 3. The Guided Changing Spiral**
*Source*: Kerber (2001)

**Continues circle of change derived from Kotter's theory**

**Guided changing alternative to the three steps from Lewin**

## Bridges' transition model

Bridge seperates planned change from transition. He explains it as planned change is the activity (functional) and the transition is what comes behind it (psychological). Transition is emotionally dealing with the change instead of the change itself.

**Ending**

Identify who is losing what, because with every change someone is losing something. Expect a reaction from them and acknowledge this reaction openly.

**Neutral zone**

In the neutral zone, the people will lose motivation and feel unsettled. This zone needs to be acknowledge and that it is part of the process. During this time managers need to check in more often and apply more structure where needed.

**New beginning**

As it states that beginnings can be planned, Bridges does suggest a structure to them. Give people the purpose behind the change, a picture how the organization will/might look like, a plan on how to get there, and the part they play in the outcome.

The beginning is achieved when they are emotionally devoted to doing something in the changed way

## The McKinsey 7-S model

As with the Nadler and Tushman model, the McKinsey model also views the organization as a system where components are connected and depent on each other. This model can serve as a checklist for aspects that need to be altered when dealing with change:

**Staff**

**Skills**

**Systems**

**Style**

**Shared values**

**Strategy**

**Structure**


## The 5 goals ADKAR

The ADKAR model is a framework to increase the chances of successfully implement change on an individual level. The model has five elements and all five elements must covered to realize change.

**Awareness**

This elements entails the individual understanding of the nature of the change, the risk of not changing, and why the change is made. This includes internal and external drivers.

**Desire**

The second element describes the willingness to change and the willingness of participation. This is on the individual level so including intrinsic motivations that differ per person.

**Knowledge**

Third element is the knowledge needed for this change. This can be skills, systems, processes, training in order to implement the change

**Ability**

The fourth element is transforming the knowledge towards action. This entails implement the change on the determined performance.

**Reinforcement**

The last element represent the factors that maintain the change. This includes internal like satisfaction and external like rewards.

## Carnall, change management model

Carnall describes his model as effective management and focusses on management skill. Through three management skills, it will be able to create an environment for creativity, risk-taking and the rebuilding of self-esteem and performance. Which in turn will result in organizational changing and learning The three skills are:

managing **transitions** effectively
dealing with **organizational cultures**
managing **organizational politics**

## Senge et al: systemic model

Senge et al does not provide a concrete approach, it describes ideas and suggestions. It differs from other change management model, because they start with the challenges of first introduction, move to sustaining, and finally redesigning the change. Therefore they suggest to start small and grow steadily, and don't plan the entire change.

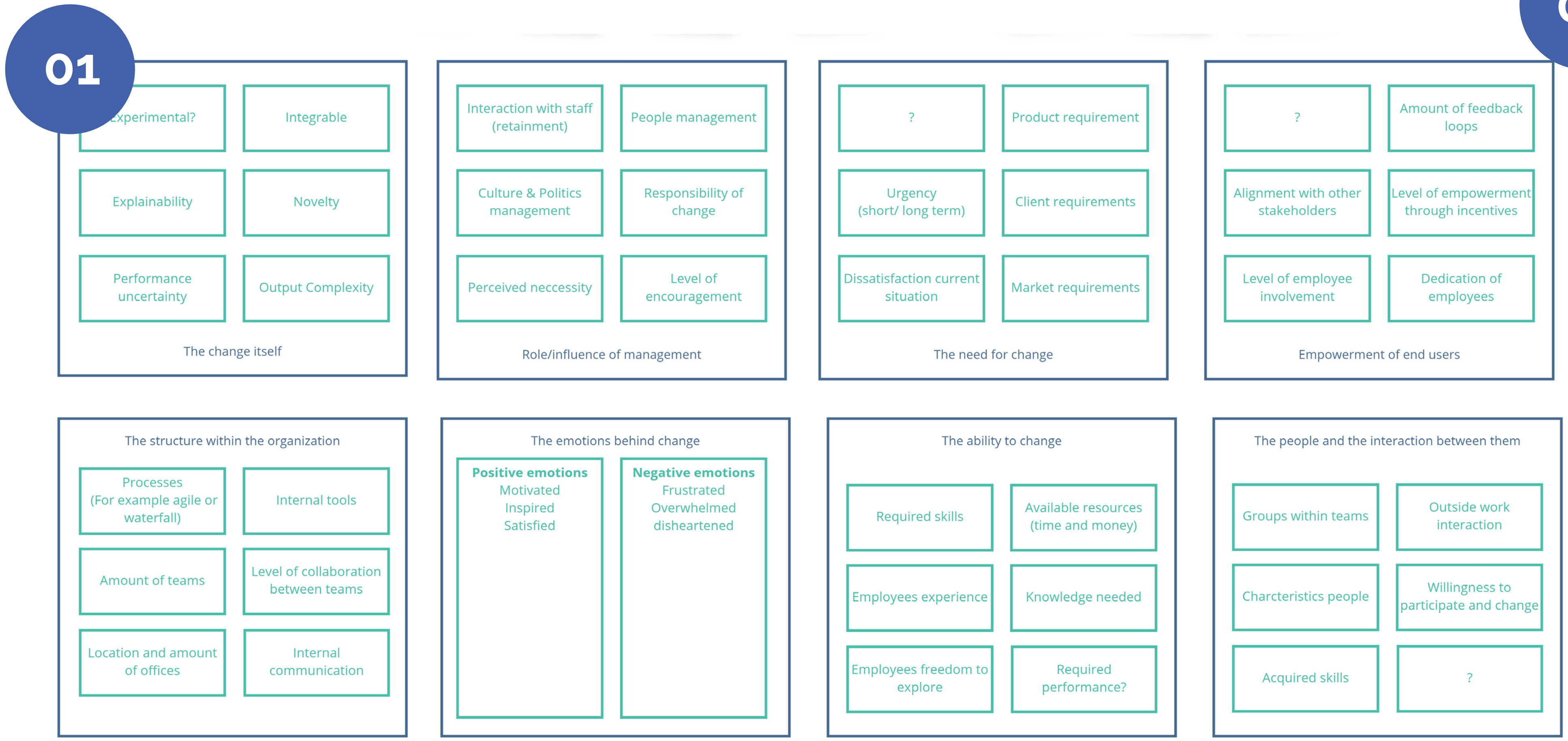
They focus on the key challenges that arise within a group that is changing their behaviour, when sustaining the behaviour, and scaling the change.

## Stacey and Shaw, complex responsive processes

They view change as something that will develop naturally with clean communication, conflict and tension. Moreover that a manager is part of the system and is nog performing outside of it.

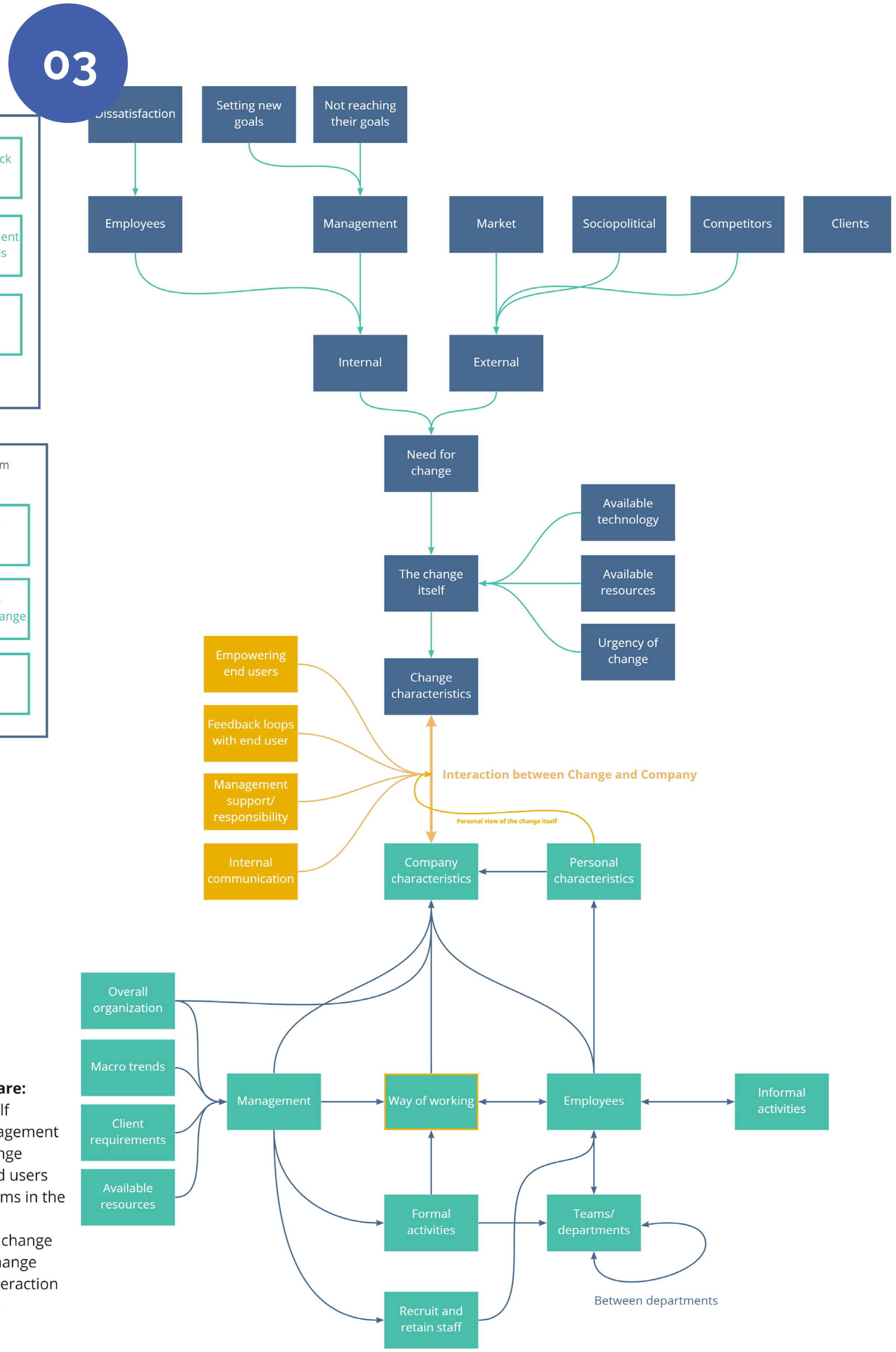
It deals with the challenge that the interactions within the change management plan with evolve over time and there is no way to control or plan everything regarding the change.

# Appendix C - Change management models analysis





**The eight themes are:**
1. The change itself
2. Role/influence of management
3. The need for change
4. Empowerment of end users
5. The structure and systems in the organization
6. The emotions behind change
7. The possibility to change
8. The people and the interaction between them



# Appendix D - Operator surveys on production line

## 3rd Factory visit - 28-10-2021

### Operators vragenlijst

Deze vragenlijst maakt onderdeel uit van een onderzoek vanuit de TU Delft. Dit onderzoek analyseert de implementatie, adoptie en integratie van nieuwe digitale hulpmiddelen op de productie lijn.

Deze vragenlijst zal op twee momenten afgenomen worden, vandaag is het eerste moment en over enkele maanden zal het tweede moment plaats vinden. Hiervoor is een deelnemer ID, zodat de resultaten vergeleken kunnen worden per deelnemer. De data zal anoniem zijn en alleen de onderzoeker heeft toegang tot de deelnemer IDs.

Daarnaast zal alleen het onderzoeksteam toegang hebben tot de data en zal er niks zonder toestemming gedeeld worden met Diversey. De conclusies en inzichten zullen gebruikt worden voor een thesis report. Al je na de vragenlijst vragen hebt of je wilt je antwoorden intrekken, dan kan je een mail sturen naar A.J.Verhoeven tudelft.nl

In de onderstaande vraag kun je aangeven of je toestemt met de beschreven voorwaarden.

Alvast bedankt voor je bijdrage!

* Vereist

1. Ik geef vrijwillig mijn toestemming om aan dit onderzoek deel te nemen, begrijp dat ik kan weigeren vragen te beantwoorden en dat ik op elk moment mezelf terug kan trekken uit het onderzoek zonder dat ik daarvoor een reden moet opgeven *

○ Toestemming geven

○

2. Graag hier je deelnemer ID invullen *

[ ]

3. De volgende vragen gaan over ODCE, heb je ODCE eerder gebruikt? *

○ Ja

○ Nee

4. Helaas is er toestemming en ervaring met ODCE nodig voor dit onderzoek *

○ Begrijp het

5. Ik ben het eens met de volgende uitspraken

| | Volledig mee eens | Sterk mee eens | Enigszins mee eens | Neutraal | Enigszins oneens | Sterk oneens | Volledig oneens |
|---|---|---|---|---|---|---|---|
| Ik ervaar de voordelen van ODCE voor mezelf | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Ik ervaar de voordelen van ODCE voor Diversey | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

6. Wat voor voordelen ervaar je?

○ Geen

○ Herinneringen van taken

○ Overzichtelijk

○ Efficientie

○ [ ] Andere

7. Graag je voordelen toelichten

[ ]

8. Ik ben het eens met de volgende uitspraken

| | Volledig mee eens | Sterk mee eens | Enigszins mee eens | Neutraal | Enigszins oneens | Sterk oneens | Volledig oneens |
|---|---|---|---|---|---|---|---|
| Ik ontvang de voordelen van ODCE met minimale moeite | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| ODCE is gemakkelijk te gebruiken | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| De tijd dat nodig is om ODCE in te vullen is passend | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

### COALA

COALA is een stem gestuurde kunstmatige intelligentie (AI), dit betekent dat je bepaalde gesprekken kan voeren met COALA met behulp van een headset. Een voorbeeld zou zijn dat je een probleem hebt op de productie zijn en dit meldt aan COALA. COALA stelt je gerichte vragen om het probleem te melden, eventuele oplossingen voor te stellen en/of mogelijke oorzaken te concluderen.

COALA zal niet in één keer perfecte antwoorden kunnen geven of vragen kunnen stellen, maar over tijd zal COALA leren en verbeteren.

9. Hoe zou jij een kunstmatig intelligent hulpmiddel zoals COALA zien?

○ Collega

○ Kind

○ Toezichthouder

○ Huisdier

○ Assistent

○ Stagiair

○ [ ] Andere

10. Graag je antwoord toelichten

[ ]

11. Ik ben het eens met de volgende uitspraken

| | Volledig mee eens | Sterk mee eens | Enigszins mee eens | Neutraal | Enigszins oneens | Sterk oneens | Volledig oneens |
|---|---|---|---|---|---|---|---|
| Ik zie voordelen van COALA voor mijn werk op de productie lijn | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Ik sta open om met kunstmatige intelligentie zoals COALA te werken | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Ik denk dat ik genoeg kennis heb om met kunstmatige intelligentie zoals COALA te werken | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Met de huidige manier van werken (omgeving, tijd en taken) kan ik leren om met COALA te werken | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Ik zal COALA blijven gebruiken omdat de voordelen voldoening geven | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Ik zal COALA alleen blijven gebruiken als er extra voordelen zijn | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

12. Maak jij je zorgen om met kunstmatige intelligentie (AI) te werken?

○ Ja

○ Nee

13. Wat zijn jouw zorgen?

☐ Gebrek aan ervaring met kunstmatige intelligentie (AI)

☐ Afhankelijk worden van kunstmatige intelligentie (AI)

☐ Kunstmatige intelligentie (AI) kunnen vertrouwen

☐ Persoonlijke veiligheid

☐ Werk onzekerheid in de toekomst

☐ [ ] Andere

14. Wat zijn jouw taken op een gemiddelde dag?

[ ]

15. Ik ben het eens met de volgende uitspraken

| | Volledig mee eens | Sterk mee eens | Enigszins mee eens | Neutraal | Enigszins oneens | Sterk oneens | Volledig oneens |
|---|---|---|---|---|---|---|---|
| Met behulp van COALA, zal ik deze taken beter kunnen uit voeren | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Met behulp van COALA, kan ik tijd besparen | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Met behulp van COALA, kan ik deze taken effectiever uitvoeren | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Met behulp van COALA, kan ik deze taken gemakkelijker uitvoeren | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| COALA zal nuttig zijn bij de uitvoering van deze taken | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

16. Op een normale dag tijdens een probleem op de productie lijn wordt er door COALA gevraagd voor een beschrijving van het probleem, het betrokken product en de locatie van het probleem. Zou je COALA beantwoorden?

○ Nee, dit helpt mij niet met mijn taken

○ Ja, dit helpt Diversey

○ Ja, als ik hiervoor de tijd kreeg

○ Nee, hier heb ik geen tijd voor

○ Ja, dit helpt mij met mijn taken

○ Nee, ik wil eerst het probleem oplossen

○ [ ] Andere

17. Wil je nog iets vertellen met betrekking tot ODCE, kunstmatige intelligentie (AI) of COALA?

[ ]

## 5th Factory visit - 06-01-2022

### Behoeftes digitaal hulpmiddel

**Voor het onderzoek van de TU Delft zijn wij op zoek naar hoe wij de productie het beste kunnen ondersteunen. Nu en in de toekomst worden hulpmiddelen om gegevens en instructies te automatiseren en aan te bieden steeds meer gebruikt. We willen graag onderzoeken welke gegevens het beste bij jullie als operators of ondersteunende medewerkers gepresenteerd kunnen worden om productie te ondersteunen. Om dit te kunnen doen zijn wij benieuwd naar de aspecten waarbij jullie het liefst ondersteuning ontvangen.**

**Daarom vinden wij het belangrijk dat jij betrokken bent bij het proces zodat jouw ideeën en zorgen meegenomen kunnen worden. Hiervoor is er een korte vragenlijst gemaakt (5 minuten) om jullie behoeftes anoniem in kaart te brengen.**

Voorwaarden van de data zijn hieronder beschreven:
*De behoeften zullen in kaart worden gebracht door een team aan de TU Delft en alleen dit team heeft direct toegang tot de data en zal alleen geanonimiseerd resultaten gebruiken. Het is een anonieme vragenlijst. Alleen als je direct betrokken wilt zijn met de ontwikkeling, dan kan je er voor kiezen om je naam te delen zodat je je antwoorden kan toelichten, als eerste het hulpmiddel kan testen en feedback kan geven.*
*Als je na de vragenlijst vragen hebt of je wilt je antwoorden intrekken, dan kan je een mail sturen naar Pim Verhoeven (A.J.Verhoeven@tudelft.nl)*

*In de onderstaande vraag kun je aangeven of je toestemt met de beschreven voorwaarden.*

* Vereist

1. Ik geef vrijwillig mijn toestemming om aan deze vragenlijst deel te nemen, begrijp dat ik kan weigeren vragen te beantwoorden en dat ik op elk moment mezelf terug kan trekken uit het onderzoek zonder dat ik daarvoor een reden moet opgeven *
   - ○ Toestemming geven
   - ○ Toestemming weigeren

2. **In welke situatie(s) zou je graag ondersteuning ontvangen?**
   - ☐ Stilstanden uitleggen aan technische dienst
   - ☐ Kennis delen met andere operators
   - ☐ Feedback ontvangen van andere operators
   - ☐ Uitdagingen op de productie lijn uitleggen aan management
   - ☐ Output van een gegeven dag toelichten
   - ☐ Uitdagingen op de productie lijn uitleggen aan andere operators

3. **Zijn er andere onderdelen van productie waarbij je ondersteuning zou willen ontvangen?**
   *(Hoeft niet digitaal specifiek te zijn)* *

4. Zou je je antwoord willen toelichten? (Optioneel)

5. **Welke aspecten zouden jou motiveren om een digitaal hulpmiddel te gebruiken?**
   *Als het hulpmiddel <vul jouw keuze(s) hierin>, dan zou ik gemotiveerd zijn om het hulpmiddel te gebruiken* *
   - ☐ erkenning en waardering duidelijk maakt
   - ☐ prestaties om trots op te zijn laat zien
   - ☐ de mogelijkheid geeft om te leren
   - ☐ mij zelfstandiger laten werken
   - ☐ gevarieerde taken mogelijk maakt
   - ☐ verbeteringen op de productie lijn mogelijk maakt
   - ☐ Andere

6. Zou je je antwoord willen toelichten? (Optioneel)

7. **Welk(e) inzicht(en) zou je graag willen zien in een digitaal hulpmiddel?** *
   - ☐ Output verschil per operator (Efficiëntie)
   - ☐ Output per productie lijn (Uptime)
   - ☐ Output groei over tijd (Leren over tijd)
   - ☐ Status stilstanden ten opzichte van lijn gemiddelde (positief/negatief)
   - ☐ Status ten opzichte van schema planning (positief/negatief)
   - ☐ Andere

8. Zou je je antwoord willen toelichten? (Optioneel)

9. **Zou je betrokken willen blijven bij de ontwikkeling van het digitale hulpmiddel?**
   *Noteer dan je gewenste emailadres hier beneden*

10. **Zijn er nog andere opmerkingen die je zou willen delen over de ontwikkeling van het digitale hulpmiddel?**



# Appendix E - Creative facilitation sessions

## Stakeholder mapping - 14-10-2021


**Move Stakeholders to the Map**

Understand how each stakeholder can help the team, how involved they should be and who to contact when things come up.

**Core Team**

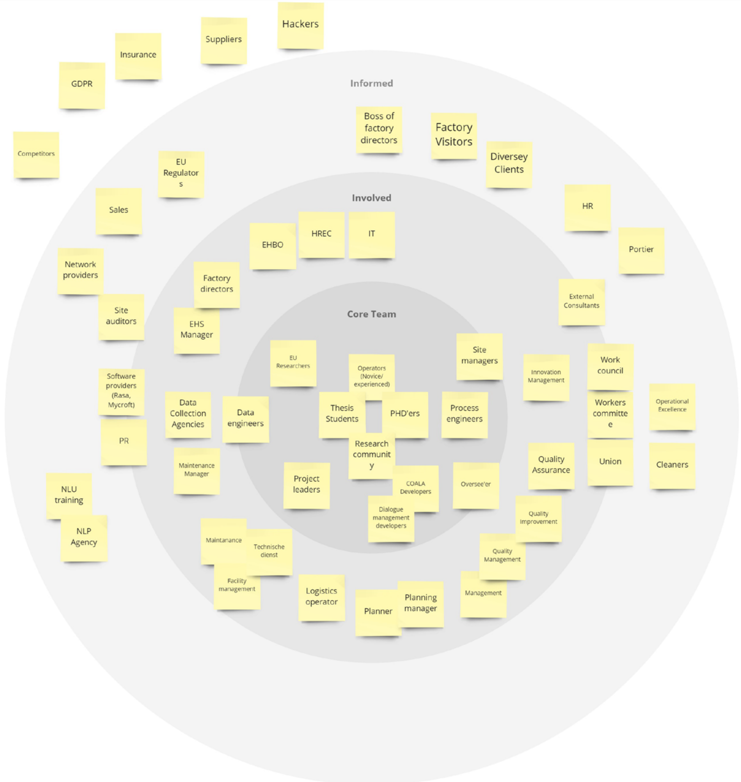
Full time on the project/team (e.g., PMs, engineers, designers)

**Involved**

Regularly providing input or helping to move work forward, but this project is not their sole focus

**Informed**

Wants to stay up to date and will provide feedback/input when necessary



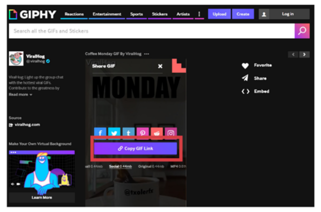

2

# Frame ideation COALA TU Delft team - 17-01-2022

### How are we feeling today?? *5 min*

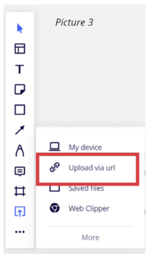
Go to https://giphy.com/ and find something that describes your Monday
1. Search a Gif that describes your mood today
2. Click 'share' and 'copy link' (picture 1)
3. Click upload in Miro (picture 2)
4. Click 'upload via url' (picture 3)

*Picture 1*




*Picture 2*

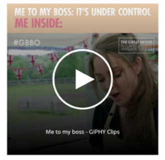
*Picture 3*

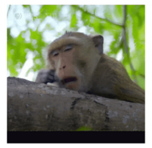



**Example:**

Not feeling it yet


Lets'Go!

The problem situation of this creative session is:
**"What AI features can we add to COALA that facilitate human centered manufacturing?"**

Human-Centered Manufacturing is the combination of the **strength, speed, repeatability and precision of automation** with the **intelligence, flexibility and skill of human operators**, aimed at obtaining hybrid systems with the highest potential in terms of both production process and human well-being in the workplace. Therfore reaching maximum suynergy between operators and intelligent systems

**What are the strengths of AI?**

*2 min*

- Explore hidden patterns
- Reason with evidence
- Quantitative proof of best practices
- Never forgets
- Can be everywhere at once and available 24/7
- Doesn't get tired, upset or impatient
- Can adapt to individuals
- Can help automate tasks without being programmed explicitly how to do so
- Can handle large volumes of data
- Can infer patterns that are not obvious to the human eye.

**What are the weaknesses of AI?**

*2 min*

- Lack of transparency about decisions and whys
- Good quality of input/data is required.
- May need some time and data before it can be applied
- It requires large sets of data
- Inability to adapt to exceptions
- Lack of data causes faulty AI
- The truth about today's AI: " It has a person somewhere in the loop, or the cost of failure, should the system blunder, is very low " (RODNEY BROOKS)
- Difficulty generalising knowledge
- Difficulty adapting behaviour to context and operators
- High initial investment needed
- Unreliable
- Challenges for user acceptance
- Potential ethical issues

**What are the strengths of operators?**

*2 min*

- Handle exceptional cases
- Generalise knowledge to new situations
- Can seamlessly use all senses when diagnosing problems (e.g., hearing, sight, touch)
- Can ask/call for help quickly
- Problem solving capability
- little data is needed for training
- Know what is needed to make their job better/faster
- They hold tacit knowledge
- Ability to adapt to similar issues
- They can tap on their empathy as an extra feedback loop when teaching a new colleague
- Experience with handling issues
- empirical approach

**What are the weaknesses of operators?**

*2 min*

- Not operating according to best practices
- Decision based on intuition and not on evidence
- Delegating responsibility to someone else
- unaware of valuable knowledge they may possess
- focused on quick fixes
- unreliable (long-term) memory
- not always motivated to improve the status quo
- They are constrained by their human nature (tired, bored, angry)
- Their interests do not always align with the interests of the management or the company
- They need to be onboarded / trained first
- It takes time to onboard them
- Can make mistakes (again)
- No medium to share their knowledge or experiences

**How to leverage or minimize certain strengths or weaknesses**
This can be specific AI models or features, but can also be something totally different

**How to ...... ?** Quantitative proof of best practices

*2 min*

- Box plot of the processes
- Keeping a check on the time taken for certain events
- Identifying the averages and the outliers
- Analysing the root cause
- Identify best practices by comparing KPIs between operators → Track the effect of best practices on KPIs
- Calculate context-aware KPIs → Track the effect of best practices on KPIs
- sequence analysis of actions
- Link with well-established and understood measures (e.g., performance, speed, errors)
- Test different approaches

**How to ...... ?** Never forgets / Can be everywhere at once and available 24/7

*2 min*

- Create structures (e.g., knowledge bases) that store and improve knowledge
- Use context-aware approaches
- Easily accessible on the production floor
- Effortless entry of data or events
- Be easily accessible (e.g., wake-words, one-touch activation on wearable)
- Support parallel (context-aware) interactions
- Manage knowledge over time and awareness of how "up to date" it is

**How to ...... ?** Lack of transparency about decisions and whys

*2 min*

- Try explainable approaches first before moving to black-boxing
- Operators should be able to challenge the decision of Cognitive assitant if needed
- Include the operator knowledge in AI
- Operators can suggest better solutions to COALA and it accepts
- Explainable AI models
- Explanations captured from operators
- Bias detection
- Shapley Values
- Explain actions
- Word questions/outputs in a way that provides informaiton/insights of it's "thinking" to users

**How to ...... ?** Generalise knowledge to new situations

*2 min*

- Categorise the data
- Process engineering SOP
- Document experiences
- Context awareness → Share knowledge/info about similar situations
- Explain predictions of AI
- Transfer Learning
- Start with pre-trained models (hugging face)
- Use diverse datasets

**How to ...... ?** They can tap on their empathy as an extra feedback loop when teaching a new colleague

*2 min*

- Learning/teaching in context
- Develop techniques that incorporate user feedback
- Use additional / novel data (e.g., facial expressions, human movement)
- Human-in-the-loop approaches
- adapt AI to different learning approaches / novice needs

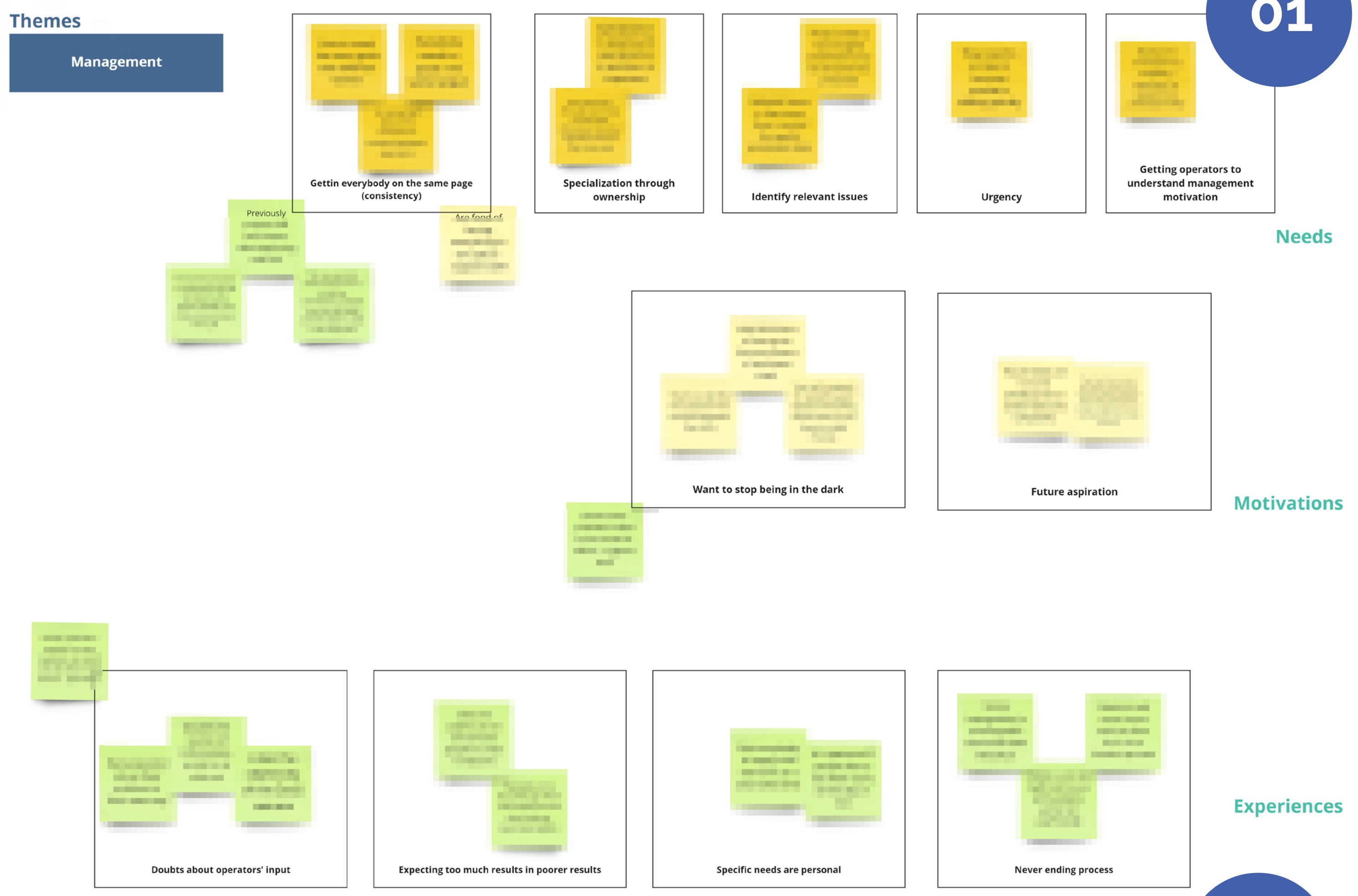
**How to ...... ?** unaware of valuable knowledge they may possess

*2 min*

- A database of the knowledge
- Organised flowchart of events
- Experience sharing sessions
- Sharing the production and issues data with operators
- Encourage them to document newly acquired knowledge (e.g., diaries)
- Engage in explanations in context by COALA, when issue appears ask for explanation and solution
- Establish policies that reward operators that contribute to knowledge-base systems (e.g., achievements)
- Make it easy for users to document thoughts / ideas for future reference
- identify moments of best practices → ask explorative/open questions about how/why operators did something

# Appendix F - Theme analysis steps

*Snippets are blurred for privacy reasons*






# Appendix G - The full Technology Acceptance Model