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The success factors of cobotics implementation in facilities management

Belin Güngör

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Supervisors

1st: Dr. R. Harms

2nd: Dr. M. Goethner

University of Twente

P.O.Box 217

7500 AE Enschede

The Netherlands

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Abstract

Collaborative robotics, commonly referred to as cobots, have gained widespread adoption across diverse industries, including the domain of facilities management. Companies are looking at ways to implement cobotics without previously having the experience, nor references in doing so. This study seeks to analyse the success factors associated with the integration of cobotics in a facilities management company, that has demonstrated proficiency in its implementation.

The research is structured around the stages of decision-making, implementation, and operation, examining each phase from the perspectives of the human operator, operational system, cobot, and the organisational context. Through this focused exploration, the study uncovers crucial factors integral to the successful implementation of cobotics. The findings contribute practical insights that are particularly relevant for companies, specifically those in facilities management, contemplating the adoption of collaborative robotics.

Keywords: industry 4.0, industry 5.0, robotics, cobotics, facilities management, success factors, change management, technology implementation

Abbreviations

BIM = Building Information Modelling

BMI = Business Model Innovation

BM = Business Model

FM = Facilities Management

IoT = Internet of Things

ROI = Return On Investment

RPA = Robotic Process Automation

Key terms

Cobotics

Cobotics, also known as collaborative robotics, refers to the use of robots and humans working together in a shared environment. This can include both direct physical interaction between the human and robot, as well as more indirect forms of collaboration such as the sharing of information. The goal of cobotics is to enhance the capabilities of both the human and robot in order to improve efficiency, safety, and overall performance (Hentout et al., 2019).

Technology Implementation:

Technology implementation is the process of introducing and integrating new technology into an organisation or system. The process includes identifying a need for new technology, evaluating different options, selecting the best solution and deploying and integrating the technology into the existing system. The success of the technology implementation process depends on several factors such as but not limited to, including the organisation's readiness to change, the quality of the technology and the effectiveness of the implementation plan (Salanova et al., 2004). Furthermore, the process of implementation can be broken into multiple phases: decision phase, implementation and operation phase, to better understand the stage of organisational implementation and viewed from multiple perspectives: human operator, cobot, working system and enterprise (Kopp et al., 2020)

Implementation success factors:

Technology implementation success factors refer to the key elements that contribute to the successful implementation of a new technology within an organisation. A successful technology implementation is the successful incorporation of new technology within an organisation, which can be determined by the achievement of project goals and objectives, such as meeting deadlines and budget, achieving the desired results and benefits for the business, and providing appropriate training and support for users to utilise the technology effectively. Additionally, factors like effective communication, proficient project management, user participation and acceptance, and a well-defined plan for post-implementation maintenance can contribute to the success of the technology implementation (Bessant & Tidd, 2015).

1. Introduction

The robotics revolution has touched nearly all industries, from healthcare to social work, and now facilities management is falling under the automation hammer.
Major technological advancements (Wong et al., 2018) coupled with a global pandemic, the facilities management industry, a service sector requiring human intervention, inevitably became a hot spot for disruptive technologies, to not innovate, but stay afloat during demanding market conditions. Circumstances in the recent years have caused major shifts, and therefore becoming an intriguing and insightful area of interest.

Facilities management, or FM, is a professional discipline, to ensure the management of built environments. FM involves coordinating building maintenance, overseeing space utilisation, managing utilities, implementing security measures, ensuring cleanliness, monitoring health and safety compliance, promoting environmental sustainability, and preparing for emergencies. Within this research the focus will be on cleanliness specifically as a sub-category of FM.
This sub-category of FM is a major pillar of European service industries, totalling a hefty 4.1 million individuals and 283,000 companies (European Cleaning and Facility Services Industry, 2020). The cleaning industry has amassed global attention, with skyrocketing health concerns and increased promotion of preventative measures to stop the spread of viruses. However, alongside these concerns, lockdowns created a unique blend of temporary job-loss, work-from-home culture, reduction of major commercial office spaces and still the need to maintain physical infrastructure, all of which creating turmoil in the FM market, which was confirmed in pre-research scoping.
These industry wide and global concerns created urgency for automation, to allow for FM companies to fulfil their contractual agreements. Technological investments were drawn into the robotics space, and disruptive solutions are now spreading across the industry. Examples of which are industrial sized robotic scrubbers and autonomous UV disinfectants which only marks the beginning of this blue-collar automation.

Although robotics in FM is still within its infancy, the adoption is showing to be successful and certain key companies within the industry are in the midst of their implementation processes and moving into operational phases. Ultimately, this industry, in combination with robotics, provides a unique opportunity to understand what has happened so far, what triggered these recent developments and how early adopters are successfully adapting and adopting technologies to help them to not only stay afloat, but to be pioneers within the market.

Additionally, the current research on collaborative robotics in facilities management is also in its infancy, therefore this research will build upon the existing literature. This work shines light on factors driving successful implementation, which allows for further research to have a stronger fundamental understanding of this process on an academic level. Currently, FM has been neglected in the collaborative robotics academic realm, unlike other major industries such as the manufacturing industries, healthcare, construction, military and agriculture (Ohio university, 2018; Distrelec, 2019). With the assistance of a real-life case study of collaborative robotics implementation, the success factors of this case study are retrospectively analysed and adapted to the existing works within academia.

The framework selected for this study proposes that the implementation process for cobotics (Kopp et al., 2020) is split on a chronological scale, decision phase, implementation phase and operation phase, divided by four elements: human operator, cobot, working system and enterprise. It is believed that there are certain key success factors within each of the phases for each of the perspectives.

The research on which the framework was based, was primarily using data from companies within manufacturing, therefore collaborative manufacturing robotics, however, it is assumed that facilities management will have wider similarities but also key differences in which factors are considered crucial to implement cobotics.

This framework will be the fundamental basis for the research, assumptions and questions, however data from the outcome is then used to build upon and shape the existing framework to better suit the academic understanding of success factor implementation within faciltiites management.

Research question

What are success factors within the implementation process of collaborative robots in a facilities management company?

The goal of the research is to understand the process of technology implementation that occurred at a facilities management company when implementing cobotics and understand how the success factors (Kopp et al., 2020) played a role in this implementation process. The framework, its phases (decision, implementation and decision) and perspectives (human operator, working system, cobot and enterprise) is expanded and built upon specifically with a focus on the FM industry and the success factors that were most relevant in this case.

2. Background

2.1 Industry 4.0 and 5.0

The influence of robotics and technological advancements both today and in the past have found place within widespread industrial shifts. Historically, industrial revolutions have taken place, redefining industrial performance levels by not only drastically altering the way products are produced, but also the degree of efficiency and productivity in value creation (Wichmann et al., 2019). Stemming from steam power, Industry 1.0, where the nineteenth century was transported to a more modern era. During Industry 1.0, focus was placed on human labour in industry and agriculture. Followed by Industry 2.0, characterised by electricity and mechanical advancements. Industry 3.0 showed an advancement between the years 1980 and 2000 where product life cycles were cut down and high amounts of digitalisation were implemented (Aslam et al., 2020). In recent times, the rise of Industry 4.0 has been triggered by market expansion, internationalization, global competition, and significant technological advancements (Cordes & Stacey, 2017). 4.0 is synonymous with IoT, Big Data, cloud computing, and artificial intelligence (Yin et al., 2017). Parallel to these advancements, approximately around the year 2016, ideas and developments in the realm of digital smart society, virtual spaces, robots, augmented reality and a greater focus, not only on connectivity between systems but the centrality of the human within the production; increased human-machine interaction (Özkeser, 2018). This is notably the main difference between Industry 4.0 and Industry 5.0: human centrality. According to Directorate-General for Research and Innovation 2021, Industry 5.0 complements 4.0, by putting research focus on transitioning to a sustainable, human-centric, resilient industry.

Being that Industry 4.0 is the foundation of Industry 5.0, and is still ongoing, one must take both into account simultaneously. Both industrial shifts include the importance of robotics, however with one more focus on cobotting; the synergy of human and robot. The term Industry 4.0 was first coined in Germany around 2011, when new, high-tech strategies were proposed (Mosconi, 2015). Since 2011 the term has shifted throughout all realms of engineering and management domains, gaining the attention of economic and management academics. According to Pan et al., 2015, the implementation and possible future developments deserve more attention. 4.0 influences globally how business processes and dynamics take place, and the structures of firms' business models (Piccarozzi et al., 2018): it comprises the entire value chain. It is seen by Gerlitz, 2016, as a tool to increase competitiveness, pointing to the value it brings to the development and strength of firms. However, with the introduction of high-tech solutions, issues of implementation arise. Assessing the works of Wichmann et al., (2019), a plethora of issues are brought to light.

With a literature review, Wichmann et al., (2019) summarised common issues of implementation being “how-to” implement, increased complexity, standardisation efforts, security and privacy, expensive investment, interfacing systems, and promise of employability. One of the major issues, security and privacy stem from the nature of the technologies, for example, IoT. Data sharing can be seen as a driver for innovation and operations performance, but some industries are adverse to such transparency due to privacy and security issues. Focus has been given to creating networks which are both identifiable service providers and safe from unauthorised exploitation and mal-intent.
Furthermore, another major issue is the human aspect. With automation and digitalisation, the human aspect has become redundant in certain tasks. Routine work especially has been the target of businesses, as repetitive work can be automated. In light of this, employees engaged in these responsibilities must redirect their focus toward tasks that demand different skills, including adaptable problem-solving, creativity, and strategic development, spanning various fields.

Vitali et al., (2017) claims that the advancements of 4.0 are rapidly increasing, giving birth to the next industrial revolution; 5.0. The previously stated issue of human-centric technology becomes less of an issue, as this is one of the focal ideas of 5.0. The European Economic and Social Committee (2018), states “While some see Industry 4.0 as wasting human problem-solving skills, value-adding human creativity, and the critical and exclusively human ability to deeply understand customers, Industry 5.0 is focused on combining human beings' creativity and craftsmanship with the speed, productivity and consistency of robots. Industry 5.0 means to better appreciate the cooperation between robotics and human beings by combining their diverging strengths, in order to create a more inclusive and human-centred future.” Although early days, it is known that industry 5.0 will disrupt business models and break the barriers between the real world and the virtual world (Aslam et al., 2020).

2.1.1 Cleanliness and FM

The research centers on facilities management, an industry defined as the function that harmonizes people, place, and processes. Its primary objective is to enhance the quality of life within the built environment, enabling businesses to concentrate on their core competencies (Patanaoiradej, 2019). The International Facility Management Association (IFMA, 2022) defines FM as “a profession that encompasses multiple disciplines to ensure functionality, comfort, safety and efficiency of the built environment by integrating people, place, process and technology.”. These disciplines include but are not limited to safety, security, cleaning and building management.

A crucial yet frequently underestimated aspect of office and facility management involves cleaning and maintenance (Ens, 2021). The cleaning and facilities sector is one of the major pillars of the European service industries, consisting of over 283,000 companies and 4.1 million individuals. (European Cleaning and Facility Services Industry, 2020). Especially since the COVID-19 pandemic, the need for high-quality sanitation has increased. The expectation that customers place on cleanliness has also increased, therefore cleaning has moved past appearance, but instead, must be conducted properly. Some of the major players within the facilities management firms include Sodexo, CBRE and ISS.

Since the pandemic, commercial cleaning has been considered an essential industry. Since the reopening of company doors, external companies are often hired to maintain high sanitation standards for staff and customers, allowing for the businesses to focus on their internal regular business processes. With the increase in quality and quantity of cleaning expectations, the facilities companies must maintain high standards, high levels of training, and a committed workforce to perform these tasks on a daily basis, leading to the absolute need to streamline work and be as fast and efficient as possible (Partner Solutions Facility Services, 2022).

According to (Bensi, n.d.), even before the global pandemic, the FM industry was dealing with severe challenges and tight margins due to pressure from the client side in need to innovate and perform. Contractors of the cleaning industry were facing a constant battle to recruit and manage high levels of absenteeism. This further pushed the need to innovate, and amplified the need to shift towards smart ways of working: agile and automated.

Research underscores a notable lack of confidence in innovation across various sectors of the industry, with 83% of FM leaders expressing concern that their innovative practices lag behind those of other companies. Additionally, 70% of supply-side organisations report mounting pressure from clients to showcase innovation (Bensi, n.d.). 81% of FM leaders reported they have failed to deliver on required outcomes in their innovation projects in the last two years. Various reasons for the lack of achievement were cited, spanning from technical complexity and a deficiency in the necessary skills and leadership within organisations to propel projects forward. About 34% of FM leaders believe that their efforts lacked an outcome-based or focused approach, while 30% attribute barriers to innovation within their organisation to high capital expenditure costs.

2.1.2 Industry 4.0 and 5.0 in FM

FM is directly influenced by the clients of the companies, and their expectations (O'Beirne, 2022). Aligning the need for streamlined processes, higher cleaning quality due to the pandemic, and the introduction of Industry 4.0 and 5.0, the facilities management industry has begun adopting robotics to assist in meeting the ever growing needs of the clients. Factors in the environment shape these client expectations, and how the facilities' services are delivered.

Factors such as culture, technological development, economic conditions, sustainability concerns, health and wellbeing, and global pandemics are highly influential. Technological advancements within FM can already be seen, with the implementation of intelligent and digital systems such as BIM, Building Information Modelling and robots (Okoro & Musonda, 2019).

An aspect of technological development, fitting with the 4th industrial revolution are IoT sensors within FM. IoT is a rapidly growing technology within FM, allowing for instant collection, transmission and exchange of data, through the use of sensors and access to the internet (Wong et al., 2018). Sensors can be utilised within large industrial spaces to assist in task performance, creating a smart, digital environment in which multiple indicators can be tracked. By combining IoT with FM, data can be collected such as employee performance, resource usage, customer satisfaction and other metrics to then shift decision-making processes from trial-and-error to a calculated process (Digiteum, 2019). A further technology which covers high-intensity repetitive tasks is disinfecting UV robots. UV disinfection robots not only take on the tedious task in large facilities but are able to perform their task to a higher quality degree, compared to their human counterparts. Robotics allows for facilities management to be automated through software-driven robotic process automation or RPA. An example of a robot which is highly beneficial on an industrial scale is a vacuum robot. Using artificial intelligence, mapping systems and built-in batteries, large-scale automated industrial cleaning can take place to provide a solution for a repetitive task performed by humans (Newton, 2022).

2.2 Cobots

The usage of robots in FM, especially cleaning robots have been coined the term “cobots” which fits in line with Industry 5.0. Cobots are defined as the collaboration between robot and worker, to take over repetitive, strenuous, tedious or even dangerous tasks; they support the worker and are both monitored and instructed by the employees. Higher skill labour, such as sanitisation, is then the focal point of the employees' work, rather than tasks such as large-scale heavy-duty vacuuming of industrial spaces. Overall, the cleaning robot takes on repetitive and time-consuming tasks, and increases overall quality through consistency and performance level, to allow for the human's time to be spent on higher value and variety of tasks. Further benefits of cobotting include increased performance, consistent service delivery, reduction in operational costs, enhanced organisational agility, and improved staff wellbeing and engagement (O'Beirne, 2022).

Furthermore, cobots play a crucial role in addressing a significant labor shortage. Market developments have contributed to a scarcity of skilled workers, particularly in highly industrialized nations such as Japan, the USA, and numerous European countries (McCarthy, 2019). Data shows that employee retention is one of the highest concerns for facilities managers (Statista, 2022), therefore many companies compete for appropriate personnel with the correct training by making the work more attractive. This consequently means that companies are also implementing technology to alleviate physically and mentally stressful tasks to increase work attractiveness and increase the company's reputation as an innovative employer (Kopp et al., 2020).

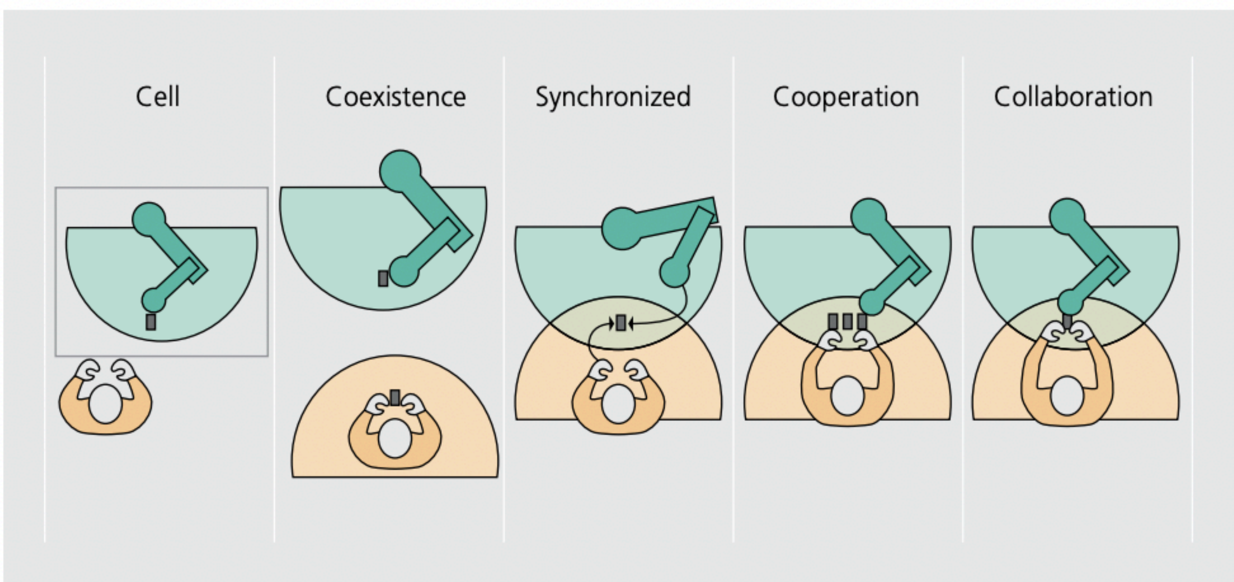

Figure 1 Various levels of cooperation between a human worker and robot (Bauer, 2016)

According to Bauer (2016), there are different levels of cobotting and ways of how the robots interact with the human with different degrees of collaboration which can be seen in figure 1. These levels are cell, coexistence, synchronised, cooperation and collaboration. Cell refers to no human-machine interaction, where the robot conducts tasks alone. Moving to the next level is coexistence, wherein the robot operates alongside the human operator. This is followed by the synchronized scenario, where both the operator and robot share the workspace, collaborating on the same component but not simultaneously executing tasks. The subsequent scenario is cooperation, where the robot and operator share the workspace, work simultaneously, but focus on separate components. The final stage is the collaborative level of human-machine interaction. Here, the operator and robot are working on the same component at the same time. These levels are described for industrial production robots, however, their human-robot interaction levels can be transferred to cobots in general.

2.2.1 Cobot challenges

Alongside a plethora of benefits, there are also challenges with the deployment of cobots. Challenges within the industry are connected to job displacement concerns, both on higher and lower levels of organisations, technology integration issues, investment requirements and lack of skills within the industry to work with the new systems. Cobotting does present a vast amount of benefits, but challenges are ever present.

One of these barriers, as mentioned by Eriksson and Mušić (2021), are being aware of the impact that cobotics have on the organisation both at high and low levels of the organisation. Without communication, the acceptance of the technology could be insufficient. Furthermore, importance should be placed on understanding the competencies of the personnel and addressing safety concerns. Research conducted by Kopp et al. (2020) reveals that overall themes of concern include occupational safety, fear of job loss, trust in the cobot and financial factors.

Other areas of concern surrounding cobots are relating to data security, as implementing new systems creates access points to data, and therefore more points of vulnerability. Furthermore, connection for effective cyber-communication is needed for high levels of reliability and stability, which can be difficult to achieve and maintain (Østergaard, 2018).

Another major challenge with implementing cobots is the steep economic investment required, versus the initial cost of human labour. Furthermore, the collaborative robot must be engineered in a way that makes sense for human behaviour, as the human input is a major aspect of the design. Cobots which are mobile or conduct movement must also be able to solve and execute the given paths or movement directions which are modifiable to adapt to the humans presence or change of environment. Moreover, the interface in which the human interacts with the robot must consider the skill level and knowledge of the operator (Bejarano et al., 2019).

When considering the implementation of cobots, the implementation strategy should be planned. Successful implementation can be achieved by dividing the tasks and stages into different segments to better target and reduce challenges and ease into the transition (Eriksson & Mušić, 2021).

2.2.2 Cobots in context

Cobots come in many forms for a variety of industries. The overarching similarity though is that they are robots which require collaborative human input to complete their tasks.

Industries in which robots as well as cobots have gained increasing traction are manufacturing industries, healthcare, construction, military, agriculture and also now facilities management. (Ohio university, 2018; Distrelec, 2019). Within each of these industries, different processes take place to solve different needs. For example, a medical collaborative robot may require finer movements versus robots in the car manufacturing plant. Within a car manufacturing plant, the item being worked on is moved through the plant to each station, to a robot with a new function, whereas a surgical robot may have multiple interchangeable attachments, where the patient is brought to the robot: mobility. Cobot's relationship with movement and its environment is therefore important to consider.

Each industry and situation requires specific configurations and skills when assessing which cobot is best suited. By definition, cobots are designed to work alongside humans, and therefore the way they interact with humans will also differ from industry to industry, even with their separate skills and abilities. For example, depending on the user skill level required, the interfaces to control the cobot will be created differently. A cleaner using a cleaning cobot will likely have a less technical and more user-friendly interface than a surgeon using a surgical cobot. In summary, the industry, environment, needs and users are all factors which are taken into consideration when designing, selecting and building a cobot.

In addition to the cobots characteristics, the business environment and how companies form around the technological systems must be taken into consideration. Operational workflow and business process optimisation allow for the cobots benefits to be fully taken into control, and for the company to correctly implement as well as use the cobot. According to Nauda and Hall (1991), businesses often are not clear in their direction and only loosely couple their goals with their actions in terms of technology implementation, as a result this technological investment may not achieve a clear competitive advantage. It is agreed upon that well-defined processes are industry and market specific, to correctly identify customer needs, competitive posture and resource allocation. Technologically strategic decisions should take into consideration the specific corporate and business environment factors for a successful deployment of technological investment (Nauda & Hall, 1991). In summary, the business and enterprise context, customer and employee needs as well as the specific cobots characteristics are of crucial importance when strategically planning implementation within the given industry.

2.3 Academic background

Within this literature review the research question will be deconstructed and key elements within the literature will be presented, being success factors and the process of implementation and how this change process can be managed.

As the goal of the research is to understand the implementation as well as the success factors within this process, existing literature can provide insight towards the general ideas found within academic research. Understanding the success factors of implementation requires the understanding of technological implementation processes, including the stages involved and perspectives within the process. Being that robotics or cobotics falls within technological advancements, a technological based implementation process is suited as a base for a framework to analyse the companies own process. Taking a deeper look into the literature gives an overview of existing frameworks, key papers and models which investigate the phenomena of implementation and attempt to create a model of reality as well as identification of mentioned stages and stakeholders in the process.

2.3.1 Success factors in the technology implementation process

Technology implementation is defined as the process of integrating a technology into a given system or organisation and the implementation process is highly dependent on both the solution and the organisation (Salanova et al., 2004). This process can include the training of users for the usage of the technology, as well as maintenance and support to ensure the technology continues to function effectively within the given organisation or system. Technology implementation occurs within various organisations and industries including but not limited to healthcare, education, manufacturing and government. It can involve the implementation of software hardware or a combination of both. The success factors of technology implementation depend on such factors like organisational readiness to change, the quality of the technology and the effectiveness of the implementation plan.

One of the key works in the field was proposed by Davis. In order to analyse the adoption and acceptability of new technology, Davis suggested the Technology Acceptance Model (TAM) in 1989. The model suggests that perceived usefulness (PU) and perceived ease of use (PEOU) are the two main criteria of success that impact users' acceptance of a technology. The term "perceived usefulness" describes how much a technology is thought to enhance user productivity or offer other concrete advantages. The degree to which a technology is seen to be simple to use or pick up refers to its perceived ease of use. TAM has been applied to a wide range of technologies and contexts since it was first created and has grown to become one of the most popular models for researching technology and acceptance (Yousafzai et al., 2007).

One of TAM's advantages is its simplicity which makes it simple to comprehend, use and apply. A wide variety of technology adoption behaviours, including the adoption of mobile devices, e-learning platforms, and electronic health records, have been explained by the concept. Over the years, a number of TAM expansions and modifications have been put forth. For instance, the Technology Acceptance Model 2 (TAM2), (Venkatesh and Davis, 2000) suggests a number of new components to the original model. The model has been modified by other researchers to include social aspects including peer influence and social norms. TAM has received criticism despite its widespread use. One of the primary criticisms is that it focuses too much on individual attitudes and behaviours and ignored more extensive social and organisational aspects that can affect technology adoption and acceptance.

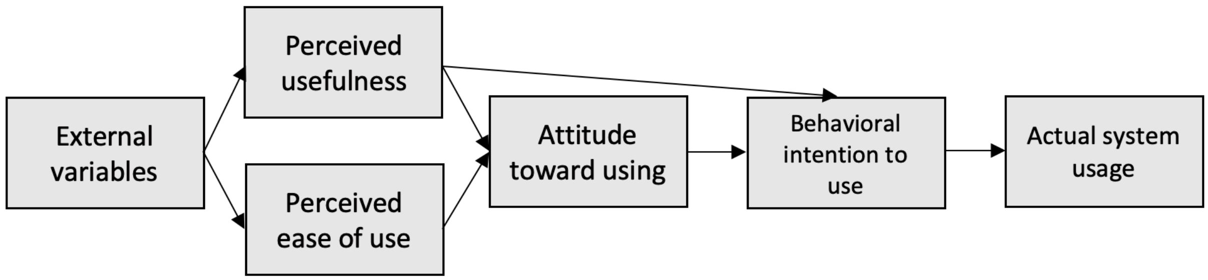

Figure 2 Technology Acceptance Model (Davis, 1989)

A further framework in the field with a focus on multiple success factors and phases of implementation is the framework proposed by Kopp et al. (2020). The framework presents success factors during the implementation process to introduce human-robot interaction within firms. With this research, the authors develop a practical implementation perspective of cobots and rank the importance of these success factors based on enterprise representatives' relative stated importance. The proposed success factors were developed through literature and empirical research with 81 German firms. The success factors for implementation were then divided into three phases and four essential components. The three phases represent the stages of cobotics implementation; the decision phase, implementation phase and operation phase. These stages relate then to the four components: the human operator, the cobot, the working system and the enterprise and context. The human operator level refers to the individual factors of the employee, who works with the robot.

The cobot component describes the functional system at hand. The two components, human and cobot work together, wherein effectiveness and efficiency are based on the combination of the skills and performance of their interaction. This working system is then found in the given environment or enterprise. This framework provides an insight into the success factors within each of these stages of implementation, from multiple perspectives, which provides a rigorous and structured view within implementation to increase the chances of success. Furthermore, The framework is also based on a literature review as well as through input of experts in the industry. This increases the credibility of the studies' foundation. Additionally, the framework is adaptable to multiple contexts and IT solutions.

The TAM framework takes a view of the implementation from the individual perspective, such as perceived ease of use and perceived usefulness. Organisational factors are not taken into account. The framework also ignores social factors and the relationship between actors in the given environment in which the implementation takes place. Furthermore, there is little to no indication of factors that influence the continued success of implementation post-adoption within the firm. Although the framework is widespread and well-known, there are shortcomings of the framework which do not align with the goal of the research. On the other hand, the framework proposed by Kopp et al. (2020), breaks down the process into multiple chronological phases and from multiple perspectives, which includes not only the individuals perspectives but also the enterprise as a whole and even takes into account the technology specifically and the characteristics of this system.

As a whole, the framework proposes a more in-depth, detailed and complex layout of the process which allows for a more realistic overview of the implementation process. Kopp's framework however also has its shortcomings. The model has not yet had widespread adoption within academia as its application is quite specific, therefore the application range is reduced heavily compared to the TAM counterpart. Furthermore, the framework was developed on a specific industry basis, which may not be applicable to most industries, such as healthcare or education for example. Both models see the implementation of technology as a process and consider success factors, however Kopp's model proposes a more in-depth focused view of the process including the perspectives of multiple stakeholders and the organisation as a whole, therefore this framework is most appropriate for the research at hand.

Taking a deeper look, the as divides the implementation process into three segments which can be seen in figure 3.

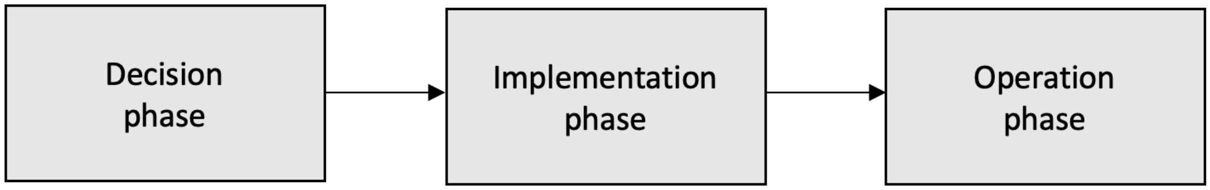

Figure 3 Three phases of the cobot introduction process (Kopp et al., 2020).

The horizontal graphic divides the chronology of the cobotics organisational implementation process. The first segment, the decision phase, refers to the assessment of the feasibility of a cobotics solution. Followed by the implementation phase, where the cobot's specifications are clarified. The final stage is the operation phase, where the cobot is brought into the organisation, monitored and evaluated on performance in its dedicated environment.

It is to be noted, that the three-stage process, in reality, may not be linear, and the separately defined segments are not mutually exclusive or separated. Moreover, the model is a simplification of reality. The authors state that the decision phase can be further sectioned into the idea and concept phase, exploration phase and actual decision phase.

Out of 81 participants for the study, thirty-eight (46.9%) have dealt with automation solutions, 16 (19.8%) with cobotics in particular, whereas twenty-one (25.9%) have had practical experience with implementing a cobot into their current or previous organisation. The participants ranked the importance of the success factors which were identified in the literature. The ranking scale is 1-5, whereas 1 = not important, and 5 = very important. In figure 4, one can see the division of the success factors between the aforementioned three phases, decision, implementation and operation, split further into the four components: human operator, cobot, working system and enterprise.

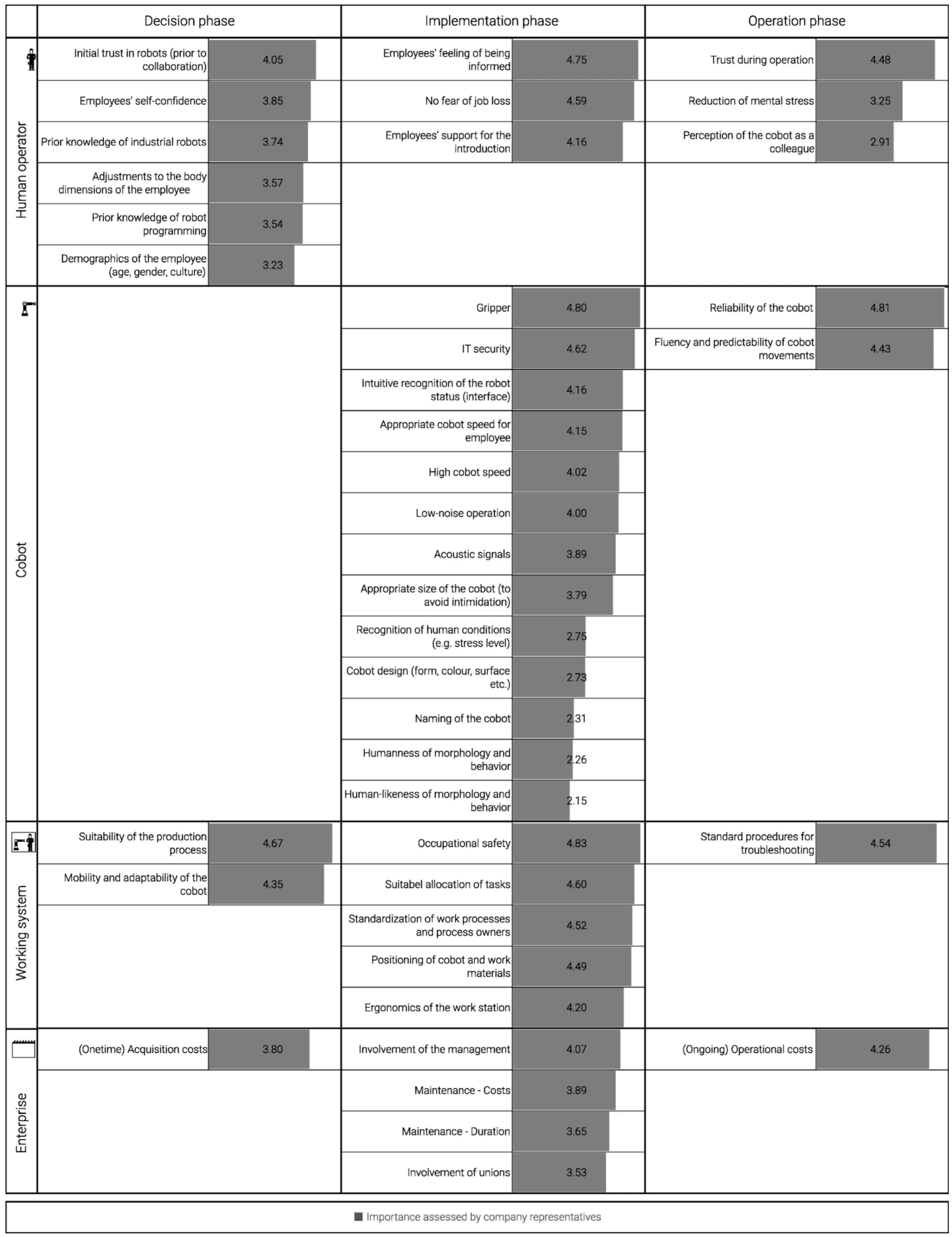

Figure 4 Success factors during cobotics implementation (Kopp et al., 2020)

Nr	Success factors mentioned in free text fields (clustered)	# of mentions
1	Financial aspects	89
2	Production flexibility	18
3	Handling and programming	18
4	Attractive working conditions	18
5	Working safety	18
6	Reliability and precision	11
7	Employee acceptance	11
8	Prior knowledge of the employees	10
9	Capacity utilisation	9
10	Compatibility with production infrastructure	9
11	Product quality	8
12	Production volume / batch size	7
13	Lead time	7
14	Maintenance	6
15	Innovative technology integrated	5
16	Preservation of jobs	4
17	Standardisation and troubleshooting	3

Figure 5 Success factors mentioned in free text (Kopp et al., 2020)

Further factors that were mentioned in the study are listed in figure 5. It is evident that financial factors are a commonly important factor within the cobotics implementation process.

Overall, the authors point out that the factors in the aforementioned phases of implementation are key to the successful integration of cobots. This framework is the basis for the success factors which will be used within the study. One characteristic of the framework's origin is that it is based on a cobot which bears different characteristics to the cobot in this study. The major differences are industrial context, cobot, mobility, design and tasks. The study mostly addresses stationary robots, whereas the cobots in facilities management are mobile. One of the factors within the framework is "gripper", referring to the gripping ability of the cobot. Therefore, the design differences between robots must be considered when assessing the importance of factors.

The overall industrial context plays a role in success factors, for example, during the preliminary interviews with experts in the FM industry, the client-service provider relationship was often mentioned, as well as the overall building layout and technological fit, some things which are not mentioned in the framework due to the context being the manufacturing industry.

The authors found that the success factors of the robot are largely independent of the company's goal wished to achieve with implementation, therefore the framework is widely generalisable, on the contrary, it has been discovered, there are underlying differences in multiple aspects which allows for the framework to be developed for the FM industry.
The manufacturing industry and the facilities management industry have both similarities and differences, which allows for overlapping and differentiating points, when assessing technology implementation within these industries.The FM industry operates as a service-based sector, distinct from manufacturing or production. Unlike industries that rely on the sale of tangible goods, service industries like FM do not center on the transactional exchange of products. Instead, value creation unfolds over an extended period within the framework of a long-term relationship between the supplier and the customer (Martinez et al., 2010). The value created within the service based industry is a process and intangible, whereas in the product based industry, the value is tangible (Shin et al., 2022).

The framework of success factors is based on a product-centric industry, versus facilities management which is service based, however the implementation of robotic systems both in a manufacturing plant and in facilities management is similar. According to research, manufacturing plants and the use of cobotics within them will allow for creation of a space with humans and robots working autonomously, shared decision making between robot and human, improved safety, health and productivity of the human worker (Evjemo et al., 2020). Although the industries may be different in their structure of value creation, the idea of innovation using robotics is a major overlapping point and provides similar business benefits and advancements therefore a framework which is able to summarise the success factors between industries is possible.

2.3.2 Change process management

Change management has many different definitions. One of which is "the process of continually renewing an organisation's direction, structure, and capabilities to serve the ever-changing needs of external and internal customers" (Moran and Brightman, 2001, p. 111).

Change within organisations is ever-present in multiple dimensions, including the operational and the strategic levels (Burnes, 2004). Another perspective on change takes the form of an organisational shift, "one state to the other", It can be seen that change within an organisation is favoured when external threats or shifts in the environment cause misalignment or lack of equilibrium in an organisation's pursuit to achieve its goals (Price & Chahal, 2006).

On the other hand, organisations in today's market are consistently pressured through external factors to adjust their internal structures, strategies, processes and technologies to not only thrive but to survive. Change is seen as a process, and not a single event in time. Therefore the study of change management aims to align the changes which encompass both individuals and groups within organisations through the practice of guiding management principles and ideas. Therefore, shining a light onto the current state of the organisation, as well as the intended future state, whilst creating clarity on the different factors that influence the organisation during the change process (Goff, 1994).

Although organisations undergo turbulence due to external factors in the environment, Burnes (1996) suggests that the organisation does not always need to adapt to these changes. Instead, the researchers advocate a selected and deliberate approach of choice. Research suggests that managers or organisational groups that choose to push forward a certain style of approach to change management should be able to choose how the change approach is conducted. Choice should prevail, rather than being forced to follow a strict set of practices.

Change within any organisation inherently creates instability, ambiguity and tension for those who are directly affected by the change. According to Carnall (2007) change encompasses five stages within the process: denial, defence, discard, adaptation and internalisation.

A finding from reviewing the literature is that, in order to implement the desired change and reach the desired future state, it is required that the culture of the organisation is altered, to allow for consistent change to be considered normal. This is a sign of an organisational culture which is ready and willing to change on a consistent basis. This culture is rooted deeply within an organisation's history, determined by the members who are a part of it and moulded over the course of the organisation's existence. Upon closer examination of the factors influencing organisational culture and its relationship with changes, several key elements were identified. These encompass professional identity, the emphasis on team versus individual dynamics, focus on people, integration of subunits, control mechanisms, attitudes towards risk and innovation, management of conflicts and diverse perspectives, means-ends orientation, and external focus (Robbins and DeCenzo, 2008).

A recent topic within the literature is the implementation of technology, specifically Industry 4.0 technology and change management practices surrounding this process. Although the organisational practices around the implementation are not exclusive to this specific technology, a literature review (Nayernia et al., 2022) dives deeper into the change management practices which enable industry 4.0. The study discussed the idea of reducing enterprise structures (Jerman et al., 2020) and leadership levels (Veile et al. 2019) to increase supervisory reach (Cimini et al. 2020). This emphasised the importance of leadership in managing digital transformations (Johansson et al., 2019; Vrchota et al., 2021). Furthermore, the distribution of structures that drives organisations to separate corportate departmenrs (Veile et al., 2019) to promote adaptability across units (Butt, 2020).
An analysis by Nayernia et al., (2022) found that there were studies revealing a gap in the literature, with a limited number of studies within change management focusing on value protection compared to those centred on value creation.

Besides established internal communication methods, group alignment appears to be influenced by the accessibility of knowledge (Salimon et al., 2019). Knowledge distribution can provide insights into performance improvement metrics (Robert et al., 2020) and facilitate the exchange of non-material assets like documents and software (Wagire et al., 2021). However, it is crucial to recognize the need for regulated resource sharing to reduce risks in cybersecurity (Raj et al., 2020).

In addition to studying the organisational structure, studies suggest that encouraging and developing an innovative cultural approach, as explained by Barata et al., (2019), significantly contributes to improving internal dynamics (Wagire et al., 2021; Bag et al., 2021). Focusing on promoting an innovative culture helps firms overcome social-cultural challenges more effectively (Kumar et al., 2021). An example of promoting organisational culture towards change is having a culture which includes openness and willingness to share information (Pfeiffer et al., 2019) which in turn influences the development of knowledge throughout the change process (Kohnová et al., 2019).

With change management, organisations and their respective managers are ultimately attempting to achieve their end goal state, which can specifically be the acceptance and adoption of a digital transformation (Cameron et al., 2015). However, accurately predicting every aspect of organisational change is uncommon, as there is often a high level of complexity and variety between cases (Perkins, 2018). Researchers are diving into these complexities to build a deeper understanding to assist in change management awareness, with still most research being centred around specific domains and technologies (Kamble et al., 2018; Schwarzmüller et al., 2018).

Conventional methods of dealing with change generally involve a set of sequenced steps to be followed when a change is required. However, this approach overlooks the idea that change is frequently an ongoing process (Weick & Quinn, 1999). This process is not consistent, exhibiting occasional disruptions, fluctuations in scale, or varying levels of predictability (By, 2005). Recognizing change as a continual and diverse process means facilitating adaptive abilities (Weick & Quinn, 1999).Utilising steps in a defined process assists managers in undertaking the transformation in a clear and structured manner (Römer et al., 2017). This way of approaching change management provides a framework to ensure the intentional integration of participants (Hansen et al., 2011). These systematic methods prove beneficial when the end-state objectives are defined, and the change process can be formalised (Cameron & Green, 2015).

Studies break down the complex processes of technology implementation in companies into high-level abstractions. These can be broken down into “sensing, seizing and transforming” (Teece & Linden, 2017), “Envision, enable, enact” (Ganzarain & Errasti, 2016), “Discovering, path making, transforming" (Trübswetter et al., 2018) and "Advancing, enabling, leveraging" (Dremel et al, 2017)

Overall, the literature on change processes recommends maturity models, structured step approaches, and outlooks linked to dynamic capabilities to manage the change process. These ideas, however, are considered individually and lack a unified framework for managers to clearly identify their transformation status and guide the change process to the desired end-state. Moreover, when approaches are combined, these categories offer various elements that can benefit change drivers within organisations. Implementing structured steps helps make the transformation straightforward, encouraging greater stakeholder participation (Römer et al., 2017). Organisations can gain value from adopting a flexible change model (Trübswetter et al., 2018) and cultivating operational and dynamic capabilities (Teece & Linden, 2017) to navigate the different levels of turbulence (Pavlou & El Sawy, 2010).

3. Methodology

Within this section the methodology surrounding the research will be explained. Starting off with the research that was done before the research question was built and how the topic came to place, followed by the research design, framework choice introduction and possible limitations to the choice of success factor research. These sections are then followd by data collection methods, the interview plan and then data analysis.

3.1 Pre-research

Prior to developing the research question and design, initial interviews were held to discover insights into the facilities management and robotics industry, how they intertwine and which issues are prevalent. The outcome of these discussions formed the basis for this research and the overall research objective. Casual unrecorded meetings were held both in person and online where the experts were questioned on current pressing issues and feelings within their industries.

In table 1 below, one can see a summary of the participants, approximate meeting time, the industry of work, as well as how the meetings were conducted. In appendix A the results of these meetings are presented in table format.

Table 1. Pre-research interviews

Participant Number	Industry	Total interview time	Meeting method
1	FM Robotics producer/	60 minutes	In-person
2	FM Robotics producer/distributor	35 minutes	Call
3	FM Robotics user/distributor	60 minutes	Call
4	FM Robotics user/distributor	38 minutes	Call
5	FM Robotics user /distributor	N/A (messages)	LinkedIn Chat

Summarising the result of the discussions, all participants emphasised the issues regarding lack of personnel, high turnover or lack of reliability. Participants agreed that the labour market for facilities management has more demand than supply, and therefore, agree that robots fill this gap. All participants mentioned that there are barriers to adoption that range between the financial and social scales. Trust and anxiety toward the robot within the workforce were prevalent. As the robot is a collaborative one, and the users have a say in its function and onboarding process as well as the purchasing decision-making process, this is considered an adoption barrier.

Another barrier to adoption is the financial aspect, whether or not the country itself has a high enough labour cost versus the cost of the robot per month. If labour costs are low enough, the adoption of the robot could be more expensive than the cost of human labour.

Reliability and quality were touched upon, as ever since COVID-19, the clients have been focused more on quality of clean than ever before. The robot does the work without complaining, every day: more than a human could do reliability. Furthermore, the robot may break down, but is generally able to work every day without sickness and without quitting.

One major result that arose during the discussions was the direct connection between the client expectations and service provider. The facilities management industry is based on serving the client and providing them with their individual expectations. It was agreed by all participants that clients have a direct influence on the robotics decision and that every building is different. Some clients have higher expectations and expect the use of high-tech equipment to ensure proof of cleaning through data, and the use of IoT sensors to optimise the FM processes. Whereas some clients do not have such high expectations and only desire basic sanitation and cleaning.

The relationship that exists between the client and service provider is unique in the FM industry versus in the manufacturing industry, as the service itself is provided directly in-office and must be intertwined with the processes of a firm which operates independently, therefore timings, expectations, budget and other needs must be met, whereas manufacturing companies often provide a finished product, and can optimise at will.

Data regulation, safety and privacy were topics of discussion among all participants. Technology which possesses cameras, sensors, cloud storage and mapping capabilities are all part of the new FM movement, and therefore there are concerns about data privacy for the clients which can act as a barrier in high-security industrial environments. However, the data is also able to provide a plethora of benefits, such as the ability of optimisation, reducing training time for new units and proof of cleaning.

Finally, the participants agreed on the newness of technology that comes with industry 4.0 and 5.0, including robots. The expectations that clients have on the outcomes of the FM processes are increasing drastically, and FM companies must meet these needs, or they will fall behind. The technology that FM companies have access to new is ever-increasing, and the need to successfully implement has become crucial to stay competitive.

3.2 Research design

The research design of this study is to to understand which factors lead to a successful implementation at the case company and to adjust the success factors framework to the facilities management industry. The question that will be answered is as follows:
What are success factors within the implementation process of collaborative robots in a facilities management company?

Due to the fact that the field of facilities management in combination with cobotics has not gained traction in academia, the research takes place in an exploratory qualitative format, with the addition of structure provided by frameworks. This is generally a more appropriate method as one can obtain rich data, allowing the investigation of effects, and further contributing to the development of theories, research, and empirical data in this field (Eisenhardt & Graebner, 2007). Within this qualitative study, the intent is to investigate the participants' perspectives, and through open-ended questions to allow for complex ideas and phenomena to emerge. A semi-structured interview format is chosen, as this assists further in bringing structure to complex ideas, and gathering as much information as possible (Hauser & Katz, 1998).

Robotics in facilities management is a new phenomenon, however, the overarching topic of industry 4.0, 5.0 and robotics, in general, has gained traction in recent years, therefore this research will build upon the existing research within the focus on the industry of facilities management. Deductive analysis in qualitative research can be characterised by applying theory to test the data, a more “top-down” method of analysis. Deductive qualitative research can be conducted by applying codes which have been predetermined. These codes are generally based on literature, theory or pre-existing knowledge from the researcher (Sauro, 2015).

Whereas the inductive method takes on a more emergent strategy, meaning the codes emerge during the data analysis phase. The key purpose is to dig deep into the data and develop meaning and identify themes. This research will take on both inductive and deductive approaches. The interview questions, and structure of the research will be guided and based on literature, frameworks and knowledge provided by experts in the pre-research phase. The results will be guided by these, however, space will be given for new results to form new codes during analysis.

Due to this specific industry, facilities management, being under researched, it will assist in developing an industry-specific view of the given framework.

Case Study

For this research, a case study format was chosen because case studies are rich and empirical sources for specific incidences and phenomena (Yin, 1994).

A case study can be defined as a as an in-depth study of a single phenomenon using a variety of qualitative or quantitative research methods, although most commonly case studies are qualitative, researches may choose to use additional quanitative methods, which can be reffered to as mixed-methods (Feagin et al., 2016). Case studies also often include an in-depth exploration, contextual analysis and multiple data sources. A case study ca be defined as a type of research design where a researcher decides to explore a specific event, program, process, activity and one or multiple individuals. The specific cases are generally limited by time and specific activity (Priya, 2020).

The reason to implement a case study is to use this scenario to conduct research on a specific case, such as an individual group, which allows for the identification of essential factors, processes, effects and relationships (Rashid et al., 2019). Single-case studies exploit opportunities to explore rare or extreme phenomena (Siggelkow, 2007). In this case, the rare phenomenon is based on a new industry shift for the facilities management companies adopting robotics. This case study at hand is investigating a contemporary phenomenon, within a real-life context, in which the boundaries between the phenomenon, context and theory are not evident. This, according to Yin (2003), is the ideal technical scope of a case study.

Within this study, access to companies that have undergone the adoption are sparse and rare, the data available is so too, therefore an in-depth analysis and study of a case study is conducted. In developing the in-depth view, and exploiting the data available to the highest possible degree, an embedded case study is the focus of the research method.

These types of case studies, also called Type 2 case studies, are a single case design with multiple units of analysis, also known as embedded case studies. An embedded case study is characterized by its incorporation of multiple sub-units of analysis (Yin, 2003). A case study can generally be seen as holistic or embedded. Holistic studies generally see a unit as single whole phenomenon, whereas embedded studies deem a single unit a total of its sub-parts (Scholz & Tietje, 2002).

For this research, two embedded units of analysis can be found within the case study: the facilities management company and their partner robotics company.
The reason for choosing an embedded single case study, rather than a holistic single case study is due to one, the lack of data within the facilities management company, and two, to develop a broader understanding of this rare case.

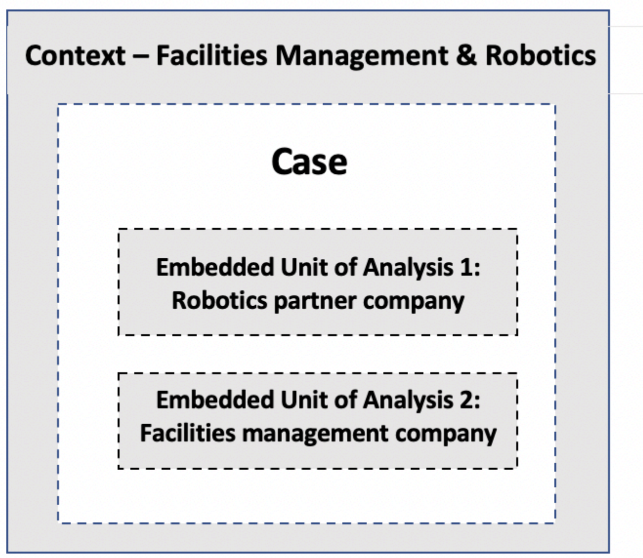

Figure 6 Single case embedded design

3.3 Research framework

Within the literature review, key frameworks were presented however success factors in cobotics implementation was selected to be the basis for the research.
It is to be understood if the cobotics implementation has been successful based on their metrics and the role of the success factors during implementation in this specific context.
The framework proposed by Kopp et al. (2020) is based on a chronological scale, decision phase, implementation phase and operation phase, divided by four elements: human operator, cobot,

working system and enterprise. The factors within the framework will be guidelines for the questions asked during the interviews. Whether or not the success factors played a role in the case companies implementation process will be assessed. Furthermore, the connection between success metrics and factors is inevitable, therefore connections will be made between these frameworks, for example, the case company may report that one of their measures for success was having no fear of job loss for the employees, which is one of the success factors within the human operator and implementation phase within the framework. In summary, the success factors will be an integral part of the questions asked and will be compared to the experience of the case company, as well as the aforementioned success metrics.

The literature used in gathering information was within the manufacturing industries with assembly lines, which are based around product manufacturing in highly industrial environments. Furthermore, the individuals which participated in the research had the following criteria: working in the manufacturing industry, production industry and logistics/materials. Therefore, the overall data origin was based on these industries. Although the authors believe the framework is widely applicable due to generalisation, there are aspects within the framework which do not apply to every industry and every cobot, therefore looking back at crucial factors such as client relationships, employee and customer needs, as well as cobot configurations, success factors will overlap, but also differ between industries, therefore the implementation strategies and success factors for each industries cobot are worth to study.

3.4 Limitations and background of success factor research

The research methodology of success factors can be traced back to 1961, whereby Daniel (1961) proposed success factors within management literature. Within this first approach, there was emphasis placed on critical success factors on an industry specific level, which applies to multiple firms within the industry in question. Later on, Anthony et al. (1972), developed on this idea with a further emphasis on not only success factor research being industry specific, but instead also being tailored to the companies goals, objectives and management with a focus on using planning and control systems which report these factors which are perceived as important within each job and industry. Bringing together the works of Daniel (1961) and Anthony et al.

(1972), Rockart (1979) confirmed, through his study of organisations, that success factors differ not only between industries but also within a particular industry.

The identification of the factors which are considered critical has been researched by Esteves (2004). It has been identified that multiple methods are relevant in reaching the critical success factors. These are case studies, group interviews, structured interviews, as well as the analysis of relevant literature. However, Pinto and Prescott (1988) claimed that the success factor's research has often been too static rather than considering the lifetime of the project and the role within this process, meaning that the factor has the same relevance throughout each phase of a project. They came to the conclusion that the relevance within each phase should be considered.

Esteves (2004) claims that relevance can be discovered through the usage of case studies, which is most common, as well as surveys stemming from interviews. Rockart (1979) suggested an interview method in which participants review a list or create a list of relevant factors for each phase within the process or project and then create a scale of importance for each of the listed factors. According to Rockart (1979), identifying critical success factors can assist individuals in managerial positions to guide focus and attention in the direction which is goal driven and strategic. Furthermore, it allows for attention to be placed on the factors and for discussion to take place about relevance within the organisation.

Rockart (1979) states that critical success factor research is based on the need to balance organisational and business characteristics as well as environmental conditions. The environment in which the company finds itself poses both threats, opportunities as well as limitations which are to be taken into account when aiming for success, therefore companies must strategically align their resources and managerial focus to meet the needs of the environment whilst balancing the organisational goals. This discussion of balancing environment and organisational goals can be found when managerial and business related topics are placed within the research focus.
Success factor research, according to Walton (1985) success factor research is an approach to balancing the rigour and relevance of a question and outcome. However, the relationship between scientific rigour and practical relevance is less balanced than it is assumed (Kieser & Nicolai, 2005). It is argued this gap is not the cause of researchers and their methodology, but

instead due to the difference in the structure of academia versus practice. This gap has been caused by the development of two different fields of logic and therefore a tradeoff between rigour and relevance is prevalent. Therefore, according to (Kieser, 2002) increasing managerial relevance is possible only at the expense of academic rigour.

In general, in reducing the gap created by these two systems, it is recommended that researchers focus efforts on real-world issues. Within this process though, the problem definition and framing can cause the researched problem to shift, as previous experience and possible solutions can influence the way the problem is defined (Bloomfield & Danieli, 1995).

For this reason, the discussion and framing process is seen as a communication process using references in the research, such as existing literature or theories. However, this discussion which takes place between the academic theories, can cause the real-world relevancy and the initial problem to be lost (Kieser & Nicolai, 2005). This gap is therefore created by the shift from a simple structure to a highly complex model (Lampel & Shapira, 1995). This is one of the reasons as to why success factor research is so successful, as it follows both the academic rules and attempts to study the managerial problems (March & Sutton, 1997).

Moreover, a piece of research is considered successful when the gap between the systems of science and management not only is a constructive dialogue but also leads to an outcome for improvement or a solution to a problem, giving cause for action (Stehr, 1994). This way, relevance is emphasised and academic rigour leads to insights which are relevant in practice.

3.4 Data collection

In developing an appropriate research design, initial market research was conducted, as previously summarised. Data was collected on problems in the FM industry regarding robotics, and a snowball effect was used in gathering pre-research information. Snowball data collection method implies that the participant or connection extends their network to the researcher, which was the case. Personal connections of initial contacts snowballed the network into the robotics industry; these connections unfortunately only remained within the robotics industry. It became evident that the ability of connection did not extend to the clients, such as the users, adopters and facilities management companies. In attempting to reach these companies, push backs were made due to privacy laws and client protection rights. Nevertheless, one facilities management company, which has adopted robotics, was willing to participate in the research discussion. Furthermore, the company which created an access point to the facilities management company was also willing to participate in the research and relay information about their client.

The company in question, which moving forward will be referred to as FM company, has undergone the implementation of cobotics into the daily operations and service provision.
However, the case study will be expanded to include stakeholders within their direct environment, being the robotics company which the FM company has been working closely with during this whole process. The robotics company, a strategic partner of the FM Company will be referred to as partner company, provides the robots and works in close collaboration with the FM company, and has assisted in the implementation of the system. The partner company produces and sells robots, operates on a global scale and has assisted thousands of companies in the implementation process of robotics, specifically in the realm of facilities management, and therefore would be a valuable source of information. The involvement of the partner company, as well as the FM company, will provide a wide range of views; internal and external.

Within research literature, the ideal number of interviews is not consistent, especially within qualitative research, however, several researchers suggested that interviews should take place until theoretical saturation is reached to avoid repetitive interviews, which may take away from the thorough depth and breadth needed within highly specific case studies (Marshall et al., 2013). Theoretical saturation takes place when additional data points do not add more value to the research. FM company's data comprises of both senior and junior management from different departments,which will be supplemented with external data from partner company to increase the knowledge obtainable from the specific case at hand.

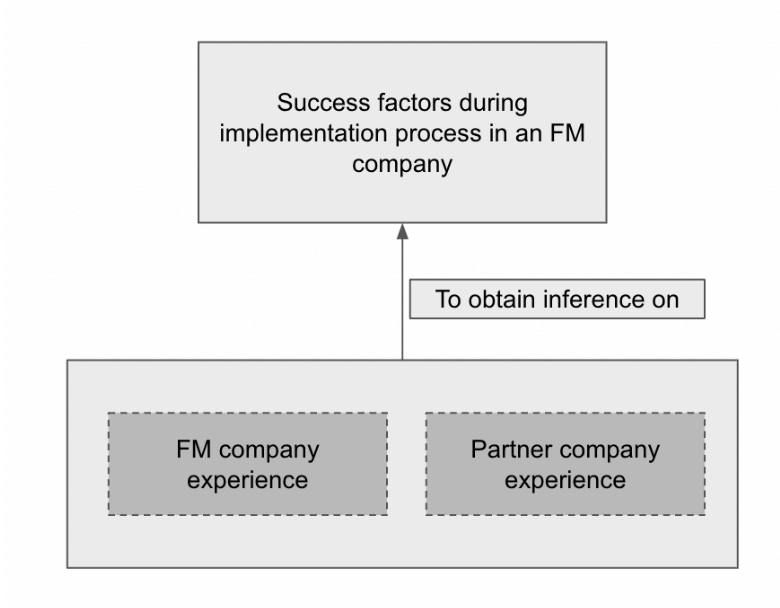

Figure 7 Units of analysis

The case study ultimately gives a detailed overview of the implementation process within the FM company, an additional broader view by the partner company, as a subsection of the overall FM robotics adoption population. In figure 7 one can see the depiction of the units of analysis, and the information they will provide: the implementation process.

3.5 Interview plan

According to Yin (2003) there are both strengths and weaknesses when using interviews as a source of data collection. Therefore, the questions are structured in a way to reduce these weaknesses, which are biassed due to poorly constructed questions, poor recall ability and reflexivity, saying what the researcher would like to hear. To reduce the recall error, the interviewee was provided with definitions and general business model questions ahead of time, so there is time to prepare answers and to understand the theoretical constructs. The definitions were still provided during the interviews. Furthermore, the questions were constructed in a way to avoid any directional bias and to reduce reflexivity, by avoiding adding in a predetermined sentimental direction. For example, instead of saying “Is this a terrible idea?” one can ask “What are your thoughts on this idea?”. Moreover, their position, name and company identity has been anonymised. The semi-structured interviews were split into three sections, based on information, context building and research question investigation. The interviews were visually aided through the use of a handout document to assist in providing definitions and explaining the theory, as the interviews will be extensive. The interview questions can be found in appendix b.

Phase 1: Context: Information regarding the individual and company

Phase 2: Context: Measurements of success

Phase 3: Role of success Factors

3.5.1 Phase 1

The first phase of the interview was dedicated to investigating information regarding the interviewees. In this phase, information such as their titles, years of experience, robotics experience, and more was looked into. Their current robotics usage and future vision were discussed. Furthermore, the interviewees were explained what the research was, what the goals were, and how the interview would be structured. Lastly, the frameworks used were briefly explained.

3.5.2 Phase 2

The second phase of the interview was related to understanding the company's success measurement of the implementation. Internal KPIs of success for multiple stakeholders were discussed, as well as the financial goals or measures of success and whether or not these were achieved within each of the phases.

3.5.3 Phase 3

The third phase of the interview dove into the successful implementation and success factors of the cobotics framework. The framework was explained and presented visually for ease of understanding.

This section was split into the chronological process, the three phases: decision phase, implementation phase, and operation phase. This change process was then split into the four elements: human operator, cobot, working system, and enterprise. The participants were questioned on the success factors for each of these elements and chronological phases regarding the success factors that were specific to them and which of the framework's aspects did not apply to them. It was understood also whether this was a general FM trait or a case-specific occurrence.

Table 1.1 Participant and interview data summary

Participant Number	Job title	Years of experience	Industry	Total interview time	FM Company or partner company
1	Head of FM	15 total, 5 at company	FM	52 mins	FM Company
2	Innovation manager FM	10 total, 4 at company	FM	35 mins	FM Company
3	Project manager for robotics and machines in FM	8 total, 3.5 at company	FM	40 mins	FM Company
4	Director of Innovation FM	11 total, 6 at company	FM	37 mins	FM Company
5	(JR) Innovation manager FM	3 total, 3 at company	FM	33 mins	FM Company
6	Director customer success	8-10 years total, 3.5 at partner company	robotics (tech start up background)	39 mins	Partner
7	Account manager	10 total, 4 at partner company	FM and Sales	41 mins	Partner
8	Account development manager	6 total, 3 at parter company	technical and FM sales	37 mins	Partner
9	Junior customer success	1 year total and at partner company	Tech / robotics in FM	30 mins	Partner
10	Senior account manager	7 year total, 5 at partner company	FM & Tech	38 mins	Partner

Looking specifically at the participants' job titles and years experience there is a great range. Focusing specifically on the FM company, the participants had a range between 3-15 years of experience in total, and 3-6 years at the company. The job titles and departments of the FM company are both junior and senior, but mostly focused on the innovation side of the company, including the head of FM. Moving onto the partner company and the participant data, the job titles are more outside of the innovation department and instead on customer relationship, tech, sales and account management both senior and junior roles. The years of experience range from 1-10 years total, with 1-5 years at the partner company.

3.6 Data analysis

Once the interviews were conducted, the data was transcribed, re-read, and analysed. The analysis of the interviews was guided by thematic analysis theory, in which overarching themes were aggregated throughout the process, within each perspective, to then bring together comparable and possibly juxtaposing viewpoints of the participants. Thematic analysis was defined as the process of identifying patterns and themes within qualitative data (Maguire & Delahunt, 2017).

For section 1 the overall information of the individuals was analysed in the following manner:
Once data was collected, the text was summerised into key information in table format for separate groups: the parter company and the FM company to better understand possible group differences. Their thoughts and opinions for questions 1.6-1.8 are then listed and summerised to better grasp their contextual opinions and current environment states, such as which cobotics they use and heir overall thought on cobotics in FM.

Within section 2 the data from the interviews was taken again in a similar format to section 1, where the unstructured data was then collected and summerised in table format. Overall themes from their answers were placed into table format, for the 2 separate participant groups, on an individual level.

Section 3 required two layers of coding. The first being pre-defined codes from the framework, and the second are codes which are an indicator of the interview outcomes.
In practice there were predefined codes which participants would have the opportunity to talk about but also add onto, these are considered the success factors. A success factor for example could be “training of human operators”. These were predefined and set a structure to the results section and how the results are presented.

The second layer to the analysis then arose during the interviews, where the participants spoke about specific factors and then alluded to this factor being important, unimportant, removed or even a new factor added to the list of success factors.

These themes then allowed the factors to be re-coded with a new set of codes, being: very relevant (emphasise), not relevant (remove from framework) or not present currently (add to framework). Furthermore, it was assessed which factors both groups did not agree upon and why that could be.

Finally, once the pre-defined factors were allocated to the codes, literature, industry information, and interview insights we used to not only summerise but to understand and explain the interview outcomes.

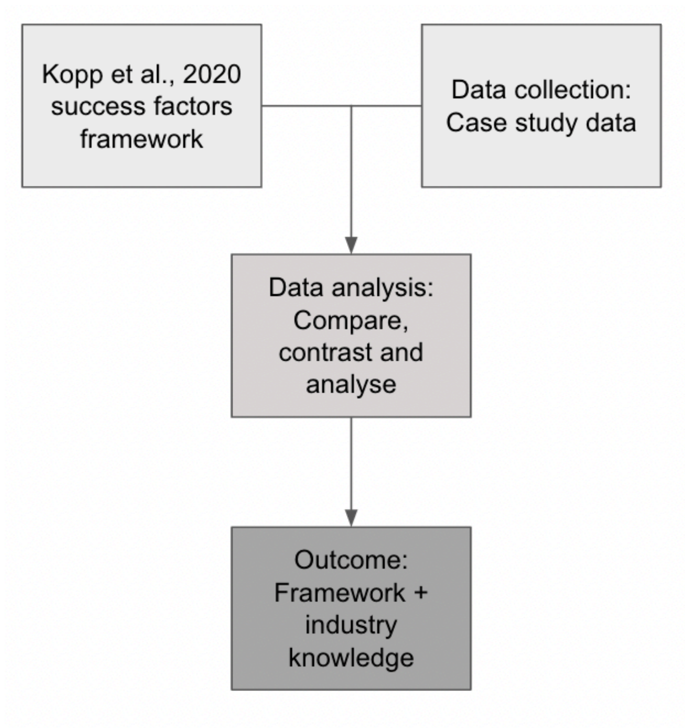

Figure 8 Research layout

4. Results

Within the following section, the interviews that were conducted and the overall results and findings of the data collection process will be presented. Firstly, the pre-interview rehearsal will be presented as well as how the interviews were adjusted based on the practice round. Following this, the ten results are presented in order of the interview phases split on both the company and the partner companies outcomes. Following this, the discussion will entail a contrast and comparison of the company and partner company to then shape and build a proposed key success factors framework for the implementation of cobotics in a facilities management company.

4.1 Interview rehearsal

In understanding the validity of the interview plan, a rehearsal was conducted with one of the participants to test the length, comprehensibility, general flow and if any adjustments were needed. The interview held was 52 minutes long which exceeded the time which was initially sought after, which was 30-45 minutes. The interview followed a general run-through with all the questions as intended, and after the 52 minutes, feedback was given by the interviewee. Furthermore, notes were taken during this process to understand what could have been improved and what worked well. Within appendix B, the initial interview questions can be found, and in appendix C.

The changes that were made relate to precision of the questions, the interaction with the interviewee, and the overall flow of the interview. Phase 1 was deemed useful, clear and easy to understand. The answers received were within the scope of what was expected and the time taken to complete this section was sufficient. However phase 2 was less clear and precise. The questions were readjusted as the interviewee did not comprehend the goal of the answers and the precision was compromised even with guidance of the interviewer. Questions from phase 2 were also found in phase 3, therefore the re-adjustment was necessary. An example of a change that was made was: “how was success measured in all of the phases?” which was adjusted to “how did you measure the overall success of implementation?”. The interviewee believes that success cannot be measured in the decision phase, as the robot has not been implemented, therefore a more general retrospective question about the implementation made more sense to both the goal of the section, and the interviewee.

In phase 3, the interviewee, even with an interview guide, required more explanations and guidance. The framework, instead of being viewed as a whole, was then broken down into smaller sections and then walked through with explanations, definitions and more precise follow-up questions. This allowed for question 3.1 and 3.4 to be combined and improved the overall flow of the interview. This combination allows for the train of thought to be focused on one section at a time, and for the interviewee to reflect better on the section at hand, also in relation to FM, rather than jumping back and forth between sections.

These changes resulted in the interview plan in appendix C, which is more precise and understandable therefore being shorter in length and focused on the research question, with an overall better flow.

4.2 Interview findings

The following section will be split into multiple sub-sections based on the interview layout which can be seen in more detail in section 3.5. In summary, there were three phases. The first phase of the interviews were dedicated to investigating information on the interviewee, their roles, overall thoughts, robotics experience, and future visions. This section gave an introduction to their background and how this may form their thoughts on the success factors which were presented to them in the following sections. The second phase was used to dive into how success is measured at their company in terms of implementation and the relevance of these KPIs.
This is to gauge an understanding on whether or not they believed they have implemented cobotics or robotics successfully in their company, or in the partners company.

With this, we can again deduct information on how success factors may be perceived and what the status is of those giving their thoughts. The final section, phase three was the most crucial and complex. Here the interviewees were presented the framework and dissected the success factors within each of the subsections, relayed what they believed was very relevant (emphasise), not relevant (remove from framework) or not present currently (add to framework). The results from phase three is the basis of the framework to present what the key success factors are for cobotics implementation in an FM company.

4.2.1 Phase 1

Phase 1 results - Company

Table 3 Phase 1 results - FM company

Participant number	1.4 Years of experience with robotics (Current / past)	1.5 For how long now have you witnessed an industry shift in FM towards robotics usage?
1	3 years	4-5 years
2	3 years	3-5 years, from fixed sensors to mobile robotics
3	3.5 years	5 years been a big increase in smart tech for FM
4	3	3 years
5	3	will continue to grow

Table 3.1 Phase 1 results - FM company

Participant number	1.6 What do you think the future will look like with robotics and facilities management?	1.7 Do you have any future plans in adopting more technology?	1.8 What does your company currently do with robotics?
1	● Growing potential over years ● More companies will enter robotics market	● Yes, demographics are changing and we need to attract workers who want to work with robotics.	● cleaning robots (scrubbers, vacuums, sensors)
2	● Will only grow: high quality work from robots	● Yes, always on the lookout.	● cleaning robots
3	● More and more tech, will soon always need cobots	● Currently have 45 units of cobots. Actively looking for more	● cleaning robots
4	● Expand and grow to meet the needs of the market ● Wider scale transformation and FM is picking up on it	● Will expand the robotics operations ● Hiring more people to manage these projects	● Cleaning robots ● “We are an FM company that hires both people and robots”
5	● Will continue to grow	● Yes, always looking	● Cleaning robots

The participants from the FM company shared their thoughts on the future of robotics and their current work with robotics. Participant 4 states "We are an FM company that hires both people and robots". The robotic type at hand are cleaning robots, specifically scrubbers and vacuums.
All participants agree that robotics will grow in the future Participant 1 states "more and more companies will enter the robotics market to offer solutions for FM". Participant 2 states "soon we will always need cobots". Overall, there is a consensus that robotics is here to stay. Regarding the further usage and adoption of robotics, the participants also universally agreed that they will not only continue with robotics, but that the company is actively looking for more robots to implement. Participant 5 states: "In our team we are always on the lookout for new technology which could improve our operations whereas participant 2 says "We are assessing tech for the future, in my role it is crucial to always be on the lookout".

Phase 1 results - Partner

Table 5 Phase 1 results - partner company

Participant number	1.4 Years of experience with robotics (Current / past)	1.5 For how long now have you witnessed an industry shift in FM towards robotics usage?
6	3.5 years	3.5 years, high increase last year
7	4 years	3-4 years
8	5 years	3 years, push during covid
9	1 year + 3 studying robotics	unsure, 3-5 years
10	3.5 years	3-4 years

Table 5.1 Phase 1 results - partner company

Participant number	1.6 What do you think the future will look like with robotics and facilities management?	1.7 Do you have any future plans in adopting more technology?	1.8 What does your company currently do with robotics?
6	• Slow but steady growth	• Yes, but expansion is slow	• Cleaning robots
7	• Tech will keep growing, but humans will always be needed	• yes	• cleaning robots • serving robots
8	• Robots will grow in every industry not only FM, dependant on need and tech availability	• Yes	• Production and sale of robot cleaners and servers
9	• It will grow based on adoption of companies	• Probably but not in immediate future	• Cleaning robots and servers
10	• Grow based on need. Long term tech will manage the buildings.	• Yes	• production of cleaning an serving robots

Regarding the future visions of robotics at the company, again, all agree on the future-proofness of robotics and that it will grow and expand in the future. Participant 7 states "I think robotics will definitely become bigger and bigger in FM, services will be smarter and more digitised, but the human presence will always be needed", participant 9 states "I think the more people will get used to it, the more it will be adopted and robotics companies like ours will invest" and participant 10 believes that "The tech will eventually manage the buildings". Whereas participant 6 is more weary on optimism "It will depend on the company. Some verticals are faster than others - hotels are faster than the governemnt sector for example - change management will take awhile". Although some were very optimistic, believing that the robots will eventually manage the buildings, others believed that human presence will always be needed and that adoption might take a long time being very dependent on the vertical of implementation.

4.2.2 Phase 2

Phase 2 results - FM company

Table 6 Phase 2 results - FM company

Participant number	2.1 Do you consider the implementation of robotics so far successful?	2.2 How do you measure success? (KPIs, surveys etc)
1	● Yes and no. Some clients are happy, others are not. Some teams accepted tech better. Workers council has stopped some implementation. Education needed on all fronts.	● Assessing contractual fulfilment ● ROI calculations ● Satisfaction surveys of workers and clients
2	● As a company yes, but it depends on the client and geography. ● Client must be willing to accept the tech too = joint commitment from us and who we service	● ROI for client ● Feedback from our client ● Business cases are varied (based on buildings, geog, overall factors)
3	● Depends on client KPIs but overall, yes.	● ROI of client ● depending on the building and infrastructure
4	● Yes but depends on client ● Clients still can influence the usage of the robots depending on the buildings and ROI	● Feedback of client ● ROI
5	● Yes but depends on the client: building and scale ● Some are adverse to the adoption	● customer feedback ● performance (how well the robot performs)

Moving onto phase two, the participants were asked about the implementation of the robotics into the company, as well as how they have measured this success. The individuals at the FM company, whose implementation is being referred to agreed mostly that the implementation has been successful. However, there were varying degrees of success according to the participants. Participant 1 says “yes and no”, Very client specific.”. They further state that some people are blockers in the implementation at client sites and that some have accepted it better than others. Whereas participant 2 confirms with the same opinion. “It depends on the client and geography, but overall as a company yes. Most are willing to adapt, but it requires a joint commitment from the client and us”. All participants from the company believe they have implemented it well into their company, but because they are using the robots at client sites, where the client still has the ability to choose and influence the decision of usage, that the success is measured case by case. In terms of how success is measured, further insights were given. A wider variety of ideas were given however most of which were based around ROI (monetary and quantitative assessments) and feedback/satisfaction (qualitative assessments). Again however, "we measure the ROI of the client. It depends on the client's building and infrastructure" (Participant 3). Participants believe that a client's verbal positive feedback, reliable and positive robot performance and positive ROI are all indicators of success.

Phase 2 results - Partner

Table 7 Phase 2 results - partner company

Participant number	2.1 Do you consider the implementation of robotics so far successful?	2.2 How do you measure success? (KPIs, surveys etc)
6	● Yes, but generally depends on how good their training is in the beginning	● no surveys ● KPI: time to activation ● % active usage
7	● With this company, yes	● Qualitative methods: speaking with customers ● Quantitative methods: order and usage amount
8	● At the company, yes	● Customer feedback ● Expand with customer ● Hit internal and customer quota ● ROI at customer level
9	● Yes	● Lack of issues ● Actual robot usage ● Reorder and continued business
10	● Yes, due to selective criteria when working with customers.	● ROI ● qualitative feedback ● usage amount of the units

4.2.3 Phase 3

Phase 3 results - FM company

This section's results have been coded to add structure to the results found during the interviews. The idea of this section is to discover the opinions of the participants on which of the mentioned factors in the respective stages are relevant for FM cobotics implementation versus that of the proposed initial framework. Therefore the results will be provided in the following codes: remove, emphasise, add. Remove: Remove this factor from the framework. Emphasis: This is particularly important. Add: Add this factor into the framework. Furthermore, if participants did not comment on a factor, it means it is relevant, does not need to emphasised nor removed from the framework.

Table 8 Phase 3 results - FM company

Participant number	Decision phase	Implementation phase	Operational phase
1	**Human:** Remove: Programming **Working system**: remove: suitability of production. Add: suitability of client needs	**Human:** Emphasis: Training. **Cobot:** Remove: gripper, human-likeness, human stress recognition, human morphology, Emphasis: ease of use, low noise, name of robot **Working system:** Remove: working materials, ergonomics. **Enterprise:** Emphasis: unions. Add: client perspective	**Cobot**: Add: Data tracking due to contractual agreements with clients **Working system:** Emphasis: Troubleshooting procedures. **Enterprise**: Add:, long-term proof of value, stability of robot cost in long-term for ROI
2	**Human**: Remove: Programming knowledge, Trust **Working system:** Remove: Production process. Add: Suitability of service. **Enterprise:** Emphasis: Cost.	**Human**: Emphasis: Support **Cobot**: Emphasis: IT security. Remove: Human stress recognition, human-likeness, human morphology, gripper. **Working system**: Emphasis: Safety. Add: Client layout feasibility. **Enterprise:** Emphasis: Management involvement, union involvement.	**Human**: Emphasis: Sees cobot as coworker. Add: Continuous updated training. **Cobot**: Emphasis: Predictability. Add: Retrievable data for client evaluation.
3	**Human**: Remove: Programming, Prior knowledge. Emphasis: Trust, training, demographics. Remove: Adjustments to body size. **Working system:** Emphasis: Mobility and adaptability. Remove: Stability of production process. **Enterprise**: Emphasis: Cost.	**Human**: Add: Ongoing training, involvement in the implementation process. Emphasis: No fear of job loss. **Cobot**: Remove: Gripper, fitting speed, human stress recognition, human-likeness, human morphology. Emphasis: IT security. **Enterprise**: Emphasis: continuous evaluation and improvement of processes.	**Human**: Remove: Mental stress. Add: Reduce physical stress. Emphasis: seen as a coworker. **Cobot**: Emphasis: Fluent movement. **Enterprise**: Add: Continuous improvement. Add: Sharing knowledge of implementation internally.
4	**Human**: Remove: Programming knowledge & body adjustments. **Working system:** Remove: Suitability of production process. Add: Fitting service provided. **Enterprise**: Emphasis: Cost. Add: Management willingness to adopt tech.	**Human**: Emphasis: Training and support, not fear of jobs. **Cobot**: Emphasis: IT security. Remove: Human stress recognition, human-likeness, human morphology, gripper. **Working system:** Emphasis: Safety. Add: Suitable client infrastructure. Remove: Ergonomics, work materials. **Enterprise**: Emphasis: Management involvement.	**Human:** Emphasis: Sees cobot as coworker. **Cobot**: Emphasis: Reliability. Working system: No changes. **Enterprise:** Add: Internal review of tech and continuous information flow.
5	**Human:** Remove: Programming, body adjustments. Emphasis: Self-confidence and trust.	**Human**: Emphasis: Employee involvement and training. Implementation	**Human**: Emphasis: Perception as a colleague.

	Working System: Remove: Production process. **Enterprise:** Emphasis: Cost of robot. Add: Management backing.	**Cobot**: Remove: Gripper, human stress level, human-likeness. Emphasis: IT, naming robots. **Working System:** Emphasis: Safety. Add: Client infrastructure. Remove: Positioning of work materials and ergonomics. **Enterprise:** Emphasis: Management involvement and costs.	**Cobot**: Emphasis: Reliability. **Working System**: Agree with all. **Enterprise**: Add: Continuous improvement of processes.

Decision phase - human operator (FM company)

Taking a look at the FM company and the results that arose from diving into the success factors framework, it was found that for the human factors during the decision phase, all participants at the FM company (1-5) agreed that "prior knowledge of robot programming" is not a key success factor for FM. Participant 4 states "programming knowledge is not relevant as we are hiring cleaners and not engineers - the systems should be easy to use." Participant 5 states "we don't use robots that require it (programming knowledge)". This result clearly indicates that programming knowledge is not necessary in their case. Regarding the success factor "employees self confidence" all participants agree that it should be kept within the framework, however participant 5 emphasises the importance of this factor. "Self-confidence is very important" indicating that the retention of this factor is agreed by all the FM company participants. The same applies to "prior knowledge of industrial robots", being a factor that some participants (1, 3, 4 and 5) believe should be retained within the framework, however participant 3 states "it is helpful but not super important" and believes it should be removed from the framework.

Adjustments to the body dimensions was something seen as relevant for participants 1, 2 and 3 but not participants 4 and 5. Participant 4 states "I also do not think that body adjustments is relevant, as long as the design is moderately fitting to the human scale" and participant 5 states "Body adjustments should be made, but the robot should be usable by a human".

Initial trust in robots was seen collectively as an important factor with emphasis coming from participants 5 and 3 saying both that "trust is very important", apart from participant 2 who believes that "trust in robotics is important but not crucial, this can be learnt over time."

Demographics as the last factor in the decision stage and human factor section was believed as important by all participants and emphasised by participant 3 “demographics is important because it influences technical knowledge and speed of learning”.

Decision phase - working system (FM company)

Moving onto the decision phase and working system, all participants agree to remove “suitability of production process” and even suggest adding in some alternatives. “production process does not apply to FM” says participant 3 as does participant 4 “The suitability of the production process is not very relevant in our case, therefore i would change it to something along the lines of “fitting the service provided” “otherwise we would not buy it or not have any success with it.” The suggestions are: “fitting service provided” (participant 4), “suitability of client needs” (participant 1) and “suitability of service” (participant 2), all of which relate to the idea that the technology must match the working needs of the client and the service provided. The mobility and adaptability were seen as relevant again for all participants, with emphasis from participant 3.

Decision phase - enterprise (FM company)

Within the following section only one success factor was present in the framework which is “acquisition costs” which participants 2, 3, 4 and 5 emphasise as being important factors.
Participant 4 and 5 add in “management backing” and “management willingness to adopt tech” as two important factors which are not yet included in the framework. Participant 4 states “Without the backup of management and budget decision-makers, there would be no investment into this (technology).”

Implementation phase - human operator (FM company)

The success factor employees feeling informed, no fear of job loss and support for cobot introduction are universally agreed on as being very relevant, with emphasis for support from participants 1, 2, 4 and 5. “The employee should definitely be supported during the implementation process. This should come along with training and guidance in the whole beginning stage” (participant 4). Furthermore, emphasis is placed on no fear of job loss by participants 3 and 4 “it is important that employees do not fear their jobs, otherwise they may become blockers rather than motivated to adopt. I think long term vision of their jobs and the impact it will have on them is important for them" "i think this goes hand in hand into them being informed, but it is still very relevant for the psyche of the individuals". Lastly, participant 3 believes that "ongoing training" should be added as a key success factor, however this would be an extension of support for the introduction, and instead be continuous support.

Implementation phase - cobot (FM company)

For the success factors humanness morphology, human-likeness of behaviour and recognition of human condition (stress levels), all participants agreed it is not relevant in their case. All participants agreed that naming the robot is important with emphasis of importance coming from participant 1 and participant 5. "The robot should have a name, to make workers feel more connected and less intimidated" (participant 1). Intuitive recognition of robot status, appropriate cobot speed, high cobot speed, acoustic signals and appropriate size of cobot was seen as relevant by all participants but received no emphasis or comments. Low noise operation and cobot design was seen as relevant from all, and both their importance was emphasised by participant 1 "visual attractiveness of the robot important" "we operate in office environments so the robot shouldnt be too loud". All participants (1-5) agree that "gripper" should be removed "gripper is not relevant for us, as we dont use robotics with arms". Lastly, IT security is relevant again for all participants (1-5) with emphasis from participant 2,3,4 and 5 "The importance of IT security is very strong and very important for our clients, and if we do not meet their criteria or pose a threat, they will not use the tech. It's a make or break point." (participant 4)

Implementation phase - working system (FM company)

The success factors "ergonomics of working station" and "position of work material" were seen as relevant by participant 2 and 3, however there were no specific comments on this. Whereas participants 1, 4 and 5 believe it should be removed from the framework "Positioning of the cobot and work materials not so relevant in this case. Nor the ergonomics of the work station, unless the workstation is related to the building and the layout efficiency" (participant 4). "Position of work materials and ergonomics is not relevant in our case" (participant 5).

Standardisation of work processes and suitable allocation of tasks were again seen as relevant by all participants (1-5) but no special comments were made regarding this. A factor in which all participants were in clear agreement is occupational safety. Participants 2, 4 and 5 emphasised its importance. “Safety is incredibly important as the robot works in a dynamic environment” (participant 2). And finally, additional suggestions for the framework in this section are from participant 2 “Client layout feasibility”, participant 4 “Suitable client infrastructure” and participant 5 “Client infrastructure”. These suggestions allude to the idea that the success factor important within the working system is the client infrastructure, as it directly affects the performance of the cobot.

Implementation phase - enterprise (FM company)

Within the next section, a success factor is “involvement of management” which was agreed on by all participants, and emphasised by participants 2, 4 and 5. Whereas the other success factors such as maintenance duration was agreed as relevant by all participants (1-5) and cost of maintenance was also agreed by all as being relevant, but only participant 5 emphasised the importance.

Operational phase - human operator (FM company)

Trust during operation is one of the key success factors in the framework for a human operator during the operational phase, and this was agreed by all participants (1-5) however did not warrant any specific comments from the participants. The following factor, reduction of mental stress was seen as relevant by participants 1, 2, 4, and 5 however participant 3 believes it should be changed from “reduction of mental stress” to “reduction of physical stress”. “Mental stress is not so relevant, physical stress is important, it's heavy work and we want to reduce this physical labour” (participant 3). The idea that the cobot should be perceived as a coworker is the following success factor, which unsurprisingly all participants agreed with (1-5). This was emphasised by participant 3, 4, and 5. An additional suggested factor was “continuous updated training” from participant 2.

Operational phase - cobot (FM company)

Reliability of the cobot is the next factor stated to be key for success for the cobot in the operational phase. This is something that unsurprisingly all participants agreed with, with emphasis from participant 4 and 5 “Reliability is incredibly important for us, the cleaner and the client. We want the robot to do its tasks with minimal issues and for the work to be smooth". Similarly, fluency and predictability of cobot movements was seen as relevant by all (1-5) with emphasis from participants 2 and 3 "it's important for the client that the robot works smoothly and looks good whilst it does so. It should be a good working and reliable system" (participant 3). An additional suggested factor was "data tracking due to contractual agreements" as a crucial factor for the cobot in the operational phase (participant 1) and "Retrievable data for client evaluation" (participant 2).

Operational phase - working system (FM company)

For the working system the success factor "standard procedures for troubleshooting" is mentioned in the framework, which all participants agree with (1-5) and participant 1 emphasises.

Operational phase - enterprise (FM company)

Lastly for the enterprise within the operational phase, ongoing costs is a success factor, which again all participants agree with, with no particular comments or remarks. However, there were suggested additional factors. Participant 1 suggests "long-term proof of value" and "stability of robot cost in long-term (for ROI)", participant 3 suggests "Continuous improvement" and "Sharing knowledge of implementation internally". Participant 4 suggests "Internal review of technology (about the cobot)" "continuous information flow (about the implementation)" and in a similar vein participant 5 suggests "Continuous improvement of processes". There were statements around the importance of continuous information flow about the process, as it is new technology within both the industry and the company, and therefore the beginning stages of implementation are crucial for internal learnings.

Table 8.1 Phase 3 results - FM company

Participant number	3.2 What do you believe the overall most important factors were that allowed for successful implementation?	3.3 During the implementation, is there something you would have done differently, and why?
1	• ROI • Client agreement • Sufficient training and education for worker acceptance	• Started sooner as benefits are very high • Start earlier to get ahead of the competition
2	• Training • clients needs • correct management of employees	• started earlier with scoping in the market. • did a good job with selecting most fitting system
3	• Employee involvement • Documentation of process • Training of employees • Good management and investment willingness from enterprise	• Created a document for the implementation process and how it is to be done and followed • Documented lessons learnt during this process • Agreeing with all parties on this process
4	• Training • Client needs • Correct employee management	• Scoping tech on market earlier • Did a good job on not rushing the selection
5	• Training and management • Reviewing processes and procedures regularly • clients voice heard in the selection of the robots	• Spent more time creating documentation for the adoption process, so we can have better info flow and learnings.

In the following part of section 3, an investigation into the overall success factors they believed to be important, which may or may not be present in the framework, as well as the actions they would have done differently during the implementation, was undertaken. Continuing again with the FM company, the results are as follows.

Most important success factors - (FM company)

Participants 1, 2, 4 and 5 all included the need for a client perspective. There was an overall consensus between these participants that the client voice, agreement and inputs are required for a successful implementation, as the technology will be utilised directly in the client buildings, their voices and inputs are crucial. This includes also the work required by the clients and their opinions. Another crucial success factor which was mentioned by participants was training and education. This factor was mentioned by all participants as key in having a successful implementation. This means that employees which are involved in the process should be trained in the usage of the cobot, so that they are educated in the usage of the cobot, but also build trust towards the system "Users should be correctly trained and involved to make them feel like the robot is their coworker" (participant 1). Correct employee/change management is another factor which was mentioned by participants 1, 2 and 5. This means that the overall organisation of the process should be controlled and well executed to facilitate a successful implementation. Surprisingly, ROI was mentioned only by participant 1.

ROI being the overall return on investment by both the client and the FM company itself. "Without an ROI, there would be no business case" (Participant 1). Further key factors include "documentation of process" and "Reviewing processes and procedures regularly" which allude to the notion that the process should be assessed as a whole, retrospectively and regularly to allow for internal learnings to be maximised, and for the process to be optimised and repeated in the future. Finally, another key success factor was "Good management and investment willingness from enterprise" mentioned by participant 3. This factor indicates that without management and willingness to invest in the technology, there would be no innovation towards cobotics usage.

Anything done differently? (FM company)

The final part of the interview went into what the participants would have done differently. Participants 1 and 2 described how they would have "started earlier" with both scoping of technologies on the market and started the implementation earlier to get ahead of the competition and reap benefits sooner. " we are happy now that we have implemented these but we wish we would have done it sooner to have increased efficiency earlier. We want to be ahead of the competition in the sense of innovation" (participant 1). Participants 3 and 5 both agree they would have spent more time on the documentation of the implementation "Spent more time creating documentation for the adoption process, so we can have better flow and learnings" participant 5), "Created a document for the implementation process and how it is to be done and followed, documented lessons learnt during this process and agreeing with all parties on this process" (participant 3).

Phase 3 results - Partner

Table 9 Phase 3 results - partner company

Participant number	Decision phase	Implementation phase	Operational phase
6	**Human**: Remove: Adjustments to employee, programming. Emphasis: Willingness, trust, demographics **Working system:** Remove: Suitability. Emphasis: Adaptability.	**Cobot**: Remove: Gripper, acoustic signals, stress level recognition, human design, human morphology. Emphasis: Low noise, cobot size, naming. **Working system:** Remove: Allocation of tasks, ergonomics, tool position. Emphasis: IT security Standardisation. **Enterprise**: Emphasis: Management	**Human**: Remove: Mental stress. **Working system:** All relevant. **Enterprise**: Relevant. Add: Total lifetime cost, ongoing success, change management over time.
7	**Human**: Remove: Adjustments to employee, programming. Emphasis: Willingness, trust, demographics. **Working system:** Remove: Suitability. Emphasis: Adaptability.	**Human:** Emphasis: support in intro, feeling informed **Cobot**: Remove: Gripper, acoustic signals, stress level recognition, human design, human morphology. Emphasis: Low noise, cobot size, naming. **Working system:** Remove: Allocation of tasks, ergonomics, tool position. Emphasis: IT security, Standardization. **Enterprise:** Emphasis: Management, unions.	**Human**: Remove: Stress. Emphasis: trust during operation
8	**Human**: Emphasis: Trust, willingness. Remove: Programming, adjustment to employee. **Working system:** Emphasis: Adaptability. Remove: Suitability.	**Cobot**: Remove: Gripper, acoustic signals, stress level recognition, human design, human morphology. Emphasis: Robot size, speed, low noise, naming. **Working system:** Remove: Task allocation, ergonomics, position of tools. Emphasis: IT security, Standardization. **Enterprise**: Emphasis: Management, unions.	**Human**: Remove: Mental stress.
9	**Human**: Emphasis: Trust, willingness. Remove: Programming, adjustment to employee. **Working system:** Emphasis: Adaptability. Remove: Suitability. Enterprise: Keep all.	**Human:** Emphasis: no fear job loss **Cobot**: Remove: Gripper, acoustic signals, stress level recognition, human design, human morphology. Emphasis: speed, low noise, naming. **Working system:** Remove: Task allocation, ergonomics, position of tools. Emphasis: Standardisation. **Enterprise:** Emphasis: Management, unions.	**Human**: Remove: Mental stress. **Working system:** All relevant. Enterprise: All relevant.
10	**Human**: Emphasis:, willingness, trust Remove: Programming, adjustment to employee. **Working system**: Emphasis:	**Cobot**: Remove: Gripper, stress level recognition, human design, human morphology. Emphasis: speed, naming.	**Human**: Remove: Mental stress. Add: reduction of heavy physical workload

	Adaptability. Remove: Suitability. **Enterprise**: Emphasis: Cost	**Working system:** Remove: Task allocation, ergonomics, position of tools. Emphasis: Standardisation. **Enterprise**: Emphasis: Management, unions.	

Decision phase - human operator (Partner)

Within the decision phase and the human operator perspective, the participants within the partner company (6-10) believe that trust is important enough to be emphasised. “Trust is very important, or else the workers will see the robot as threatening” (participant 7). Furthermore, the factor self-confidence was seen as relevant by all participants but did not warrant any emphasis as “trust in robotics” did. Going hand in hand, the factor “prior knowledge of industrial robots” was again seen as relevant by all participants but did not receive special consideration by the interviewees. Contrastingly, the success factor “adjustments to body dimensions” was seen as irrelevant by all participants (6-10).

“Adjustments to employees are not relevant. The cobot should be built in a human usable way, but it doesnt need to adjust to the body” (participant 8). Prior knowledge of programming was also believed to be irrelevant for the implementation of cobotics in this case. “Programming is not relevant. We don't make ‘complicated to use’ products” (participant 9). Demographics was seen as relevant by all participants (6-10) but only emphasised by participants 6 and 7. “Demographics is relevant as it indicates things such as language, age and willingness to learn about new technologies” (participant 6).

Decision phase - working system (Partner)

Suitability of the production process is again seen as irrelevant by all participants at the partner company, with clear indication as to why it is irrelevant from participant 10. “Suitability of the production process is not super relevant for our customers. We don't produce robotics for production, but cobotics for services”. In a similar vein, the participants believe that the mobility and adaptability of the cobot to its environment is crucial as a success factor. “Adaptability and mobility is very relevant to the environment. The cobot is a mobile system and should be able to adapt to the environment it is working in to some extent" (participant 8).

Decision phase - enterprise (Partner)

From the enterprise perspective during the decision phase, unsurprisingly, participants believe that acquisition costs are relevant, however only one participant commented on its relevance "Cost is incredibly relevant for our clients. If we are not priced correctly, they don't select us. They may opt for competitors or not move forward at all, because if there is no ROI there would be very little justification for purchase" (participant 10).

Implementation phase - human operator (Partner)

Within the implementation phase from the human operator perspective, the participants agree that all factors are relevant. These factors include "no fear of job loss". "feeling of being informed" and "employee support for introduction". Participant 9 states "No fear of job loss is incredibly important. The end users should feel comfortable with the system or else they could be major blockers in implementation. We also work in an industry where they really do need automation because they are struggling to find staff". Participant 7 believes that feeling informed and having support during the introduction are key to success. "In my opinion, feeling informed and having support in the beginning go hand in hand. The employees who are working with the cobot should perceive the cobot as exactly that: a collaborative robot, which requires time to properly inform, educate and support the introduction".

Implementation phase - cobot (Partner)

Factors within the framework surrounding the cobot during implementation are extensive, however there is a great deal of overlap on what the partner company participants see as key success factors, and which they do not. "Gripper" - the arm or hand - is seen as not important by all. "The gripper factor is not relevant for our robots, as we dont produce robots with manipulation, however this of course might change in the future" (participant 8). In terms of noise and acoustic signals the framework presents two factors "acoustic signals" and "low noise operation". Interestingly, participants 6, 7, 8, and 9 agree that the robot should have low noise and that acoustic signals should be removed from the framework “Low noise is important in office environments, we don't want the robot to disturb people” (participant 9). However, interestingly in contrast, participant 10 believes the opposite, that low noise operation is not a key success factor and should be removed from the framework, whereas acoustic signals are relevant “Low noise doesn't matter, the robots are usually operated outside of office hours anyway. Having acoustic signals is a nice addition and could help increase safety and understandability of the system for the users” (participant 10).

IT security and cobot size are considered important factors with all participants seeing it as relevant and with emphasis coming from participants 6, 7 and 8 “One of the first questions we are asked is the security of the system. If the security is weak, it can be a major blocker in wide adoption.” (Participant 6). Appropriate cobot speed was similarly deemed as relevant by the participants with emphasis from participants 8, 9 and 10 “Speed is important, needs to be quick enough to cover tasks in time” (participant 10). Intuitive recognition of the interface and cobot design were all seen as relevant by participants 6-10, however did not warrant special emphasis nor to be removed from the framework. Contrastingly, human-likeness and humanness morphology were universally agreed upon as not being success factors. Lastly, naming the robot was emphasised by all participants. “Naming the cobot is important to humanise it, and help make it feel like an actual coworker.” (participant 8).

Implementation phase - working system (Partner)

Within the working system, the participants believe that the factor “occupational safety” is relevant for success, however there was no emphasis on this during the interview. This also applies to “standardisation of of work processes” however participants 6-10 emphasise its importance, with participant 8 stating “Standardisation is important as you need to have a robot which covers standardised work” “Suitable allocation of tasks” “position of work materials” and “ergonomics of the work station” are however believed to be irrelevant by participants 6-10 to be removed from the framework. “Position of tools is not relevant, as we aren't a manufacturing line, and the robot doesn’t use tools per se” (participant 8).

Implementation phase - enterprise (Partner)

From the perspective of the enterprise, unions are seen as relevant, with emphasis on this coming from participants 7, 8, 9 and 10. Participant 6 states they are "unsure" about the relevance as they personally have not encountered any topics relating to this in their role, whereas participant 9 states "Unions are important, they could be blockers in wider spread adoption within the industry". "Involvement of management" is another key success factor which was emphasised by all participants, for good reason. "Management is very important to push ideas in the company. Without their backing, there would be no internal support for companies to adopt the robots" (participant 10). "Management must be onboard. This allows for both financial support of adoption projects but also good change management, which puts the robots to use instead of collecting dust" (participant 9). In a similar manner, maintenance cost and duration were also deemed as relevant and to be retained within the framework, however received no special attention during the interviews discussion.

Operational phase - human operator (Partner)

Moving onto the final phase of the framework, the operational phase.

Within the human operator perspective "trust during operation" and "perception of cobot as a colleague" can be found. Participants believed that the trust during operation is an important factor towards achieving success. Participant 7 emphasised this importance "Trust is an indicator for a plethora of other factors such as a reliable system, good understanding of the robot and no fear of job loss. These are all very important indicators" (participant 7). Reduction of mental stress is unanimously agreed on as not relevant. Participant 10 suggests a replacement for this factor to instead be "reduction of heavy physical workload". "Reduction of mental stress is to be considered, but what we want is to reduce the amount of heavy workload the users undertake, which will in turn allow them to work on more valuable tasks".

Operational phase - cobot (Partner)

"Reliability of the robot" and "fluency and predictability" were universally agreed on as a relevant success factor within the framework, however the participants did not comment on the importance.

Operational phase - working system (Partner)

"Standard procedures for troubleshooting" was also universally agreed on as a relevant success factor within the framework, however the participants did not comment on the importance.

Operational phase - enterprise (Partner)

Finally, ongoing "operational costs" were evaluated as relevant. However participant 6 also added their own factors within this section being: Total lifetime cost, ongoing success evaluation and change management over time. These indicate the importance of lifetime finances over the life of the robot. Ongoing success evaluation refers to the continuous check if the technology is working for the given company and change management over time refers to the need for management to keep up with the implementation and to allow for continuous updated training.

Table 9.1 Phase 3 results - partner company

Participant number	3.2 What do you believe the overall most important factors were that allowed for successful implementation?	3.3 During the implementation, is there something you would have done differently, and why?
6	• The beginning stage of implementation (training) • Good change management • Involve all and take different perspectives into account. • Incentivise use	• Communicate of management down to users
7	• Forward thinking management • Willing operators (users) • Need for implementation	• More time working with the company to plan out implementation and reduce learning curve for the client
8	• Management that is willing to push tech • Involved and motivated employees • Tech brings value to company	• Focused on long term goals from the beginning
9	• Innovative client team • Willingness to learn	• No
10	• Management that is willing to push tech • Involved and motivated employees • Products that bring real value	• Focused on long term goals

Most important success factors - (Partner)

In the final section of the interview, the partner company shared their thoughts briefly on the most important success factors overall, regardless of the phases and processes. The first result was that participants 6, 7, 8 and 10 believed that management has a strong influence on the success of the implementation "management willing to push technology", "forward thinking management". Another interlinked success factor mentioned by participant 6 states, is "good change management". This being the correct management of employees which are involved in the process. This success factor is again linked to the actions taken and the way individuals are handled within the process. These types of actions which are also considered success factors are "training","involving all and taking different perspectives into consideration", "incentivise use" (participant 6), Participant 6 discussed how they have seen certain companies incentivise use, however not at the company within this research focus.

They discussed how incentivising use can help to increase the willingness of use, which for the partner company is a measure of success for implementation. Looking at success factors from the user perspective, the participants deemed "Willingness to learn" (participant 9), "willing operators" (participant 7), "involved and motivated employees" (Participant 10) and "Innovative client team" (participant 9) as key for success. Furthermore, a crucial factor for participants 10 and 8 were about the product, and that they actually bring value. It was discussed that no matter how well the implementation is thought out and executed, the product will not be a success if it doesn't bring "real value" (participant 10) to the company.

Anything done differently? (Partner)

Lastly, the partner company shared their ideas on how the FM company or themselves could have done better during this case of implementation. Participant 6 believes that the partner company could have improved their top-down communication. "Sharing the 'why' and the vision down to the users makes a huge difference". Participants 8 and 10 believe the company could have spent more time thinking about long-term planning for the implementation, rather than only buying a robot they believe the company should think about long term success.

Interestingly, participant 9 believes that they would have done nothing differently, nor the FM company. And finally, participant 7 believes they should have spent more time working together with the client to properly plan out the implementation, to reduce the learning curve for the client and leverage their experience for this process.

5. Discussion and conclusion

In the following section, the key findings of the interview will be presented and discussed.
To simplify the analysis of the outcomes the discussion will present two frameworks which have been colourised with stickers to show a few outcomes. Once this is presented, a discussion will proceed to dive deeper into what both groups agree are completely relevant factors for success for cobotics implementation in FM, followed by a dive into what all participants agree to remove from the framework. Next, key differences between the groups and additional factors are presented. Throughout these discussions, interpretations using literature and participant perspective will be central to understanding the background behind the results. Lastly, limitations of the research will be presented and discussed.

- All agree to remove from framework
- All agree to keep within framework
- Mixed opinions on keep or removal
- Add (at least 1 factor)

Figure 9 Adjusted framework with codes - FM company

All agree to remove from framework
All agree to keep within framework
Mixed opinions on keep or removal
Add (at least 1 factor)

Figure 10 Adjusted framework with codes - partner company

5.1 Discussion

For an in-depth structured discussion, it is split up into multiple sections to help better interpret the results presented previously. These sections include irrelevant factors, factors which were not agreed upon by the parters and FM company to be relevant or irrelevant, additional factors as well as relevant success factors.

Table 10 Irrelevant factors

Nr	Factors considered irrelevant
1	Prior knowledge of robot programming
2	Suitability of the production process
3	Gripper
4	Recognition of human condition
5	Humanness of morphology and behaviour
6	Human-likeness of morphology and behaviour

Between both the partners and the FM company, there was a total agreement that prior knowledge of robot programming is not a success factor. Prior knowledge of programming, however, would be important if the robot were to be a complex system which would require this set of skills for regular usage. This finding aligns with the literature, where it is found that the complexity of the robot usage should be appropriately scaled to the users expected knowledge base, otherwise there will be high barriers of entry of usage (Yigitbas et al., 2021)
Due to the simplicity of the robot, it is not needed, therefore it is appropriate to place the reason for irrelevancy on the type of robot instead of the industry of FM. The following factor which was considered unimportant is the "gripper" also known as a robotic arm or manipulator. Due to the characteristics of the robot in this case study, participants agreed that a gripper was not important. Again, like the previous factor, the lack of importance can be tied to the robot style and function, rather than the industry. The cobots assessed during the creation of the framework (Kopp et al., 2020) were robots with manipulators, therefore the importance of a gripper is relative to that of the robot design.

Suitability of the production process is a factor again seen as irrelevant. Participants pointed out that "Production process does not apply to FM" (participant 3). Participants pointed out the need to switch out this factor directly with "service" and not "production" therefore directly resulting in "suitability of service provided". This change directly reflects the difference between the framework's industrial focus, manufacturing, versus the case study of this research, facilities management. It can therefore be said that this factor and lack of importance is tied to the industry and application, and that changing it to service, results in a more fitting success factor.

Recognition of human condition, human-likeness and human morphology are factors which connect somehow to the human: through mimic or understanding. These factors again were seen as irrelevant for FM in this case study. Research has found that human-like robots, as well as robots which react to human demeanour are generally effective in healthcare, education and social assistance (Choudhury et al., 2018), whereas the goals of FM are to ensure the efficiency of buildings (IFMA, 2022), rather than the connection to humans. Therefore, it can be assumed that the lack of need to recognise and mimic human behaviour can be tied to the industry. The goal of the robot plays a role in what characteristics or functionalities the robot has, therefore influencing the success factors.

Additionally, It was found that there were factors which individuals within either group did not come to a conclusion on, and factors which one group may have agreed on, but the other group, not. Taking a look at the differences between the groups, the following factors were not agreed on as being key, nor irrelevant by all. These factors can be seen in table 11 below.

Table 11 Factors not agreed upon

Nr	Factors not agreed upon (as relevant or irrelevant)
1	Prior knowledge of industrial robots
2	Adjustments to the dimensions of employees
3	Low-noise operation
4	Acoustic signals
5	Suitable allocation of tasks
6	Positioning of cobot and work materials
7	Ergonomics of the workstation
8	Reduction of mental stress
9	Initial trust in robotics

Interestingly, a factor which was not agreed upon completely was the idea of initial trust. Although trust during operation, as to be discussed later, is considered a key factor, initial trust is not. It was stated that trust can be trained, and earnt, but it is not crucial for it to exist prior to implementation from the perspective of the human operator. The initial trust can be tied to the prior expectations or beliefs of the cobot. The absence of trust can be relating to the belief that the robot, for example, is not competent, or even the design choice of the robot (Hiroi & Ito, 2008). The following factor of "trust during operation" vs "initital trust" can be linked to an an expectation gap (Kok & Soh, 2020). Therefore it can be said that, with high and reliable performance of the robot, the initial trust level is less important than the perception after experience with the system.

Some factors, such as adjustments to employee body dimensions, were mixed. It is believed that the size of the cobot overall is important, but the cobot should generally not need to adjust to the employee. It has been found that robots which are lower than the eye level are considered less threatening than robots taller than this level (Hiroi & Ito, 2008). Furthermore, due to the collaborative nature of cobots, the size should be aligned with the human scale for usage.
A contrasting effect was seen for the factors low-noise operation and acoustic signals. It was found that the FM company believed both low-noise operation and acoustic signals are important, but from the partner company there was a belief that low-noise didn't matter as much, as the robot is being used outside of working hours. Therefore, the perspective of the users versus the partners played a role in how the robot is being perceived to be used, versus how it is actually being used.

A controversial factor was the ergonomics of the work station. Within the FM companies interviews, two participants believed ergonomics of the work sation is relevant, however made no special comments or emphasis on the factor, versus three participants believed it should be removed. For the partner company, all participants in this group believed it should be removed from the framework. It can be said that the overall majority believe ergonomics is not relevant as a success factor. Participant 8 specifically pointed out that it is not relevant for FM, as there is no

‘one’ working station, like there might be in a manufacturing process line. Therefore, this factor can be tied to the overall industry and application context. Generally, a working station or working cell is seen as a specific area in which the robot and humas collaborate, whereas pre-cobotics, these areas were always caged off to avoid humans to enter these spaces. It can therefore be said that, if the robot and human are to work in a working cell or station, there must be thoughts on the ergonomics of this collaboration, whereas if there is no specific collaborate zone, this factor is less crucial (Colim et al., 2021).
Another factor which surprisingly was not unanimously agreed upon was “reduction of mental stress”. Within the FM company, participants 1, 2, 4, and 5 agree that reduction of mental stress is relevant, however it was added by participant 3 that overall it is not the goal, and that reduction of physical stress should be the factor instead. Research lacks behind on works regarding reduction of mental stress outside of the social work setting. Extensive studies are done on robotics in psychiatric care (Scoglio et al., 2019) however few not on stress in combination with work processes. One of these few studies finds that the addition of robots reduces physical injury and load, whereas no effect was found on mental health and work satisfaction (Gihleb et al., 2022).

Moving onto factors which participants believe should have been in the framework. These factors have been clustered together.

Table 12 Additional factors

Nr	Additional (new) factors
1	Suitability of service
2	Suitable client infrastructure
3	Data tracking
4	Long term proof of value
5	Stable robot cost over time
6	Continuous updated training
7	Reduce physical stress
8	Internal review of tech and continuous information flow
9	Management backing

Within the framework, the participants noticed some factors which were missing, which they would have added to make the framework more appropriate for the application within FM.
Suitability of service is related to the decision phase. When assessing the cobot, the company at hand is assessing whether or not the cobot would fit into the service they are looking to provide to their clients, which is a direct replacement of the factor "suitability of the production process". Similarly, suitable client infrastructure is a new factor which is closely related to both the service aspect of facilities management, as well as the mobility of the cobot. Being that the industry is structured often so that third party companies offer their services to other companies, a client based relationship is commonplace within facilities management. Furthermore, the client infrastructure being suitable refers to the ability of the robot being able to traverse the environment of which the service should be done, therefore this factor is crucial for FM, but also directly tied to the application in mind for the cobot and whether it is required to be mobile in its intended use.

Data tracking is a key success factor which was mentioned regarding the importance of being able to track work progress. With this tracking, the FM company was able to not only conduct the work with cobotics, but also use the data collected to provide the quality and frequency of the work.
Long term proof of value and stable costs over time are both factors which connect on the financial terms of the cobot, and how the company calculates the ROI. Financial benefits are considered crucial for FM but also are considered one of the key factors by participants in the creation of the initial framework by Kopp et al. (2020). However during interviews, participants elaboraeted on one of the key benefits of cobotics was the stable cost of ownership and ability to calculate the long term cots of ownership, versus that of a human employee. This lack of stability refers to high employee turnover, need to train new employees, sickness and income increase.
Reduction of physical stress was introduced as a replacement by one of the participants for the factor of stress reduction. The reasoning behind this new factor is that the ultimate goal is not to reduce mental stress but instead physical stress, by reducing the workload of the employee and allowing this to be given to the robot, as discussed in the previous section.
Continuous updated training was a theme which arose from participants, which gave a long term perspective to the cobot within the company. It was discussed that participants should not be

trained once or twice, but continuously and overtime to keep them up-to-date with the technology.

Furthermore, a similar reasoning applies to factor of internal review of tech and information flow. It was mentioned that processes, technology and information is not static and should be treated as such. Information should be passed through the organisation to help assist the company internally to learn from their own experience. Participant 3 discussed how he wished the process for implementation was better documented to help facilitate the implementation across the organisation. This factor coincides with the literature findings that group alignment is influenced by the accessibility of information (Salimon et al., 2019). Information sharing can provide insights into performance improvement metrics (Robert et al., 2020) and facilitate the exchange of 'soft resources' like documents and software (Wagire et al., 2021).
Lastly, management backing was a key factor mentioned by participants not only in the framework review of phase three, but also when asked which factors overall were the most important for successful implementation, management backing and willingness was one of the key factors which was described to be absolutely crucial. Within implementation of new processes, or technologies the need for internal champions is vital in ensuring success (Johansson et al., 2019; Vrchota et al., 2021). This is a common theme within literature, therefore aligning with the overall consensus of importance, and can be considered a factor for success. Moreover, this finding aligns with the literature in he belief that management influences direction, and therefore also company culture, specifically the overall management willingness. An example of promoting organisational culture towards change is having a culture which includes openness and willingness to share information (Pfeiffer et al., 2019) which in turn influences the development of knowledge throughout the change process (Kohnová et al., 2019).

Within the research there were factors which were considered true success factors by all participants within both groups. In understanding these factors, we can understand what is actually considered important for this case study, from both perspectives: the FM company and the partner, combined.

Table 13 Success factors agreed by all participants

Nr	Success factors
1	Employee self-confidence
2	No fear of job loss
3	Demographics
4	Employee feeling of being informed
5	Employee support for the introduction
6	Perception of cobot as colleague
7	Trust during operation
8	IT security
9	Intuitive recognition of robot status
10	Appropriate speed for employee
11	High cobot speed
12	Appropriate size of the cobot
13	Cobot design
14	Naming of the cobot
15	Fluency and predictability of cobot movements
16	Occupational safety
17	Standardisation of work processes and process owners
18	Standard procedures for troubleshooting
19	Mobility and adaptability of the cobot
20	Involvement of management
21	Maintenance costs & duration
22	Involvement of unions
23	Operational costs (ongoing)
24	Onetime acquisition costs

The research showed that 25 factors within the framework from Kopp et al. (2020) are considered key success factors for the implementation of cobotics within facilities management, based on the interviews conducted. As the goal of the research is to understand which factors are indeed important, a deeper dive into the outcome will be done. Breaking the 25 factors down into the different perspectives, it was found that there are seven factors which are important from the human operator perspective, being: employee self-confidence, no fear of job loss, demographics, employee feeling of being informed, employee support for the introduction, perception of cobot as colleague and trust during operation. Participants not only believed these were important, but all emphasised their importance.

It can be stated that the factors relating to the human perspective influence one-another. More support can lead to better self-confidence, feeling informed can lead to better trust during operation and perception of the cobot as a colleague et cetera. However, Participant 7 believes that demographics is *the* underlying crucial factor which can influence all factors. Demographics indicate the age and indirectly the background of the individual, which can be an indicator of how they will approach the cobot as a system in general. Furthermore, this claim can be backed up by research, as it has been found that that age is an important demographic variable and has a direct and moderating effect on behavioural intention, adoption and acceptance of technology (Tarhini et al., 2016). Additionally, Venkatesh et al. (2000) found that higher education is a strong predictor of willingness and ability to work with new technologies.

Within the pre-research it was discovered that the users of the cobots are not decision makers, but instead cleaners which conduct the work. This finding may indicate to some that the operators opinion is not crucial, however the users of the technology can be blockers or champions of the technology being implemented (Dillon & Morris, 1996) therefore, it is highly recommended that companies planning to take on cobotics into their companies should consider the human operators as key drivers of the implementation.
Moving onto the cobot, and the factors which participants believed to be important: IT security, intuitive recognition of robot status, appropriate speed for employee, high cobot speed, appropriate size of the cobot, cobot design, naming of the cobot, reliability of cobot, fluency and predictability of cobot movements. Due to the nature of the cobot, and being that it is a cobot which works together with the human, there are factors of success which would differ from a, for example, fully autonomous robot working in an isolated environment. It can be said that the characteristics of appropriate size for the employee, naming of the cobot and appropriate speed for employee are directly connected to the collaborative nature of the robot, therefore reinstating the importance to consider the nature of the human in the context of technology usage, and to

view these stakeholders as an ecosystem rather than separate entities. However, the industry and application context are not always the most important overarching themes, as there are also industry agnostic factors, such as IT security and reliability are industry agnostic, which aligns with the literature findings.

Interestingly, naming of the robot was considered a success factor by all participants, and was directly tied to another success factor of the cobot feeling like the robot actually is a colleague. This contrasts the earlier discussion that participants do not believe the cobot should look like or mimic human behaviour, however naming the cobot has a similar goal as does human design or mimic (Ladwig & Ferstl, 2018).
Additionally, factors which were considered important for the working system are: occupational safety, standardisation of work processes and process owners, standard procedures for troubleshooting and mobility and adaptability of the cobot.

Unsurprisingly, safety is considered one of the key factors of success. Ensuring safety and wellbeing is one of the most common goals across companies (Friend et al., 2023). This factor, therefore, is industry agnostic, and not specific to FM. Infact, the implementation, according to some participants, was not to reduce mental stress, but to reduce physical stress on the employees, therefore also reducing heavy workload and reducing risk of occupational hazards.
Furthermore, the nature of the work has a certain level of repetitiveness and therefore allows the tasks to be automated through the use of robotics. Understandably therefore, the factor of standardised work and work owners is key. Moreover, mobility and adaptability is one factor which was often emphasised, as the robot in this case study must be mobile and move around the environment, whereas the cobot which was used in Kopp et al. (2020) study is stationary. The cobots value is partially tied to how much of its environment it can cover, therefore this factor is not necessarily tied to the industry, but more to the task which the cobot has been created to do.

Lastly, taking a look at the enterprise factors which were key: involvement of management, maintenance costs and duration, involvement of unions, operational costs (ongoing) and onetime acquisition costs. Unsurprisingly, financial factors are considered important by all participants. If the costs are higher than the ROI, the investment into this specific robot would be considered unjustifiable and adoption would likely not be widespread across multiple companies.

When the participants were asked to discuss how they measure KPIs, there were multiple methods which arised, which can be found in table 14.

Table 14 KPIs to measure success

Nr	KPIs
1	Assessing contractual fulfilment
2	ROI for client
3	ROI for internal
4	Satisfaction surveys
5	General feedback
6	Robot overall performance

Although success is often looked at through the financial lens, many other factors are involved in the assessment of success, and not only ROI.

This outcome can be directly tied to the nature of the industry, being that it is service focused, whereas manufacturing is product-outcome driven. The quality of the service is crucial, however because the work is done directly at the clients infrastructure, the qualitative feedback of the clients becomes a vital part of the assessment. Another factor is the involvement of management. Participants stated that the need for management to back the project within the company is absolutely crucial for the implementation. Within the interview it was discussed also what the overall most important factors were for the implementation of cobotics, and participants pointed out that management of the project was one of the, if not the most important factors. This includes not only financial backing, but also qualitative drivers such as effective change management and aligns with the literature.

5.2 Research limitations

Within the research there were limitations based on the type of methodology selected.
In understanding the success factors of cobotics within a FM company, such a company was scoped and selected to become the research focus, however due to the size of the data sample, and to increase the perspective of the case study, a second company was selected which supplied the robots to the FM company, and assisted them on their journey. The use of an external vision on a single case case study can cause results to be skewed by the other companies experiences. Although in this case, because of their vast experiences, the inputs from the partner company created additional value. Furthermore, the inherent choice of qualitative research didn't allow for a ranking system, therefore all factors were considered as equally relevant, however in reality it is likely that not all factors are considered equally important. Additionally, the option was given for participants to emphasise factors if they felt it was particularly relevant. Participants may have only commented on factors if it caught their eye during the interview, versus the actual real life relevance. Lastly, participants introduced new factors within the interviews which were not validated through the additional review of other participants, therefore will remain as "additional" factors and are not included in the list of critical success factors.

5.3 Future research

For future research it is recommended that the additional factors which were presented during the interviews are validated, and implemented into the proposed framework for FM. Furthermore, as time passes, robotics and cobotics in general within FM will grow, as also believed by all of the participants. This means that the, once scarce and niche case study which was in focus during this research, will become less rare and more data points can be abstracted from the market. Therefore, it is recommended that the proposed framework is validated on a quantitative basis, not only qualitative, so that a base level of statistical knowledge is built around the industry and the knowledge of cobotics implementation.

5.4 Practical implications

This research has a theoretical and academic goal to help grow the knowledge within academia on the success factors of cobotics implementation, however success factor research has an inherent practical essence. Ideally, FM companies which are going through or considering to jump into cobotics are able to take a look at the research and learn what this case study has brought forward, and help them to understand what is important for them to consider and to expect. Research like this is able to deepen the industry knowledge on a topic which will grow in the coming years, and become normality. As companies read this, or similar research, they should consider how they can best prepare and understand what resources to invest into which channels to achieve the best outcome. An example is, as training has been considered crucial from this case studies participants, that readers looking to embark on the cobotics journey also consider investing into a well thought out training plan for their employees.

5.5. Conclusion

To conclude the research, what are success factors within the implementation process of collaborative robots in a facilities management company? There is no 'one size fits all' list of factors which are relevant to every company in a specific sector to ensure success. With a wide variety of parameters within each case, influencing every outcome, it is of value to develop a general understanding of how cobotics implementation takes place and factors which should be considered, rather than creating a perfect blueprint. In undertaking qualitative research, participants were able to share and explain their reasonings for why they believe certain factors are important, versus others. This research broke down the individual complex aspects of an implementation case with the assistance of a framework, to then be built upon to better mirror the needs of the FM industry. The results of the study are extensive, however there are a few key factors which were considered universally fundamental. Furthermore, participants believe that there are a few common themes which the framework did not mention which are important to facilities management being the importance to consider that FM companies do not work on their own buildings but instead conduct services on client infrastructure. Overall the factors proposed by Kopp et al. (2020) were perceived as being relevant to the participants in relation to their case and companies within manufacturing. Further crucial factors which were listed outside of the framework also include ROI, overall satisfaction and general client feedback as well as robot performance.

Overall, the framework from Kopp et al. (2020) proposes a substantial basis for factors which are relevant in the case cobotics implementation process within a facilities management company, of which few factors were considered irrelevant, and others were added based on the contextual map of the FM industry, in which the companies used within the research find themselves.

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Appendix

Appendix A - Pre-research interview results in summary

Participant Number	Challenges in industry	Benefits of cobots
1	● High number of staff deficits ● High staff turnover rate ● Unreliability of human workers (sick, quitting etc) ● Privacy and safety ● Humans using cobots: afraid of tech, shy away, not tech savvy ● Back out of adoption because of non-acceptance	● Cobot helps solve labour shortage ● Cobots reliable ● Fixed costs vs high variable costs every month ● Reduces safety issues of massive jobs ● Ready available cleaning data: proof
2	● Proving, will it work? ● Safety and privacy ● Proving return on investment ● Feeling of replacement ● Why are some not even considering cobotics? ● Slow adoption rate	● No high CAPEX initially ● Both small and large firms use robotics
3	● All comes down to ROI and costs ● Labour shortage ● Long adoption learning curve ● High expectations of clients ● Technical shortcomings of cobot ● Feeling of: job loss, change of routine ● “now works, why change” mentality ● County’s labour costs considered	● Usage to also seem visionary ● Ability to access aggregated data
4+ 5	● Cobotics have a limited impact so far ● Labour shortage ● Replacement feeling ● Lack of adoption ● Cannot work without human assistance ● Change may be difficult for firms ● common problems in starting working with the robots ● General approach in tackling others ● Cleaners afraid of damaging equipment ● Over time they get used to the unit ● Client is involved in the implementation process!!!! ● Schedule of the robot is based on client ● They work at the same time as robot, 3 hours	● Freeing human from hazard ● High-quality reliable cleaning ● Removes mundane tasks

	• Intervention with unit: charging, mapping, cleaning the unit, moving the unit to new location, troubleshooting if breakdown • Reactions to technology are very different. Some are open-minded, others are apprehensive. Some are very afraid of losing their job • ROBOTICS in general, digitalisation, not only cleaning robot • They realise not everyone can lose their job • High turnover, not enough workers • FM not all about cleaning floors • Workers can influence the purchase • Labour cost in Romania lower, slowing adoption • Clients needs are very dependent	

Appendix B - Interview Questions

Interview questions

Phase 1

- Job title
- Years of experience
- Industry
- Years of experience with robotics (Current / past)
- For how long now have you witnessed an industry shift in FM towards robotics usage?
- What do you think the future will look like with robotics and facilities management?
- Do you have any future plans in adopting more technology? What do you currently use?
- What does your company currently do with robotics?

Phase 2

1. Do you believe robotics has been successfully implemented/deployed within the company?
2. Through the decision phase to the operation phase, did you measure success of implementation?
3. How was success measured in each stage? (decision, implementation, operation)

4. Of these, which have you achieved and which not? Why?

Phase 3

Success factors framework presented visually and explained

1. Clarify: the implementation of the robotics was successful? > Did the success factors play a role? If yes, why, if no, why?
2. For the specific changes that occurred in the specific phases > did the success factors play a role? If yes why, if no why? Which not? Why? (split also into the 4 elements)
3. What do you believe the overall most important factors were that allowed for successful implementation within each of the phases?
4. Is there something missing from the framework that is applicable to your case specifically? Does this apply to FM overall or just your case? > follow up on this, on what makes the case unique, what makes FM unique etc.
5. Out of all the measurements of success and factors in the implementation of robotics, is there something you would have done differently and why?

Appendix C - Adjusted interview questions

Phase 1

1. Job title
2. Years of experience
3. Industry
4. Years of experience with robotics (Current / past)
5. For how long now have you witnessed an industry shift in FM towards robotics usage?
6. What do you think the future will look like with robotics and facilities management?
7. Do you have any future plans in adopting more technology?
8. What does your company currently do with robotics?

Phase 2

1. Do you consider the implementation of robotics so far successful?
2. How do you measure success? (KPIs, surveys etc)

Phase 3

Success factors framework presented visually and explained

1. Did the success factors play a role in FM? If yes why, if no why? (split also into the 4 elements and the 3 phases) (go through one by one) > which factors are relevant to FM which are not within each of these blocks?
2. What do you believe the overall most important factors were that allowed for successful implementation?
3. During the implementation, is there something you would have done differently, and why?