Process modularization and process mapping supporting perceived proximity

A case study focusing on the complex process of producing CGI-content

Master's thesis in Quality and Operations Management

RAGNAR COLEBRING
JOSEF MELIN

DEPARTMENT OF TECHNOLOGY MANAGEMENT AND ECONOMICS
DIVISION OF SERVICE MANAGENT AND LOGISTICS

CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2023
www.chalmers.se
Report No. E2023:056

REPORT NO. E2023:056

Process modularization and process mapping supporting perceived proximity

A case study focusing on the complex process of producing CGI-content

RAGNAR COLEBRING
JOSEF MELIN

Department of Technology Management and Economics
Division of Service Management and Logistics
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2023

Process modularization and process mapping supporting perceived proximity
A case study focusing on the complex process of producing CGI-content
RAGNAR COLEBRING
JOSEF MELIN

Report no. E2023:056
Department of Technology Management and Economics
Chalmers University of Technology
SE-412 96 Gothenburg
Sweden
Telephone + 46 (0)31-772 1000

Gothenburg, Sweden 2023

Process modularization and process mapping supporting perceived proximity

A case study focusing on the complex process of producing CGI-content

RAGNAR COLEBRING
JOSEF MELIN

Department of Technology Management and Economics
Chalmers University of Technology

SUMMARY

A company creates value through its processes; companies that do not manage and improve their processes risk being out-competed by those who do. Process management aims to improve processes' efficiency by standardization, however, complex processes might demand both efficiency and flexibility. This thesis investigates how to improve efficiency and flexibility of a complex, multi-actor, inter-organizational process through process mapping and modularity in a way enhancing perceived proximity. Consequently, a case study at a multinational manufacturing company was performed where the process of producing CGIs (Computer Generated Images) for information and marketing purposes was investigated. A total of 20 unstructured and semi structured interviews were conducted, as well as two focus groups. The respondents originated from different departments and organizations involved in the process. In addition, one benchmarking interview was held.

Our analysis shows that the challenges of the CGI-process are a lack of structure, non-defined responsibility, high product complexity, and non-optimal perceived proximity. Moreover, parts of the process are shown to be suitable for modularization, but not all. Furthermore, the analysis suggests that a modular, cross-functional process map can serve as a shared mental model between the actors to facilitate quality communication and increase perceived proximity. Furthermore, process map provides structure and defines responsibilities through mapping the activities and roles/actors. Last, it copes with the high product complexity through adding three modules.

Keywords: process modularity, process mapping, perceived proximity, shared mental models, CGI.

Acknowledgements

This thesis was conducted during the spring 2023 at the division of quality science at Chalmers University of Technology in cooperation with the Case Company. We would like to extend our gratitude to everyone that has contributed to this thesis. We would like to express a special acknowledgement to our supervisor Ida Gremyr at Chalmers University of Technology and our supervisors at the Case company. We would also like to express our appreciation to all employees at the Case company that has participated in interviews, provided valuable information and shared their experience.

Josef Melin & Ragnar Colebring, Gothenburg, May 2023

Contents

List of Acronyms

Below is the list of acronyms that have been used throughout this thesis listed in alphabetical order:

CAD	Computer Aided Design
CGI	Computer Generated Image
CMF	Color Material and Finish
ICT	Information and Communication Technology
IT	Information Technology
R&D	Research and Development

List of Figures

List of Tables

1
Introduction

This chapter serves as an introduction to the study, providing context and background information. A brief overview of the case together with the need for the study will be discussed. Furthermore, the purpose and research questions will be addressed in this chapter followed by its limitations.

1.1 Background

Balancing individual customer needs and at the same time maintaining an optimal level of service efficiency is challenging as customer demands become more diversified and complex (Bask et al., 2011). Standardization of service processes is a common approach to achieve efficiency in service processes (Böttcher & Klingner, 2011; A. Davies et al., 2007; Sundbo, 2002; Tuunanen & Cassab, 2011). However, establishing a balance between efficiency and customization is challenging since these two factors are often correlated (Rust & Huang, 2012), especially as customer demands in service processes are diversified in nature (Rahikka et al., 2011).

As an answer to standardizing processes, firms have used *process management* as a way to analyse, improve and control processes (Palmberg, 2009), while *process modularization* has recently gained more researchers' interest as a way to increase customization without the drawback of inefficiency (Carlborg & Kindström, 2014).

Process management is used to increase the customer perspective within an organisation, thereby providing increased customer value. Moreover, since processes works across functions and includes internal and external stakeholders, focusing on the process enables functions that previously worked in silos to align their goals (Gremyr et al., 2020). A process is characterised by transforming an input to an output that bring value to a stakeholder, which can be an internal stakeholder or the final customer (Palmberg, 2009). Furthermore, a process is repeatable, which allows for learning and improvement (Gremyr et al., 2020). However, one critique towards process management is that it sometimes fails to incorporate human and organisational issues as a result of focusing exclusively on standardization. The processes thus become rigid and does not fulfill the customer need (Vakola & Rezgui, 2000).

Modularization is a concept that has been proposed as a solution to ease the challenge of balancing customization with efficiency (Araujo & Spring, 2010). This concept is mainly based on standardizing sub-processes and products (Jacobs et al., 2007), while at the same time allowing a certain level of customization through its modular design for individual customers (Bask et al., 2011). According to Campagnolo and Camuffo (2010), the majority of research on modularity has been focused on product modularity. However, there is a growing interest in exploring its potential in other areas as well (Araujo & Spring, 2010). Adopting a modular approach in businesses could offer cost efficiency and effectively address the growing diversity of customer demands (Pekkarinen & Ulkuniemi, 2008). Nonetheless, the modularization of processes is linked to the standardization of sub-processes. However, maintaining a balance between standardization and flexibility remains a challenge, particularly when multiple actors participate in the ordering process. Therefore, comprehending and exploring the interaction between adjacent modules and other aspects, such as the perceived cognitive level between actors becomes crucial as it could influence the perceived proximity.

Originating from virtual teams, perceived proximity refers to how close one feels to another, instead of only focusing on the geographical distance (Wilson et al., 2008). Boschma (2005) argues that the five dimensions of perceived proximity is cognitive proximity, social proximity, geographical proximity, institutional proximity and organisational proximity. Further, Wilson et al. (2008) defines communication and identification as the core processes that affect perceived proximity, followed by individual and socio-organizational factors. Moreover, too much perceived proximity has a negative effect on performance and can lead to frustration and inefficiency (Boschma, 2005; Paananen et al., 2013; Wilson et al., 2008).

Building on Wilson et al. (2008) idea of communication and identification being the core processes of perceived proximity, Zamani and Pouloudi (2022) argues that shared mental models are a way to achieve just that. For instance, sharing an understanding of the tools of communication and collaboration, which is usually an information and communication technology (ICT) (Zamani & Pouloudi, 2022).

1.2 Case Company

The case is a multinational company that provides a diverse portfolio of products for individual customer needs. The company has identified a process that is unclear and leads to quality issues, higher cost and higher workload. This process is connected to computer generated images (CGI), which in this case are 3D-pictures that are mainly used for marketing purposes, product information and congfigurators. The aim with ordering a new CGI is to be able to show different variants of products or new features that are not produced yet. These CGIs could therefore be used instead of a real picture and still show the functionality and design to the customers.

Since the company manufactures a variety of products and different variants where the customer can adapt and choose between many different features, it challenges the way to bring forth CGIs for new design and functionality. The personnel recognizes the need for clarification in several areas, such as defining the process, clarifying responsibilities, and creating mutual understanding among stakeholders.

The orderers of the CGI is part of the sales organisation, but the process requires input from both the R&D organisation and an external supplier. The R&D organisation for some products sits at the same site as the sales organisation, however, for other products it is located abroad. In both instances, it is clear that the collaboration and coordination is hampered by the difference in perspectives and proximity. Recently there have been efforts made to improve the process which have had positive impacts, such as appointing a project coordinator, but the process still has difficulties.

1.3 Purpose and Research Questions

Extensive literature exist on how process management and process modularity can improve innovation and customer value. However, there exists a gap in the literature on how improvements and redesigns of a process can be made to enhance perceived proximity. All concepts strive to achieve increased performance, however, perceived proximity has, to the knowledge of the authors, not been applied in the context of process improvement outside innovation or productivity of virtual teams (Boschma, 2005; Wilson et al., 2008). As a result, the purpose of this study is:

Investigate how to improve efficiency and flexibility of a complex, multi-actor, inter-organizational process through process mapping and modularity in a way enhancing perceived proximity.

To fulfill the purpose, the thesis aim is to answer the following research questions:

RQ1: How can process mapping be used to increase understanding of work procedures in a multi-actor process?

RQ2: How can process modularity be used to simultaneously improve efficiency and flexibility?

RQ3: How can a process be designed to enhance perceived proximity in a multi-actor process?

1.4 Limitations

This study is limited to the CGI-process and does not take other processes into account, in addition the study will only map the case company's process, not the supplier's. The result will provide recommendations for internal improvement, but does not include recommendations for external stakeholders. If the suggested recommendations are put into effect, there will be no measurement or evaluation of the implementation outcome.

2
Theory

The purpose of this chapter is to introduce the theoretical framework compiled from the literature study, which will serve as a basis for analyzing the findings in the following chapters. As the research focus on how to improve a complex and multi-actor process and its efficiency and flexibility by process mapping and modularization, there is a need to understand topics such as process management, process modularity, and perceived proximity.

2.1 Process management

Process management within an organization have the purpose of enhancing the customer-centric approach, and thereby improving efficiency and effectiveness (Gremyr et al., 2020). Process management use several perspectives to achieve the purpose of having a customer view in the organization. One of those are process mapping, used for visualizing a process by outlining the steps for the process and the connection between them to increase understanding of the workflow (Damij, Damij, et al., 2014). Moreover, process re-engineering and process improvement are slightly different perspectives to achieve better performance. Process re-engineering means to completely rethink a process and "start from scratch", while process improvement makes less drastic changes. An improvement can be e.g., elimination of bureaucracy or simplification of methods (Davenport, 1993).

Processes can be defined in different ways, e.g., a group of activities that leads to some sort of output or result (Harrington et al., 1994; Khoong, 1997; Madison, 2005; Palmberg, 2009) or a mechanism for creating and delivering value to customers (Madison, 2005; Martin & Osterling, 2012). Hence, in short, processes are how work gets done and by whom in organizations (Davenport, 1993; I. K. Davies, 1994; Madison, 2005; Martin & Osterling, 2012; Rummler & Brache, 2012). Furthermore, workflow and information flow could be considered to be the two primary processes that are involved in any organization (Madison, 2005), where workflow is a systematic approach to handle processes and tasks which follow a specific order. In the context of process management, the information flow could be considered the exchange of information between people, organizations, systems or processes.

As processes form a fundamental part of an organization, understanding process can be valuable in analyzing and diagnosing problems and find the root cause (Madison, 2005). The same author also highlights several crucial aspects for effective process management. First, to define the scope of the process clearly. Second, it is important to identify all relevant stakeholders and process variations to ensure that the process map is realistic. Moreover, in multinational organizations with complex processes, these aspects can be challenging to address, as there may be many stakeholders involved and assigning responsibilities can be difficult. Marriott (2018) stresses the need to overcome these challenges and ensure that all stakeholders understand their roles and responsibilities to achieve successful process management. According to the same author, creating process maps aids in visualizing work procedures, which enables understanding of what you are doing and overcoming the mentioned challenges.

Trkman (2010) provide a case study on a medium-sized bank to discover critical success factors for process management. In line with the arguments provided by Marriott (2018), Trkman (2010) also mention critical success factors such as standardization of processes, level of IT (information technology) investment and organizational changes such as structural changes. The main idea behind these success factors were to create continuous improvement to sustain benefits from process management, create a fit between business environment and business processes, and construct a fit between available technology and the organization's processes. Moreover, to be able to manage processes, an initial step is to map them to visualize the activities involved and the work that gets done to deliver output in an organization.

2.1.1 Process mapping

Process mapping is a powerful tool for visualizing workflows and enabling teams to gain a clearer understanding of processes and the steps involved (Damij, Damij, et al., 2014; Kalman, 2002). Furthermore, process mapping is useful in communicating processes to stakeholders and identifying areas for improvement (IBM, 2023).

There exist various form of process maps, such as cross-functional flowcharts, value-stream maps, process flowcharts, workflow diagrams and deployment maps to name a few. Moreover, a cross-functional flowchart (figure 2.1) inspired by Kalman (2002) identifies the interrelationship between departments and stakeholders, and creates potential improvement for simplifying the workflow, communication and cooperation across functional boundaries. Damelio (2011) continues stating that a cross-functional process map represent the workflow of an organization, and includes interrelated work activities and resources that follow a specific path as inputs (resources) are transformed into outputs that are valued by customers. Such a map demonstrates that the end-to-end work process spans across multiple functions or other organization entities and is useful for mapping complex processes with multiple actors involved from different areas (Damelio, 2011).

Regardless of the industry or setting, the fundamental principle of process mapping is that it is not possible to manage something that is not measured (Marriott, 2018). Without understanding the steps involved in a process and their sequence, it challenges the decision of what and how to measure. Gremyr et al. (2020) state

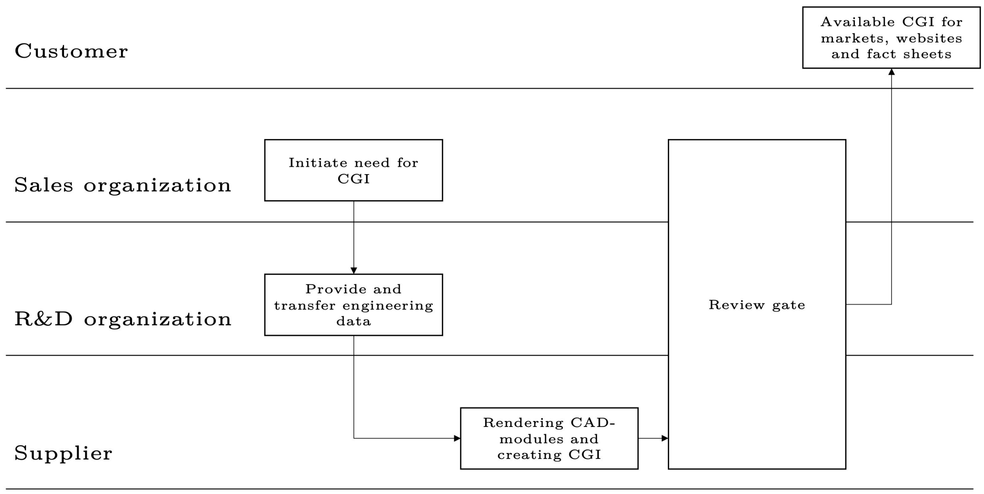

Figure 2.1: A simple cross-functional flowchart for the case company inspired by Kalman (2002)

that inability to describe a process means that you do not know what you are doing, which may lead to the risk of being outcompeted by other organizations that possess the knowledge of what, when and how to improve.

The stakeholders that are involved in a process on a daily basis serve as the most valuable source of information for providing a realistic process map (Graham, 2006). These individuals are familiarized with the daily work and possess experiential knowledge from observing instances of failure in the process. Therefore, they could contribute to their resolution, or as mentioned, simplifying the workflow and improving communication and coordination between functions (Kalman, 2002). Furthermore, according to Graham (2006), there are three key factors to ensure successful process mapping. First, the individuals performing the work that is being mapped must provide accurate information and comprehend and support the rationale behind the mapping. Second, the map must be structured in a way that enables everyone involved to clearly understand the process. Third, the compiled information to support the mapping must be valid.

It is essential to consider critical aspects such as individual's concerns that the process map could potentially eliminate their daily work, or their reluctance to delve into minute details due to perception that such information is unnecessary (Graham, 2006). These aspects could be dependent on that employees experience concerns towards a change in power dynamics, the requirement to acquire new skills, or the potential stress of integrating into a new team (Kegan & Lahey, 2001). Moreover, resistance to change does not solely rely on opposition or inertia, it is rather a complex phenomenon where individuals, despite their genuine desire for change, unconsciously channel their productive energy towards competing commitment (Kegan & Lahey, 2001). Hence, this leads to a balance that might hinder progress and can be misunderstood as resistance, but is, in reality, a manifestation of personal immunity to change (Kegan & Lahey, 2001). To clarify, the immunity is a hidden commitment to change, e.g., when someone fears to complete the task at hand because s/he want to avoid the next task due to the fear of failing or take on a tougher assignment.

2.1.1.1 Examples of process challenges

Within the healthcare sector, Marriott (2018) provides an example of a process map for a clinic visit that illustrates its complexity and challenges. The more people, groups, departments, and specialities, the more complicated the process map become. Moreover, new technology and techniques do not always fit into existing process, which challenges the clarification of the process map (Marriott, 2018). Hence, these factors needs to be considered when investigating and mapping processes, not only within healthcare but also for other organizations that have complex processes with similar or other critical aspects. Difficulties in clarifying the process to increase understanding for the work that gets done (Damij, Damij, et al., 2014), or to understand what organizational changes that needs to be done to achieve better performance is therefore important to acknowledge (Davenport, 1993).

Another example is the design process of a product, which is a multifaceted process that involves numerous integrated efforts. This includes generating ideas, developing concepts, modifying details, and evaluating prototypes as pointed out by Hsiao and Chou (2004). However, the complexity of designing complex products is not solely dependent on technical engineering aspects (Seol et al., 2007). The managerial complexity, which arises from managing collaborations among different engineering disciplines, posses an additional challenge to the design process (Tang et al., 2000; Yassine et al., 1999). To clarify, in other complex processes besides the design process, these engineering disciplines could be equivalent to different departments for example. To be able to tackle such complexity problems, it is essential to document all constituent design activities and identify their inter-dependencies (Yassine et al., 1999). Moreover, design process decomposition is a valuable technique for dividing the workload between design teams and expediting the design process (Smith & Morrow, 1999). By breaking down the components, the complexity of the design process can be managed effectively and is the reason for why several studies have embraced this approach (Seol et al., 2007). Even though this research is focused on design processes, implications, according to Bask et al. (2011) could be drawn to other areas to decompose processes into subsystems to achieve customization.

2.2 Process modularization

The following section offers an exploration of the concept modularization, including its definition and purpose. Additionally, a framework for various classifications of service process typology alongside a model which explains the potential benefits of external integration in enhancing service performance is presented.

2.2.1 Definition of process modularization

Tuunanen and Cassab (2011) define service process modularization as "*the systematic combination of service encounter processes known to both the customer and the firm that generates new, customizable service packages of increased utility to the customer*". The objective with modularization is to group individual functionalities into modules, and therefore making them as reusable as possible (Hyötyläinen & Möller, 2007). Moreover, Böttcher and Klingner (2011) divide the aim with modularization into five aspects; reduction of efforts, configuration, improved transparency with reduced complexity, enhancements and improvements, and reusability. These modules can be useful in constructing complex processes from smaller, independently designed sub-processes that could function together as a whole (Baldwin & Clark, 2003). Hence, process modularity could be used to break down processes into subsystems in order to achieve customization on a higher level (Bask et al., 2011). However, in order to fully exploit the benefits of modularization, the modules must be clearly defined (Carlborg & Kindström, 2014).

Clearly defining the modules is a task that is easier said than accomplished, but as stated by Böttcher and Klingner (2011), two methods could be utilized for constructing service process modules. The two approaches are the creation of modules that can be utilized for service offerings (creation), or dividing existing service offerings into service modules (decomposition). However, it is essential to specify and scientifically address the suitability of each method for the particular case. In order to create a scenario with a useful method, aspects such as staff education (how to work with the modules), organizational changes (restructuring departments), and the creation of development methods have to be addressed sufficiently (Böttcher & Klingner, 2011). Moreover, Burr (2016) states that the construction of modules is dependent on the potential of the existing resources, thus emphasizing the significance of evaluating the available resources before initiating process modularization.

2.2.2 Purpose of modularization

The advantages of using a modular strategy have been known for a relatively long time in the area of software engineering, where reuse and variation of different software modules aids in developing new functions in an efficient manner (Tuunanen & Cassab, 2011). Furthermore, Böttcher and Klingner (2011) states that modularization typically involves acknowledging three aspects: an architecture that outlines the modules, an interface that explains the modules interaction, and standards for testing a module's suitability to the design rules. This perspective is also supported by Baldwin and Clark (2003). To clarify, within software engineering, components as modules are artefacts that are identified in the software system (Böttcher & Klingner, 2011). According to Sametinger (1997), these components have an interface, carry internal details, are documented separately to one another, and are characterized by reusability, accessibility and encapsulation of functionality (Böttcher & Klingner, 2011). Moreover, testing a modules suitability to the the design rules means to investigate if module X function in the system or investigating how good module X is compared to module Y, i.e., the relative performance (Baldwin & Clark, 2003).

The purpose of utilizing software modules is to simplify complexity, combine customer specific and standardized software, eliminate redundant code, promote reuse, and realize cost benefits (Czarnecki et al., 2002; Gao et al., 2006; Szyperski et al., 2002). The advantages of modularization are pursued by both industrial engineering and software engineering (Böttcher & Klingner, 2011). While there may be differences in how modularization is implemented, the basic methods are comparable in both areas. Therefore the experience of industrial and software engineering can be applied to benefit modularity of service processes. However, it is important to adapt the modular approach to the specific context at hand (Böttcher & Klingner, 2011).

2.2.3 Framework for service typology

According to Carlborg and Kindström (2014), services as processes with respect to the role of the customer could be divided into four different types (Figure 2.2). The process could either be rigid or fluid, and the role of the customer could be either passive or active. The characteristics of a rigid process are high formalization and centralization, standardization and low task variety and relatively low information exchange between actors. The fluid process on the other hand requires high level of information exchange between customer and service provider, high level of technical skills as well as several judgmental decision points in the process. As mentioned, Carlborg and Kindström (2014) emphasize that the customer could either have a passive or active role in the process, which is concerned with the degree of participation between the provider and customer. Active participation refers to a high level of involvement or co-creation, while passive participation implies a low level of engagement. However, according to Droge et al. (2012), the external integration in the supply chain could either be a supplier or a customer. Hence, whether the supplier's role is active or passive in the process is of interest. Moreover, in processes where there exist both customer and supplier interaction, creating different process paths, Grönroos (2011) states that the processes are not two parallel processes working independently of each other. This is an interactive, unified and coordinated process that involves both the customer and the supplier contributions.

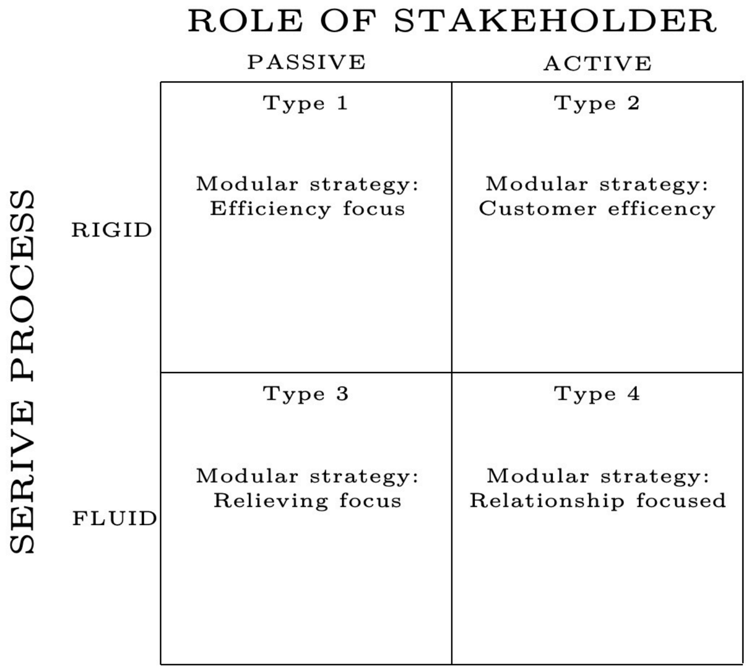

Figure 2.2: Different service process types influenced by Carlborg and Kindström (2014)

When the stakeholder is inactive (i.e., type 1 and type 3), the modular strategies are *efficiency focus* and *relieving focus*. Since standardization is important for type 1 processes, the modules also needs to be standardized. This leads to cost effective processes. For type 3 processes Carlborg and Kindström (2014) suggests that there needs to be a large number of modules to cope with the fluid service process. Furthermore, a project coordinator role should exist to solve the individual customer need.

In the cases of an active stakeholder role (i.e., type 2 and type 4), there are two modular strategies suggested by Carlborg and Kindström (2014). First, for process of type 2 where the stakeholder is active and the process is rigid, a *customer efficiency* modular strategy is suggested. This means to have standardized modules but high customizability, so the customer can choose how to spend their resources. Second, the modular strategy for a type 4 process is instead *relationship focused*. Since this process requires resources/inputs from different departments, the actors needs to understand each other and communicate well. The modules for this process needs to be independent and combined into bundles (Carlborg & Kindström, 2014).

2.2.4 Framework for process integration

Droge et al. (2012) introduced a research model (figure 2.3) that explores the interrelationships between process strategy, external integration, and service performance. This model also exhibit that changes in performance can be both directly and indirectly influenced by integration and process strategies. Droge et al. (2012) suggest that process strategies can stimulate socialization (external integration) and hopefully impact service performance for the better. Moreover, the integration of the supply chain is described as a process of redefining and linking entities through the coordination and sharing of information and resources (Katunzi, 2011). Petersen et al. (2005) defined supplier integration as a practice where suppliers provide information and directly participate in decision-making, which is characterized by a cooperative relationship between the buyer and the upstream supplier. On the other hand, customer integration involves the flow of products in the forward direction and the flow of information in the backward direction, from the customer to the supplier (Frohlich & Westbrook, 2001; Narasimhan & Carter, 1998). Therefore, successful integration within the supply chain requires effective coordination and collaboration with both customers and suppliers (Droge et al., 2012).

In the study conducted by Droge et al. (2012), various automotive manufacturers were examined. The findings indicate that managers lacking the flexibility or financial means to invest in supply chain integration can achieve service performance enhancements by investing in modular architectures. First, product modularity encourages integration within the supply chain. Second, since modular product architectures have a noteworthy cumulative effect on both support and delivery performance, investing in such architectures is likely to result in some form of service performance benefit, either directly, indirectly, or both.

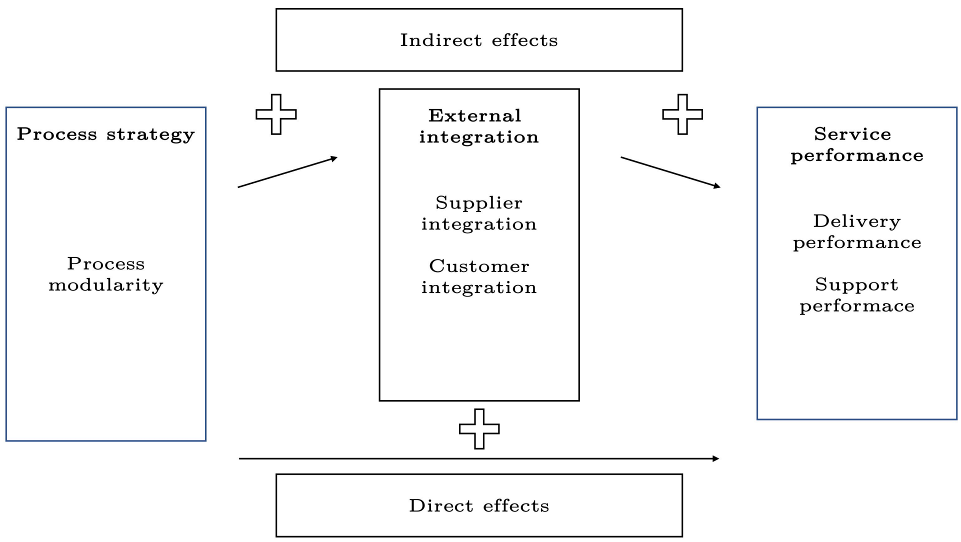

Figure 2.3: Research model inspired by Droge et al. (2012)

2.2.5 Customers and suppliers role in processes

The customer´s role in service processes is crucial because they are often co-creating the service alongside the provider (Carlborg & Kindström, 2014). However, most studies on service modularity have focused on an internal supplier oriented perspective, ignoring the customer´s co-production role (Tuunanen & Cassab, 2011). The customers contributions to the service production process have in general been considered minor and supplementary (Xue & Harker, 2002). This narrow view of service modularity is a result of its goods-centric foundation (Bask et al., 2011). Nonetheless, it is misleading to view customer as a non co-producer since they typically play a significant role in service processes (Xue & Harker, 2002). Moreover, customer integration also affects the organization´s performance, particularly in terms of operational efficiency (Ostrom et al., 2010). Hence, understanding the customers role in service modularity is critical, as the level of customer contact and understanding of their needs influence the choice of a suitable modular strategy (Ulkuniemi & Pekkarinen, 2011).

In sum, when complexity in the process increases, modularity can reduce the complexity and increase flexibility by breaking down the process in sub-processes. However, when tasks in the process are uncertain and require coordination from several stakeholder resulting in the heavy cognitive load mentioned by Droge et al. (2012), it is difficult to break down and simplify them. Moreover, process management has received critique for failing to capture the human and organisational aspects in a process (Vakola & Rezgui, 2000). Therefore, perceived proximity is introduced in the next section as a way to understand the reasons behind this complexity. Furthermore, it can be put into consideration when designing a modular process.

2.3 Perceived proximity

In the following section, two theoretical models of perceived proximity will be presented. Next, the relation between perceived proximity and process management and process modularity will be examined followed by a framework.

In contrast to geographical proximity, perceived proximity is defined as how close or far one feel to another (Wilson et al., 2008). Although several decades of research on geographical proximity held that you feel closest to those physically close to you (Allen et al., 1984; Wilson et al., 2008), organizational and regional researchers started to question this notion with the development of information and communication technologies (ICTs) started to be used by firms (Amason & Sapienza, 1997). Several researches has since presented different complementary dimensions of proximity (Bunnell & Coe, 2001; Kirat & Lung, 1999). Boschma (2005) was the first to present a framework for proximity including the five dimensions Cognitive, Social, Organizational, Institutional and Social, when studying proximity's role in learning with relation to innovation.

Another model was developed by Wilson et al. (2008) using perceived proximity to explain the paradox of "far-but-close" in relation to virtual teams. In contrast to Boschma (2005), this model shows how shared identification and communication are the two main processes to achieve high perceived proximity. Furthermore, it argues that individual and socio-organizational factors also affects perceived proximity (Wilson et al., 2008).

2.3.1 Boschma's view on proximity

Drawing inspiration and building on the three dimensions of proximity: organizational; institutional; and geographical; presented by Shaw and Gilly (2000), Boschma (2005) defines the five dimensions of proximity that affect how close one feels to another. Arguing that perceived proximity reduces uncertainty and solves coordination problems, the author applied the model to understand its effect on innovation within firms. However, R&D does not work in isolation with innovation. Downstream actors are connected, and therefore, affected by the innovation process (Wheelwright & Clark, 1992). As a result, a complex and multi-actor process also suffer from uncertainty and coordination problem which can be understood and reduced by applying Boschma (2005) proximity dimensions.

2.3.1.1 Cognitive Proximity

Cognitive proximity can be defined as to what extent two actors share the same knowledge base. Without sharing a knowledge base, actors will be unable to effectively transmit knowledge, which is needed to innovate (Boschma, 2005). In other words, this means actors with non-overlapping knowledge bases do not understand each other and thereby can not innovate.

Cohendet and Llerena (1997) highlights the importance of knowledge diversity to foster innovation. In addition, the understanding that knowledge is spread inside and between organizations makes it challenging for firms to bring this knowledge together. Boschma (2005) means that cognitive proximity is a reason for these types of challenges, sharing some parts of the knowledge base is required to effectively interpret, exploit and transmit new knowledge and collaborate effectively.

As opposed to the other dimensions of proximity, the cognitive dimension is a requirement to learning and can not be substituted. This means that no matter how proximate two actors feel with regards to social, geographical, institutionally or organization proximity, it will not foster learning unless they share some knowledge base (Boschma, 2005).

2.3.1.2 Organizational Proximity

In the work provided by Shaw and Gilly (2000), the cognitive dimension was a part of organizational proximity. However, Boschma (2005) treats them as two separate dimensions and defines the organizational proximity as the extent to which relations is shared in an organizational arrangement. In the context of intra-organizational proximity, it refers to the relation between two units, for example R&D and sales.

Its effect on knowledge transfer and learning is that it reduces uncertainty and opportunism. Having high organizational proximity leads to strong control measures that actively reduces uncertainty and opportunism (Boschma, 2005). Furthermore, the need for feedback advocates high organizational proximity. Feedback require communication which is challenging to achieve when organizations does not share a relationship (Hansen, 1999).

2.3.1.3 Social Proximity

Social proximity refers to the closeness of socially embedded relations between actors. To what level a relationship is embedded depends on trust, which comes from friendship, kinship and experience according to Boschma (2005). Through high social proximity actors are able communicate more open, which enables learning (Lundvall, 1990).

Similarly to organizational proximity, social proximity can reduce the risk of opportunistic behavior. Through strong and committed relationships, actors are more likely to solve problems as opposed to pure market based relations (e.g., on the spot market) that dissolve when problems occur (Boschma, 2005).

2.3.1.4 Institutional proximity

Institutions are common habits, practices, rules and laws that regulate the relations and interactions between individuals and groups (Edquist & Johnson, 1996). Boschma (2005) uses this definition to say that institutional proximity is to the extent these institutional attributes are shared between two actors.

In one way, especially formal institutions (laws and rules), can hamper learning and innovation since they are regulating mechanisms. However, when focusing on proximity, it is instead interesting whether or not two actors share these attributes (Maskell & Malmberg, 1999). E.g., if two actors share the same law system, language, and habits, it enables them to communicate effectively and learn. In addition, it would secure intellectual property and other law related questions.

2.3.1.5 Geographical proximity

Simply put, geographical proximity is the spacial distance between two actors. It's effect on learning, economic value, and competitive advantage has been studied thoroughly before Boschma's (2005) paper, but as previously mentioned, not considering other dimensions of proximity. As a result, studies show that by literary bringing actors together it increases the ability to transfer tacit knowledge, and thus facilitate learning (Audretsch & Feldman, 1996).

2.3.1.6 Negative effect of too much proximity

Central in Boschma's paper is that too little proximity is detrimental to learning, collaboration and innovation, and too much proximity has negative effects as well. The effects are summarized in the table 2.1.

Table 2.1: Key variables and consequences of too much and too little proximity in each proximity dimension (Boschma, 2005).

Proximity dimension	**Key variable**	**Too little proximity**	**Too much proximity**
Cognitive	Knowledge gap	Misunderstanding	Lack of sources of novelty
Organizational	Control	Opportunism	Bureaucracy
Social	Trust	Opportunism	No economic rationale
Institutional	Trust	Opportunism	Lock-in and inertia
Geographical	Distance	No spatial externalities	Lack of geographical openness

Two reasons why being too cognitively proximate can be negative are highlighted. First, as aforementioned, innovation requires knowledge from different sources and backgrounds (Cohendet & Llerena, 1997), thus if two actors shared knowledge base is too similar, this diversity is not present. Second, being to close cognitively limits the team's ability to view new technologies and markets, instead relying on what has worked previously. This lock-in effect exist due to learned habits that is difficult to unlearn and has become insufficient compared to newer developments.

High organizational proximity is related to a hierarchical organization structure which also poses three issues. First, being locked in a specific relation or communication channel creates high dependencies on that single channel. Second, these channels does not have mechanisms for feedback as a result of the asymmetrical relations created in a hierarchical organization. Third, organizational flexibility is needed for innovation (Blanc & Sierra, 1999), and too high organizational proximity does not permit this flexibility.

Similarly to how high cognitive proximity can lead to lock-in scenarios, so can social proximity. Long term and strongly committed relationships can lead to actors not adopting new ways of working or new technologies. Moreover, although it might seem contradictory, high social proximity can lead to underestimation of opportunism. This is true in a world of calculating actors and dynamic environment (Boschma, 2005). It can be summarized as having a lack of economic rational when dealing with close relationships (i.e., valuing the social relationship over the more economically rational decision).

It is obvious that high institutional proximity can lead to lock in as it is under those laws and rules actors work in. However, since the institutional system is built up by numerous, and sometimes independent parts, it can cause inertia when adjustments needs to be made. These adjustments are frequent in the context of innovation or dealing with anything novel (Boschma, 2005).

Finally, geographical lock-in is the main negative aspect of too much geographical proximity. This lock-in refers to the ability to look outside of your immediate surroundings to find new technologies or solutions (Boschma, 2005). Imagine an industry complex where a business only seeks for partners or supply inside the complex, thus failing to spot a superior solution.

2.3.2 Wilson's model for perceived proximity

The paradox that Wilson's model of perceived proximity tries to explain is the "far-but-close" or the opposite, "close-but-far" in virtual teams (Wilson et al., 2008). Similarly to Boschma (2005), it means that the feeling of closeness does not correspond to the spacial distance, the geographical proximity, but instead other factors. In Wilson et al. (2008) model these factors are communication and identification, followed by socio-organizational and individual factors. The advantages of increasing perceived proximity in a virtual teams are reduced uncertainty, increased commitment to the team (Wilson et al., 2008), growth and well being of team members (Hackman, 1990). Thus it offers another perspective on perceived proximity not directly linked to innovation that, through combination with Boschma's (2005) model can lead to a more complete view on perceived proximity. Figure 2.4 shows Wilson's (2008) model.

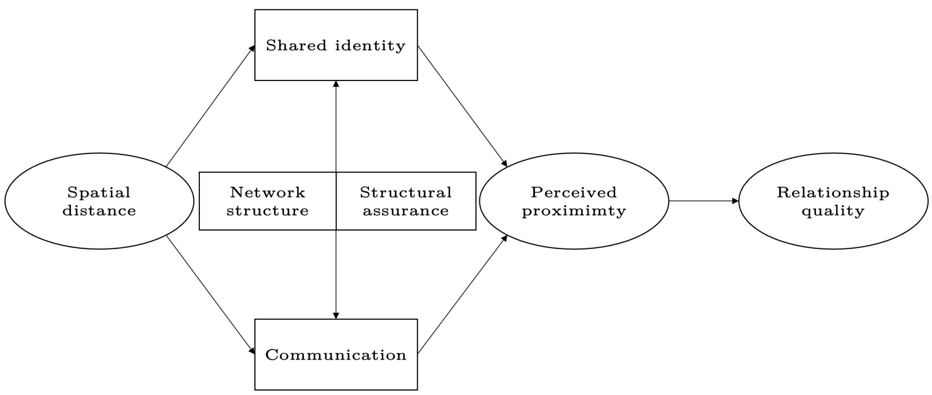

Figure 2.4: Wilson's (2008) model for perceived proximity

2.3.2.1 Communication

The first core process to increase perceived proximity is communication, which is measured with regards to how frequent, deep and interactive it is (Wilson et al., 2008). First, frequent communication increases cognitive salience, e.g., how often and readily something comes to mind (Sutrop, 2001). As a result, it reduces the problem of out-of-mind-out-of-sight seen in colleagues who do not naturally meet physically. Second, if the communication is both frequent and deep it allows actors to visualise each other's local situation better and therefore make informed decisions (Wilson et al., 2008). Third, if the communication is also interactive it allows for the optimal setting for communicating, thus reducing uncertainty further (Wheelwright & Clark, 1992; Wilson et al., 2008). However, too much communication can have negative impacts on relationship quality according to Wilson et al. (2008), hence labeling it insufferable proximity. Similar to Boschma (2005), Wilson et al. (2008) highlights that there exists an optimum where the level of proximity is just right.

2.3.2.2 Identification

The other core process that increases perceived proximity is identification, which is defined as the process of self-categorization with others (Wilson et al., 2008). Moreover, it affects perceived proximity through three mechanisms: establishing a common ground, reducing uncertainty (as with communication), and trust. First, to share a common ground you must share some social category, experience or entity. Consequently, it will lead to more understanding of another person (Clark, 1992). Second, through sharing an identity, it leads to uncertainty being reduced (Wilson et al., 2008). By projecting positive traits on the person you experience shared identity with, the person becomes more predictable (Cramton, 2001). Third, identifying with another makes you give them the benefit of the doubt as a result of trust (Wilson et al., 2008). Consequently, it is easy to fault a person's, that one does not identify with, motivations when data is absent (Cramton, 2001).

2.3.2.3 Socio-organizational factors

The two other factors from Wilson et al. (2008) model is structural assurance and network structures since these also affect communication and identification. Network structure is essentially the relationship ties to, in this case, team members. Strong ties represent strong relationships that consequently lead to more frequent and deep communication and identification (Wilson et al., 2008)

Structural assurance on the other hand refers to organizational safeguards like contacts, regulations, guarantees and legal recourse (McKnight et al., 1998). Wilson et al. (2008) makes an example where if the firm has rigorous hiring policies, it leads to increased communication and identification because you trust the new hire to be competent.

2.3.3 Achieve perceived proximity

Recent empirical studies based on Wilson's (2008) model show that one way to achieve quality communication (frequent, deep and interactive) is by having a shared mental model between actors (Zamani & Pouloudi, 2022).

2.3.3.1 Shared mental models

Mathieu et al. (2008) defines shared mental models as "*an organized understanding or mental representation of knowledge that is shared by team members*". Although used most extensively to understand team effectiveness (Mathieu et al., 2008), it can also be used to understand perceived proximity (Zamani & Pouloudi, 2022) and therefore also understand process challenges experienced at the case company.

The shared mental model can be broken down into four sub-models; equipment model; task model; team member model; and team interaction model. The definition of the models are shown in table 2.2 (Cannon-Bowers et al., 1995). Consequently, the more sub-models two actors share, the more of a total shared mental model these actors have. Moreover, to have high perceived proximity in virtual teams, all four models needs to be shared (Zamani & Pouloudi, 2022).

Table 2.2: The four sub-models of shared mental models (Cannon-Bowers et al., 1995)

Models	**Definition**
Equipment model	Shared understanding of the tools necessary for the completion of the task.
Task model	Shared understanding about what needs to be done for the completion of a task or a project.
Team member model	Awareness of each other's skills, desires, habits, beliefs etc.
Team interaction model	Shared understanding of what is known and/or believed about team processes.

2.3.4 Comparison and aggregated model

The models are different in three ways. First, the aim of the models are different. Boschma's model (2005) aims to understand what dimensions build up perceived proximity. In contrast, Wilson's model (2008) aims to understand what factors directly affect perceived proximity. I.e., Boschma (2005) investigate the building blocks of perceived proximity, while Wilson et al. (2008) investigate how to affect perceived proximity. Second, the context of the models also differ. Boschma (2005) studies perceived proximity's affect on innovation and learning. This is slightly different from Wilson et al. (2008), which focuses on relationship quality in virtual teams regardless of the activity of the actors (e.g., design, marketing, accounting etc). Third, shared identity is one of the core processes, besides communication, that Wilson et al. (2008) argues affects perceived proximity. Boschma (2005) on the other hand, does not mention shared identity in neither of the five dimensions.

Although differentiating in some areas, the models also overlap in three ways. First, even though not highlighting as it as a factor or dimension, communication is mentioned frequently in relation to cognitive, organizational and social proximity (Boschma, 2005). Second, Boschma's institutional proximity and Wilson's structural assurance are similar except the former operates at the macro-level, while the latter operates at the organizational-level. However, both deals with the rules and policies the two actors operates under (Boschma, 2005; Wilson et al., 2008). Third, social proximity and network structures both reflect how strong a social relationship is between two actors. Thus, having high social proximity could be expressed as having strong network ties or vice versa.

2.4 Framework

To summarize and connect the theoretical concepts process management, process mapping, process modularization and perceived proximity, a framework will be presented in the following section.

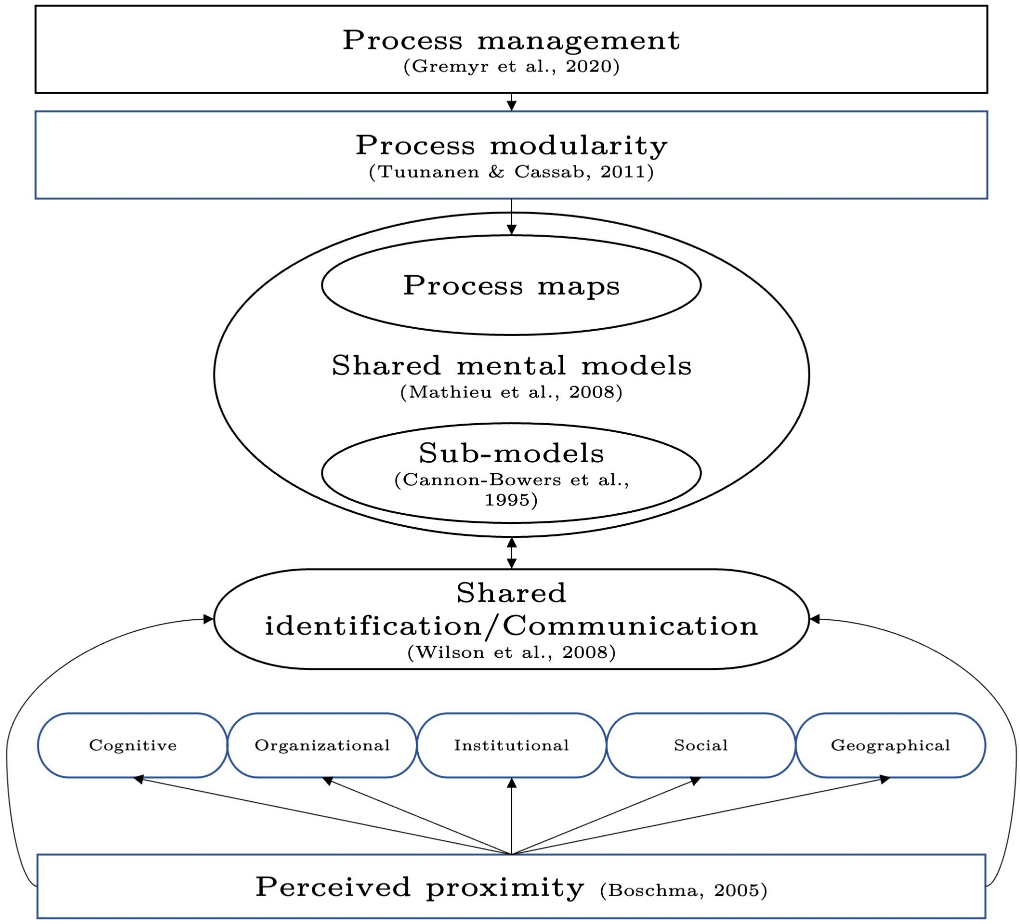

Figure 2.5: Framework connecting the process management, process modularity, process maps with perceived proximity and shared mental models

As aforementioned, process management is a way to achieve better performance in the terms of efficiency and effectiveness (Gremyr et al., 2020). To make changes to achieve a performance increase, understanding the process is a prerequisite, therefore, process maps can be used. Process maps serve as guidance for the stakeholders to understand their task and responsibility related to the final goal (Damij, Damij, et al., 2014). Moreover, process performance can be achieved through standardization, with the subsequent trade-off with flexibility (Trkman, 2010). In a complex, multi-actor and inter-organizational process, flexibility is necessary to cope with customization. Hence, in the traditional sense of process management, only standardization can not satisfy the needs for the process.

Process modularity aims to push this trade-off between standardization and flexibility further, i.e., allowing for both increase efficiency and flexibility (Czarnecki et al., 2002). It achieves this balance through creating or breaking down (creation and decomposition) the process into modules. Each module needs to be clearly defined and the users needs to be educated on how to use the modules. If done successfully, the process will consist of defined and standardized modules, that through the module's interfaces interact efficiently with each other and allows for customization and flexibility (Böttcher & Klingner, 2011). However, when certain tasks in the process are complex, uncertain and require input from several actors from different organizations, the corresponding module will also suffer from complexity (Droge et al., 2012). As a result, it will not be standardized and act as a bottleneck, thereby, reduce efficiency. To understand the nature of the complexity, one needs to understand the relationships between actors and organizations to ultimately reduce the uncertainty and improve efficiency.

Perceived proximity could help in understanding these relationships, furthermore, designing a process to support perceived proximity can help decrease uncertainty, which reduces complexity. Referring to how close two actors feel, as opposed to how geographically close they really are; perceived proximity can be broken down into five dimensions: Cognitive, social, organizational, institutional and geographical (Boschma, 2005). In addition, the main factors that influence perceived proximity is communication and identification (Wilson et al., 2008; Zamani & Pouloudi, 2022). How proximate you feel to another actor is determined by the overlap in each dimension. Furthermore, quality communication and shared identification serves as ways to impact at least cognitive-, organizational- and social proximity.(Boschma, 2005; Wilson et al., 2008)

One way to increase quality communication and shared identification is that the actors have a shared mental model. By having a shared mental model of the equipment, task, team members and interaction (team processes), the team will experience high perceived proximity (Zamani & Pouloudi, 2022), and reduce the uncertainty regarding complex modules/tasks. Furthermore, a process map could be used both as a form of mental model per se, and to further increase the shared mental models as it defines the process for all actors involved.

3
Methods

In this section, the research methodology is described. The section describes the research strategy and research design that this research is based on, including the data sources and methods used. Additionally, trustworthiness is discussed to increase the quality of the study as well as consideration of ethical principles.

3.1 Research Strategy

The choice of research strategy is determined by the suitability for the specific study and could either have a qualitative or a quantitative approach (Bell et al., 2022). The selection of an appropriate approach is based on its alignment with the purpose of the study and the research questions under investigation. There is a notable distinction between the two approaches, and according to Bell et al (2022), quantitative research relies on numerical data, while a qualitative research incorporates written or spoken words and images. In this study, the CGI-process was investigated with the purpose of improving the process by redesigning it with support from process modularity and perceived proximity. To understand the CGI-process, what actors that are involved, and the complexity of different needs, it was necessary to collect data through verbal interaction and images. Hence, it was appropriate to use a qualitative approach since the understanding of the process was not based on numerical data, but rather on text based data capturing experiences and views.

In traditional research, the connection between research and theory is commonly revealed through the use of either inductive or deductive reasoning (Bell et al., 2022). The two reasoning methods differ in their approach, as the deductive method aims to test existing theories using research hypotheses, while the inductive method aims to form new theories based on empirical data (Bell et al., 2022). However, in the field of business research, abductive approach has emerged as an alternative to the traditional methods of reasoning. This approach combines the elements of both deductive and inductive reasoning by starting with observations, forming hypotheses, and then comparing them with available information in order to arrive at a conclusion (Bell et al., 2022). Mantere and Ketokivi (2013) explain that the abductive reasoning process involves identifying the conditions that would explain a phenomenon and make it less mysterious, and hence, gradually transform unclear facts into expected outcomes. In order to fulfill the purpose of redesigning the complex multi-actor process, it was necessary to clarify the process through ongoing data collection, i.e., through continuous interviews and discussions. As the process became clearer and the questions were answered, the process map served as a foundation for transforming unclear aspects into actionable improvements as an outcome. Therefore, an abductive approach was considered suitable for this study.

3.2 Case study

The proposed research design for this research was a case study, and as outlined by Bell et al (2022) it is a method that involves a thorough and in depth analysis of a particular case, and in this study a specific process at a specific organization. Furthermore, qualitative case studies is a common approach for areas that previously has not been studied (Barratt et al., 2011).

The topic within manufacturing strategies has been researched for several decades (Hayes, 1979; Miller & Roth, 1994; Skinner, 1980), and it has been discovered that qualitative case studies within manufacturing strategies are integrative in nature (Barratt et al., 2011). For instance, when combining theories in manufacturing strategies with other related areas such as modularity, a case study appears to be suitable (Salvador et al., 2002). Even though this study did not investigate a traditional manufacturing process, implications could be drawn to other processes such as producing CGI. The rationale behind using a case study as a research design was due to the need to examine a particular phenomenon within a specific company. This required thorough gathering and analysis of data specific to this case.

This specific case company suited the purpose of this study since it is a large enterprise that manufactures complex products. Therefore, the processes are also complex which leads to several actors involvement is needed. Furthermore, due to the size of the company, these actors are spread out in different departments or organization. As a result, the purpose of investigating a complex, multi-actor and inter-organizational process suits the case company well.

3.3 Data Collection

The basis for this case study was conducted through an exploratory phase, literature study and an in-depth empirical study. The latter including interviews, focus groups, benchmarking and observations. These formed the basis for fulfilling the purpose of the study and answering the research questions. Figure 3.1 illustrates the data collection procedure as a funnel, showing the data collection tapering off towards the in-depth empirical study as a result of the previous steps.

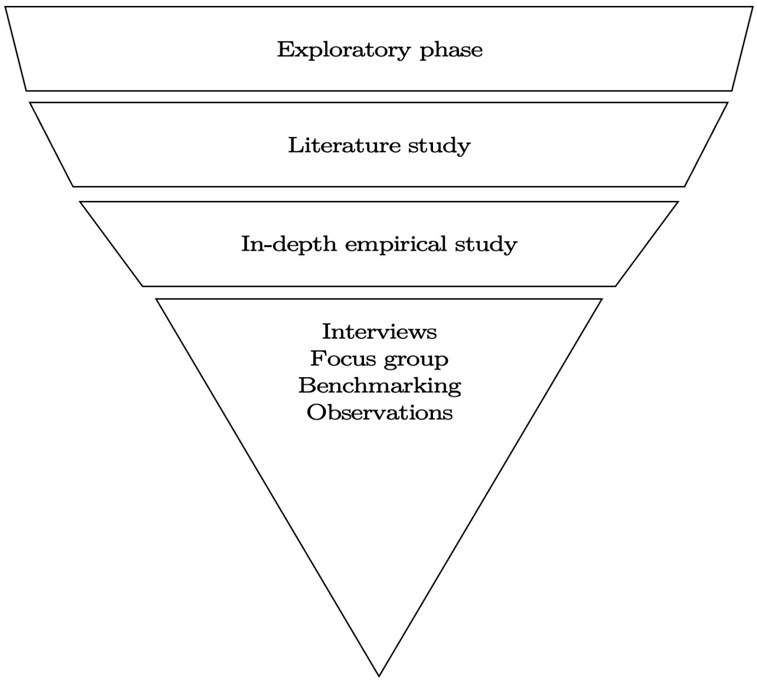

Figure 3.1: Data collection funnel

3.3.1 Exploratory phase

As mentioned by Bell et al (2022), at the starting point of a project, it is important to conduct an exploratory phase to gain a comprehensive understanding of the problem to be addressed, the project timeline, and available resources. Given the complexity and comprehensive nature of the investigation in this study, it was necessary to undertake an exploratory phase. Furthermore, this exploratory process includes elements of learning, listening, and sharing (DiCicco-Bloom & Crabtree, 2006). Neglecting to acknowledge the aforementioned requirements could have resulted in missing crucial information and making it challenging to execute the study.

The objective with the exploratory phase in this study was to gain a comprehensive understanding of the process and workflow associated with CGIs at a multinational company. In order to achieve this, the case company supervisors held an initial presentation of the problems they where experiencing with the process. Furthermore, the researchers had opportunities to ask questions frequently during the first weeks of the study both during meetings and through Microsoft Teams.

3.3.2 Literature Study

The literature study was conducted to understand what theories and concepts that already been investigated and applied in similar business field. This made it possible to get a better understanding of the concept, patterns and themes that arose in the case study as well as connecting these to other cases and contextualize possible findings within a scientific frame. The literature study took place concurrently with the exploratory phase and served as a tool to familiarize with the subject and understand the advancement made by previous researchers (Säfsten & Gustavsson, 2019). Hence, through this process, crucial and relevant information about issues or questions that could be useful throughout the study could be collected (Säfsten & Gustavsson, 2019).

The literature was mainly collected through search engines, such as Google Scholar, Emerald insights, Chalmers Library´s database and other recommended websites provided by Chalmers supervisor. Throughout the project, as more literature were examined, the keywords for searching became clearer. Hence, adapting to more specified and defined search was possible and enabled a deeper knowledge regarding how to examine patterns in the research findings, which is a key aspect for later interpretation of the material (Osanloo & Grant, 2016). Keywords such as *Process innovation, Process management, Perceived Proximity*, and *Process modularity* was used. In addition, relevant course literature in the master´s program Quality and Operations Management at Chalmers was used.

3.3.3 In-depth Empirical study

To gain a comprehensive understanding of the specific subject, this study was also based on an empirical study, which utilize a diverse range of method including interviews, focus groups, benchmarking and observations. The intent was to gather valuable data and insights that enhanced the understanding of the specific case, which facilitated the completion of the research study in a successful way. By aggregating data from various sources with multiple point-of-views, it was possible to gain a more complete understanding of the process.

Interviews

To gain knowledge and get a deeper understanding of the subject, a snowball sampling technique was used. This technique entailed that a limited group of interviewee candidates were collected and interviewed that had a relevant connection to the research. Subsequently, these individuals nominated additional participants they believed possessed experiences or characteristics relevant for the research, and this chain of nominating other candidates maintained iteratively, which is the characteristics of the snowball sampling technique (Bell et al., 2022). For this study, the researchers were given a list of people that were considered as suitable interviewee objects at the beginning of the research, and they in turn recommended others. Having a predetermined list from the beginning could challenge the evaluation if the candidates is truly the right people to talk to. Especially when the list was provided at such an early state when the researchers were not familiar with the subject yet. However, this list had a particular advantage in that it allowed the researchers to schedule interviews early without the need to identify relevant individuals, resulting in potential time savings. However, with a snowball sampling technique, where a group of people nominate others, uncertainty about the relevance of a respondent could be reduced as the iterative technique provided the interviewers with relevant candidates.

Both unstructured and semi-structured interviews were conducted throughout the research process. During the opening weeks, unstructured interviews were favoured, allowing for a dynamic questioning approach (Bell et al., 2022). These interviews was used to understand the background to the CGI-process, the stakeholders involved and the organizational structure. There was a total of three unstructured interviews. Additionally, the research also included semi-structured interviews. In these interviews, the interviewers had a set of pre-determined questions, but the questioning order varied to better suit the flow of the conversation (Bell et al., 2022). The three sections of questions used was *understanding the current state of the process* (process management/process map), *understanding the condition for modularity* (process modularity) and *proximity between actors and organizations* (perceived proximity). Furthermore, to increase the ability to go back to what was said during the interviews, substantial notes and transcriptions were done when the respondent gave the permission to do so.

21 semi-structured interviews were held with respondents from different departments, organizations and with different roles in the CGI-process (figure 3.2). The respondents most frequently chosen for interviews worked at departments such as marketing and sales and product information. The interviews were performed through digital interaction and face-to-face interviews with around 50% distribution and both researchers present. When the interviews were conducted digitally, Microsoft Teams was used to transcribe and record the interviews. However, during on-site interviews, phone recording was utilized and transcription was performed manually after each interview. Moreover, the interviews was mainly lead by one researcher when the other took notes and added additional questions when needed. Each interview was booked for one hour and lasted, on average, the same time.

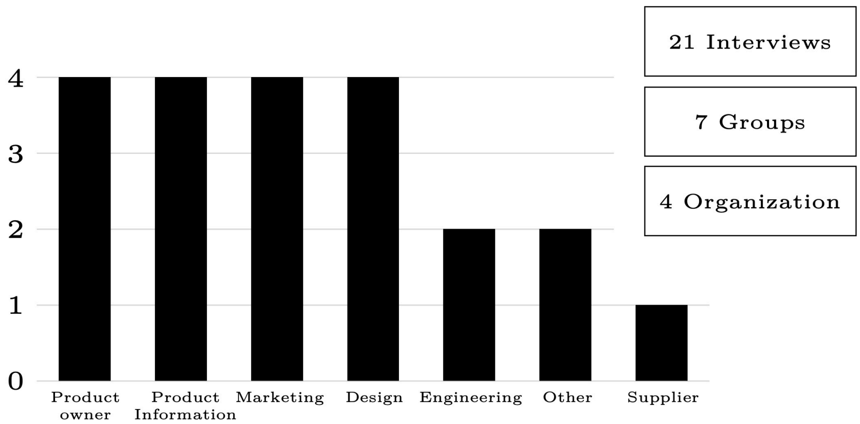

Figure 3.2: Summary of the interviews and number of concerned groups and organizations

Focus groups

Focus groups served as a basis for validating the results from the literature study and empirical study, but also to explore preliminary results and create discussion. A crucial aspect for a successful focus group lies in fostering opportunities for deep discussions and sharing individual perspectives through interactive engagement between participants on a shared topic (Carter, 2014). Bell et al. (2022) also emphasizes the interaction between the participants in the focus group and the joint construction of a mutual meaning. Furthermore, involving the right people from various departments aided in determining how to implement the findings to improve the process while having all the stakeholders in consideration.

This study included two focus groups with four participants in each, where the chosen participants were based on the involvement in the process. One of the participants were the one who produced the prerequisites to make an order of a CGI (product specialist), the second participant was the actual orderer (product information/marketing), the third was connected to design and engineering data (R&D/other), while the fourth was the coordinator of CGI. To create discussion, emphasize interaction, and create mutual understanding between participants as mentioned by Bell et al. (2022), the focus groups were organized with a two hour slot with a 15 minute break in the middle. The first half were focused on the introduction and presentation of the process map based on the data collection from the interviews. It also included the possibility for each participant to write down the two main problems they thought could appear in the presented process map discussed in the group afterwards. The second half of the focus group included discussion regarding where each problem could be placed in an impact feasibility matrix, and furthermore, discuss and go through the propositions and summarize the result.

The reason for conducting focus groups, was as mentioned, to create mutual understanding and creating discussion regarding the issues involved in the process. However, it was also a possibility to create a sense of ownership for the organization and participants connected to the produced process map. Hence, it enabled visualization of the issues within the workflow and created a clearer understanding of the steps involved as stated by Damij, Damij, et al. (2014). Moreover, it also contributed to a further understanding of who was and should be involved in the process.

Benchmarking

This study also included benchmarking after all the internal interviews and focus groups were done. The benchmarking involved an interview with another company in similar business field regarding their work with CGI to gain insights into their practices, thereby inspire improvement suggestions. This provided the opportunity to assess the internal effectiveness for the case company but also gave an indication of the companys´s competitiveness (Zairi, 1994). Furthermore, benchmarking provides momentum to quality programs and inspires organizations to continuously maintain an external focus while identifying performance gaps and developing effective strategies to close them (Zairi, 1994). Since the sample of benchmarking interviews was low compared to interviews at the case company, insights gained regarding the benchmarking company's operations was low. However, since the purpose was to inspire improvement suggestions the low relative low sample still serves the aforementioned purpose.

Observation

The possibility to attend bi-weekly meetings between the external stakeholder that creates the CGI together with the case company were given throughout the project. These meetings served as a basis to understand how the context of the meetings were set up as well as observing and listening to what issues that often occurred.

3.4 Data analysis

This section describe how the data analysis were done for the collected data. First, the collected and transcribed data were structured and analyzed with the software program Nvivo. The tool was used to organizing what was said during the interviews regarding specific questions or topics and how respondents answers deviated from each other. Initially, a deductive approach was taken to derive codes based on the theory. Examples of such codes used include: *Process variation, communication, coordination, perceived proximity high, perceived proximity low* and *CAD-data*. After starting to code, an inductive approach was used to add codes based on the data at hand. Examples of such codes included *Process complexity, consequences*, and *variance*. Second, the data from the two focus groups were analysed by grouping the 13 improvements discussed in the focus groups into themes. These themes were based on the problem the solution was trying to address, e.g., communication, CAD-data quality and structure. Third, data from observations were structured as notes and was segmented based on relevance. The observations that was deemed relevant was inserted as codes in the same topics as the interviews using Nvivo. Forth, as the benchmarking only contained one interview, that interview was transcribed and analysed through Nvivo as well.

A result from the collected data was the process map for CGI (see figure 4.1), which was a key factor in understanding the workflow and information flow, therefore it was also a way to analyze the data. The program used to visualize and create the process map is called Freeform and was used throughout the whole project, during the interviews and focus groups. Moreover, both the process map used in the focus group and the process map used as a final result were based on the interviews.

3.5 Research quality

Trustworthiness serve as an evaluative criterion in qualitative studies (Bell et al., 2022) and is divided into four aspects; *credibility, transferability, dependability and* *confirmability* which are described in this section. Furthermore, how this research took these aspects into consideration will also be discussed.

3.5.1 Credibility

Credibility in business research corresponds to internal validity, i.e., the extent to which the research findings can be considered trustworthy and aligned with the theoretical concepts developed in the study (Bell et al., 2022). Moreover, credibility is achieved through ensuring that the research design and methods are rigorous and appropriate for the research questions. Two tactics were used to increase the credibility in this study. First, while using Nvivo as a tool to analyze the findings, the transcriptions of interviews enabled the collected data to be reexamined, hence mitigating the risk of misinterpretation, and enabled pattern matching. Second, during the data analysis, the possibility to connect and further build on the explanation from one respondent to another made it possible to create a realistic image of the process.

3.5.2 Transferability

Transferability corresponds to external validity and refers to whether the outcome of a study can be applied beyond the particular research in which is was executed, i.e., if it is possible to generalize to other research contexts (Bell et al., 2022). Lincoln and Guba (1988) argue that a descriptive background serves as a base for individuals to make judgement regarding the potential transferability of findings to other contexts. Hence, this study offers a comprehensive description and background of the examined case, enabling other researchers to evaluate its transferability and generalizability. The findings and analysis is the basis for the conclusion. Furthermore, the constructed framework based on the theoretical and empirical evidence suggest that the result could have practical implications for other organizations. However, Yin (2003) mentioned that one limitation in case studies is that they often focus on a single case and involve small samples, which may not provide a reliable foundation for generalization. However, for this case study, where the theoretical pillars are connected to a process at a multinational company with competitors all over the world, it could be considered to have helped to increase the generalizability.

3.5.3 Dependability

Dependability corresponds to the aspect reliability and refers to whether the same conclusion would be reached if another researcher replicated the same operations and conducted the same case study (Bell et al., 2022). To increase reliability for this study, it was beneficial to have an academic supervisor that was consulted in matters of how interview question should be asked and what the focus groups included. This could arguably enhance a study´s dependability, hence, the reliability for a case study according to Bell et al. (2022). Moreover, Yin (2003), advocates that a case study protocol should be created to guarantee the reliability of the data collection. As a result, this research present a table of the interviewee participants under the empirical study (figure 3.2).

3.5.4 Confirmability

Confirmability refers to the objectivity of the research findings, meaning that they are not influenced by the researchers´s biases or values (Bell et al., 2022). To comply with this, several individuals were identified as key informants for the progress of this study, which were the academic supervisor and the three supervisors affiliated at the organization. Furthermore, the opportunity to attend a mid meeting was provided for all the key informants to discuss and arrive at current consensus, thereby reducing researcher's bias. Moreover, the academic supervisor engaged in ongoing review of selected sections of the report as well as a more thorough review near the finalization of the report. Additionally, weekly reconciliation meetings with the supervisors at the case company were held to keep everyone in the loop. Hence, all key informants were offered the chance to provide ongoing feedback and insights to the progress of the study, thus reducing the chances of only the researcher's values being considered.

3.6 Ethical considerations

Since the case company is a multinational company and have trade secrets, the ethical considerations became important. Moreover, the case company and the researchers signed a non-disclosure agreement which allowed the researchers to gain access to a broader range of internal documents and discussions. However, bias is an important aspect to consider when gaining access to internal documents and discussions related to an organization. E.g., not understanding the context of such data could lead to misinterpretation. Therefore, interviewing multiple people with various responsibilities related to these documents and discussions helped the researchers reduce this bias. In addition, to reduce the risk of leakage of trade secrets and other confidential information, the researchers kept such information on the case companies servers and work computers. Furthermore, through frequent communication with the organizations supervisors lead to increase understanding about the sensitivity of information. As a result, the researchers were able to approach the information with reasonable caution.

The case study was steered by the ethical principles for conducting business research articulated by Diener and Crandall (1978), which include *avoidance of harm, lack of informed consent, invasion of privacy* and *deception.* Harm to participants could involve a number of aspects, such as harm to participants development or self-esteem. It could also concern stress factors, such as harm to individuals career or future employment. Lack of informed consent refers to situations when a participant is not fully informed or does not provide voluntary agreement to participate. Moreover, invasion of privacy refers to the violation of an individuals right to control their personal information and under the circumstances which that information is shared. Furthermore, when researchers misrepresent their research as something other than its true nature, it constitutes deception (Bell et al., 2022). To comply with these principles, all respondents were guaranteed anonymity and were informed beforehand about the purpose of the study and the researchers background. By maintaining the anonymity of respondents and emphasizing the study´s agenda, the researchers believe that the research has fulfilled and followed the ethical principles.

4
Results

This chapter presents the results of the investigation carried out on the CGI-process for the case company. The practice-oriented objective of this study was to improve the multi-actor inter-organizational CGI-process. The result is broken down to three parts. First, the process is described with current roles and ways of working. Second, the challenges of the CGI-process is divided into practical- and process challenges and organizational challenges, followed by consequences. Third, the result from the focus groups are presented which covers both challenges and improvement suggestions from the respondents, followed by the result from the benchmark interview.

4.1 Process map

The CGI-process has been formed on a ad-hoc basis as the demand for CGI has increased over time. As a result, there did not exist a process map before this study. The process map in this study is a result of the data collection and is presented in figure 4.1. In order to enhance comprehensibility, the process has been categorized into four distinct phases: A - The need phase, B - CAD-extraction and dispatch phase, C - Rendering phase, and D - Review and finalizing phase.

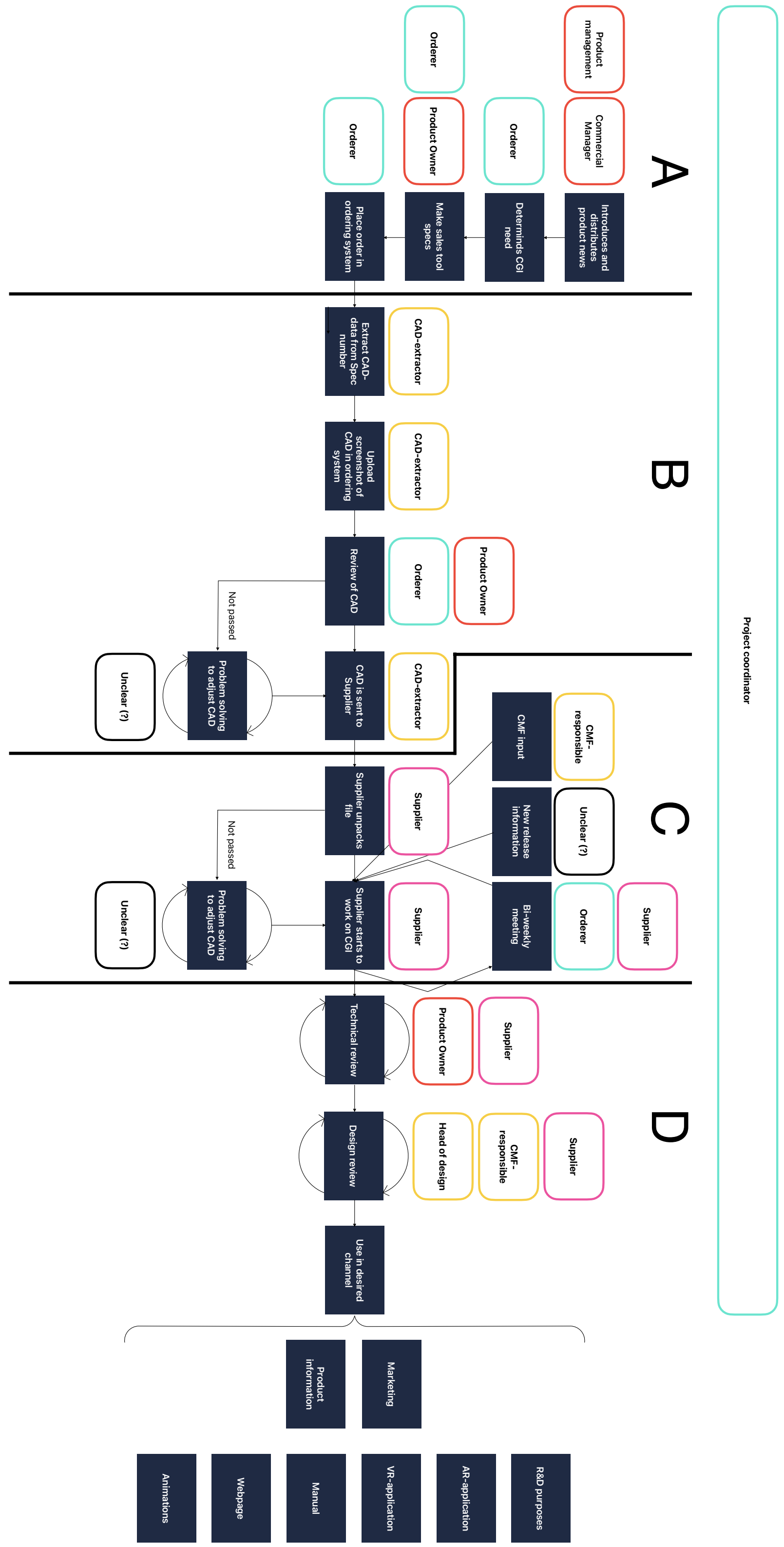

Figure 4.1: Process map of the CGI-process at the case company.

A - The need phase

The initial need for a CGI may arise for several reasons. These reasons could be due to new designs, updated versions of parts or a specific CGI requirement from an individual, department or organization for various purposes including but not limited to campaigns, marketing, product information sheets or new launches. The initiation of the process begins with the involvement of product management and commercial managers, who are responsible for introducing and distributing product news. Furthermore, there are mainly three orderers in the CGI-production. These individuals work closely to each other but with different purposes in relation to the CGI-production. The first orderer is mainly responsible for producing product information content, the second is involved with a website that is linked to marketing purposes, and the third works with both photos and films, such as posters and videos for marketing purposes.

If product information content is going to be produced through CGI for a new launch, it is the responsibility of the first orderer to understand the need based on the product news. To clarify, nobody will inform the orderer about what kind of product information content that need to be produced. Rather, the orderer needs to interact with the nearest manager to find out the need, which is also based on experience. Moreover, connected to quarterly updates, there is a pre-release and a release meeting where the news are compiled into a document. This document include features/parts that are new and the orderer thereafter uses this information to decide if there is a need for a new CGI. The second orderer rely on information from quarterly updates. This include input on what and how the news should be presented based on the commercial plan and a product news document. The latter document originates from the R&D organization and is used to communicate what the next updates will be. In addition, the second orderer gets the strategic communication plan which include news and communicative extraction of necessary CGIs. The third orderer follows a similar process as the first orderer for recognizing the need for CGI. Hence, identifying the need on their own or obtaining information from a project or website.

Once the orderer has identified the need, one of the product owners and CGI orderers collaborate to determine what should be incorporated in the CGI. Thereafter, the product owner creates a sales tool specification which include all necessary information about specific parts that suppose to be included in the finalized CGI. Subsequently, the first or second orderer utilize this specification and sends it through an ordering system to the CAD-extractor.

B - CAD-extraction and dispatch phase

The CAD-extractor extract the details based on the sales tool specification from the engineering data which is provided by the R&D organization. As a result, a CAD-module is created and the extractor uploads a low quality screenshot of this CAD-module to the ordering system. The orderer which placed the order then decide if the screenshot is approved, if the orderer can not approve the screenshot due to uncertainty, a problem solving phase starts to find someone who is able to approve. The process for resolving problems in this phase can be iterative and is experienced as unclear, as there are uncertainties about who is responsible for verifying and providing correct feedback. Consequently, a considerable amount of inquiry through mail, phone calls and Microsoft Teams messages are necessary to identify relevant individuals that could verify. Eventually, when the screenshot is approved, the CAD-extractor take the CAD-module and converts it to the correct format and send it to the supplier.

C - Rendering phase

The supplier in turn unpack the files which could take up to a few hours depending on the number of parts and level of complexity. Next, the supplier review the unpacked file, if there is an issue, they contact the case company. The individual whom the supplier typically contact is either a product owner or an orderer, and the communication often occur through email, phone calls or reoccurring meetings. This results in another problem solving phase to rectify the issue, and this phase could be an iterative process depending on how much effort is required. Eventually, when the supplier have the correct CAD-data, they start working on the CGI based on information regarding CMF (Color Material Finish) and the document with product news. Moreover, CMF refers to the surface treatment or coating applied to an object or material to give it a particular color and texture.

D - Review and finalizing phase

When the supplier have finalized their work or need input from the case company, they contact them for the final review steps. The number of iterations needed to fully review an image varies. First, a more technical review takes place with the product owners. Second, a design review is done with the CMF responsible or head of designs. However, both of these review steps are sometimes iterative as well since there are uncertainties regarding who should verify specific parts of the CGI. If everything is approved, the CGI is used for the intended purpose within the case company. Moreover, the use of the produced CGIs could be distributed to different channels, so one CGI is not necessarily used for only one purpose.

To conclude, the duration of the entire process from A to D varies depending on the complexity of the CGI as well as the purpose. First, for a large project the CGI-work is estimated to take a year. However, it is not something that the actors devote all their time to. Furthermore, this project include 16 full renders of the different product variants, which result on 100+ total CGIs. Second, CGIs produced in relation to the quarterly updates can take from one week up to six months depending on complexity and issues occurring in the process. The aim regarding these updates is to get them done by the quarterly update (i.e., within three months). Third, orders outside the two former cases have even higher variation and the respondent being unable to specify an approximate duration.

4.2 Practice - and process challenges

In this section the challenges regarding extraction of CAD-data, the product complexity, structure of the process, the geographical location and variation between different CGIs is presented.

4.2.1 CAD-data

It is a common issue that there occur deviations/errors when the CAD-modules are extracted from the engineering data (CAD-data). This could be due to incorrect placement of a part in relation to others, missing or old versions of parts. Sometimes it is possible for the CAD-extractor or supplier to rectify these issues, but it is essential to ensure accuracy from the outset to minimize the workload. Even apparent errors must be corrected by the case company, which require significant effort and repetition since these issues occur often, which is also emphasized by the quote below. And according to one of the head of designs, it is a drawback to not have accurate data from the start.

“It is almost always something wrong when the data is extracted, such as parts being placed incorrectly” - CAD-extractor

The process performance relies on having accurate and up to date engineering data that adheres to the sales tool specification. Therefore, the accuracy of the data depends if the part, placement or version is correct. In addition, it is essential to recognize that creating CGIs can be expensive, particularly when outsourcing the work to a supplier if the data is incorrect and the budget is reported to be exceeded in most cases. Related to this, several stakeholders mentions that it is crucial to ensure the accuracy of the data before the supplier commences their work. Consider an analogy of building a house, it would be unwise to begin construction only to realize halfway through that you have used the wrong bricks stated one of the orderers. Moreover, garbage in, garbage out, as one of the head of designs said. However, a respondent form the engineering unit, which is a part of the R&D organization, was not surprised that there was issues in the CAD-data. This was because there was no requirement to have every product variant to be quality checked.

“Many hours are devoted into rectifying things that went wrong” - Orderer

The case company may only be aware of the CAD-data issues after the supplier has received, unpacked and reviewed the CAD-data sent by the CAD-extractor. As a result, the supplier could spend several hours unpacking flawed CAD-modules, leading to unproductive work and additional time spent resolving issues, which results in unnecessary expenses. Consequently, the supplier inform the case company that something went wrong, however, it is unclear who the point of contact is and it differs from time to time. Typically, it is one of the product owners or orderers that receive information via email or during bi-weekly meetings held between the supplier and the case company. However, it is not always the contacted person at the case company who is responsible for verifying. Therefore, an iterative process of finding the correct individual occur in many cases which is time consuming.

4.2.2 Product complexity

All respondents agree that the product complexity is affecting the CGI-production. The product has a high customizability, which creates many possible variants. In addition, there are different product series that further extends the number of possible variants. Respondents say that this directly affects the reliability of the CAD-data and the ability to review both CAD-data and finished images since no one has the competence to do so.

“The product is a world of it’s own!” - CAD-extractor

Moreover, the two product series can be described as a larger and smaller series, when it comes to volumes. The development of the larger product series is co-located in the same city as the sales organization, however, the development of the smaller product series is located abroad. Both product series are in need of CGIs but the engineering data originates from the two different R&D sites. Furthermore, there are slightly different team setups for producing CGIs depending on product series. The larger has a project coordinator, which is elaborated on in the following section. In contrast, the smaller product series does not have this role, instead these responsibilities are put on the product owner.

4.2.3 Structure

The individual (CAD-extractor) that possess the knowledge of how to extract and convert the CAD-module to the correct format and send it to the supplier is limited to one person. Hence, if the CAD-extractor is out of office, there is nobody who manage this work. The respondents in the interviews pointed out their concerns regarding relying on only one person for this crucial work task, claiming it being too vulnerable. Furthermore, the CAD-extractor have the possibility to look at the extracted data and check for obvious mistakes before it is sent to the supplier. Nonetheless, the role description for the CAD-extractor does not encompass that task. Instead, it pertains to extract the CAD-data and create a CAD-module and then send it to the supplier if authorized by the orderer.

In addition, as of today there is not any documented process for producing CGIs. Several respondents say that the process feels unstructured and they do not know the entire process flow. Moreover, this production takes place between different business areas and there is nobody who have the overall responsibility.

“There is no process for producing CGIs” - Orderer

Frequently mentioned during the interviews were that there is no one who is responsible for being the contact person towards the supplier. The supplier usually contacts one of the product owners and orderers if needed. However, the aforementioned project coordinator was added to the ordering process for CGIs recently turned out to benefit the process through decreasing ordering mistakes such as duplicated orders. The coordinators role is to ensure that all CGIs, especially for the larger product series are aligned. If a certain orderer needs to s/he can use same CGI for other purposes. Hence, this is an example of what the coordinator could provide with in terms of connecting different stakeholders involved in the CGI-process. In contrast, these responsibilities are put on the product owner when it comes to the smaller product series.

4.2.4 Geographical distance

Defined as the spatial distance between actors, the results show that the majority of the CGI-process's actors are located within a relatively short distance. The sales organization and the R&D organization for the larger product series are co-located in the same company complex. It is walking distance between the offices. However, the CAD-extractor is working off the complex due to capacity restrictions, but still being within a 10 minute car ride. Similarly, the supplier is based in the same city as the case company, also being located approximately 10 minutes away by car. This leads to on-site visits from the supplier both easy and reoccurring.

In contrast, the R&D organization responsible for the development of the smaller product series is located abroad in Europe. This makes face-to-face meetings infrequent. The only actor that has frequent communication with the abroad unit is the product owner responsible for the smaller series. As a result, if anything needs to be checked with this unit it passes through that actor.

"I'm the one that checks the drawings (CAD-modules), if I'm unsure I need to check it with the abroad unit" - Product owner of the smaller product series.

4.2.5 Variance

Target products is used within the R&D organization. The purpose of target products is to establish a common specification for a product, on which various customer feature evaluations, such as cost, weight, and other factors are conducted. These target products usually have the correct engineering data with updated versions of parts at the correct place, but is not used in relation to CGI. Moreover, a project could include multiple target products and an quarterly update on average have five target products for the R&D organization. These projects have an assigned individual who is responsible throughout the project for ensuring that the target product is correct with updated data.

"Having a target product for a specific sales tool specification would probably create a basis for a good outcome of the CGI" - Engineering unit respondent.

"It roughly takes one day for one person to create a complete target product" -

Engineering unit respondent.

The CGIs could be divided into different categories based on level of complexity and quality. E.g., a picture on a part with no specific color might not need as high resolution and quality as a CGI which represent the whole product and is used for marketing purpose. Furthermore, the same applies to website pictures and larger physical prints. The latter needs to be high resolution and high attention to detail, on the contrary, website pictures are lower resolutions.

It is mentioned that it is challenging to establish a CGI standard when the role description is unclear and employees have varying perceptions of the expected CGI quality and appearance. How good is good enough, and who is responsible for deciding what is good enough is a question brought up by one of the head of designs.

4.3 Organizational challenges

In this section the challenges regarding communication, knowledge sharing and organizational relations are presented.

4.3.1 Communication

Communication regarding the CGI-process can be divided into communication within the sales organization (intra-organizational), and communication outside the sales organization (inter-organizational). The latter being with the R&D organization and the supplier.

Intra-organizational communication

Within the sales organization, the marketing department and the product information department have similar needs of CGIs, but for different purposes. Furthermore, they are co-located in the same building and floor along with the product owners. The four main actors from the case company, the three orderers and the project coordinator are part of one of these two departments.

The communication, relating to the CGI-production, between these four actors are something that is discussed frequently both during meetings and informal office conversations. The meetings consists of a reoccurring weekly status meetings and other scheduled meetings when issues arise. In addition, Microsoft Teams is used for communication within this group as well. As the delivery draws closer, often connected to a launch or quarterly update, the frequency increases further, which can mean several interactions per day.

As aforementioned, the two product series have slightly different setups as the project coordinator is only formally a part of the larger product series. Instead, the product owner of that series is partly taking that role with help from the project coordinator. Not having this role in the smaller product series reduces the frequency of communication says the current project coordinator.

There are instances of actors that are not directly connected to the process that take part in certain activities. One respondent says this is due to their previous experiences and therefore ability to help.

"I'm not formally a part of the CGI-process, however sometimes I'm part of meetings to help solve problems. The reason is that I have previous experience with the department."

Inter-organizational communication

As aforementioned, the process involves three organizations, the sales organization, the supplier and the R&D organization. First the results regarding communication with the supplier will be described followed by communication with the R&D organization, which consists of design and engineering units.

As mentioned in the Structure section, the supplier does not have one single contact person at the case company, instead the communication takes place through different channels and people. First, there is the ordering system used by the orderer, which the supplier is invited into after the CAD-data has been sent to them. Here, comments can be made about the order and files can be uploaded. Second, there is a weekly status meeting with the supplier, a bi-weekly supplier-lead meeting, a weekly meeting between product information department and the supplier, and a bi-weekly budget meeting with one representative from the supplier and the project coordinator. Furthermore, other people are sometimes invited depending on the purpose of the meeting, e.g., if a certain knowledge is needed to make a decision. Third, a SharePoint is used to store documents related to CGI-production like time plans, quotes and meeting notes. Fourth, the supplier has direct contact with several actors at the case company depending on their need. One supplier respondent says that they have an easier time finding the right person to talk to than the company itself. The quote below also highlights this. Moreover, this contact is usually done through mail, phone calls or text messages. According to the project coordinator, the smaller product series has more direct contact points then the larger one due to not having a project coordinator. In total there are 12 people that have some direct contact with the supplier.

"They probably contact me or the orderers, it is a miss match that we need to look into" - Product Owner

There are four actors that is connected to the process from the R&D organization, namely the CAD-extractor, the CMF-responsible and head of design. The product can be split into two design parts, hence there are two heads of design. First, none of these four actors have the production of CGIs as their main workload. It is limited to some hours per week. Second, when there is uncertainty about either the CAD-data or the CMF, the communication path to find a solution to these problems are unclear.

“Finding the right person is easier said than done because the actual part of the product have a specific responsible individual” - CAD-extractor

The individual mentioned in the quote, is usually not co-located to other actors in the process and belong to the engineering unit. As a result, the person tasked with finding the information regarding CAD-data or CMF has to ask colleagues or other organizations until they find an answer. For some orderers orders it have proven so difficult to locate the information that it took several months or was ultimately canceled. Third, many channels for communication is used including phone calls, text messages, mails, Microsoft Teams, and the ordering system.

The engineering unit of the company is not directly involved in the CGI process, however they are the creator of the CAD-data. The communication with this unit is infrequent. One respondent of this unit says.

“It feels like the CGI-process is very far from us (R&D organization), not many know about it existing” -Engineering unit respondent.

Similarly, a respondent from the sales organization says that the engineering unit does not think they(sales organization) have any interest in knowing about how and when updates are made to the CAD-data. In contrast, both the manufacturing and aftermarket organizations are part of quarterly update meetings earlier than the sales organizations where for instance CAD-data is discussed.

4.3.2 Knowledge sharing

Knowledge sharing between the organizations and actors are described in this section. The knowledge sharing between the design unit of the R&D organization and the sales organization is described, followed by the knowledge sharing between the engineering unit and the sales organization.

Between the sales organization and the R&D organization, the knowledge sharing is low. Respondents from the design unit, providing input on both CMF and feedback on image accuracy, have knowledge regarding those subjects. Consequently, this knowledge is not shared with the sales organization. Similarly, the CAD-extractor is the only person that currently has the know how to extract the CAD-modules and format them into the desired format and send to the supplier.

“No one else on design can do it (extract and convert CAD-data). If I get sick, there won’t be any CAD-data.” - CAD-extractor.

Furthermore, this view is shared by the sales organization with respondents expressing they do not have insight into the R&D organization. This is exemplified both with knowledge about the system used by the R&D organization which the sales organization is affected by, and the development process. However, exceptions exist with three respondents having previous experience of either working at the R&D organization or working in a technical role at another company. One of these actors are, as of recently, involved in the CGI-process as a product owner.

“People working here (Marketing) are not product focused, even if they need to understand what the product is” - Long time employee.

Both actors interviewed from the engineering unit share the perception of low knowledge sharing both ways. As aforementioned with regards to communication the CGI-process feels far away from this unit. The feeling of low understanding is highlighted in the quote below.

“I understand they want better CAD-data quality, however I am not sure they understand how we work” - Respondent from the engineering unit.

4.3.3 Organizational relations

As organizational relations is defined as to what degree two actors share relations in an organizational arrangement, the result will again be divided in within the sales organization, as well as between the sales organization and the supplier and the R&D organization.

First, all actors connected to the CGI-process that works in the sales organization has a high degree of shared organizational relations. Examining the organizational chart it can be concluded that these actors (i.e., project coordinator, orderer and product owner) share the same third level manager (manager’s manager’s manager). However, since the project coordinator was introduced recently, the actors and respective departments have worked cross-department since they share the need for CGIs.

Second, the supplier and sales organization does not share the same relations as within the sales organization. However, the supplier has worked with the case company for many years and, accordingly, has developed relationships. As mentioned in the Communication section, the supplier is integrated into the case company to the extent that they are able to directly contact people if issues arises.

Third, the degree of shared relations between the sales organization and R&D organization is low. The CEO is the first common responsible looking at the organizational chart, corresponding to the sixth hierarchical level. Moreover, the development for the smaller product series is part of an entirely separate unit making it more organizationally distant.

4.4 Summary of challenges and consequences

In this section a summary of the challenges from the interviews are outlined in table 4.1. Moreover, the consequences of these challenges are described and exemplified.

Table 4.1: Summary of the challenges from the interviews

Practical- and process challenges	**Summary**
CAD-data	The CAD-data is frequently incorrect, resulting in extra work, delays and expenses.
Product complexity	Two product series exist, in both cases there are large customization and many possible variants.
Structure	Unclear process description, role descriptions and responsibilities.
Geographical distance	The sales organization and the R&D organization are located in the same complex, while the supplier is in the same city. The development unit of the smaller product series is located abroad.
Variance	Different complexity and purposes of CGIs increase the ambiguity and quality assurance.
Organizational challenges	**Summary**
Intra-organizational Communication	Frequent communication through meetings and office conversations. No coordinator in the smaller product series.
Inter-organizational Communication	No single point of contact with supplier. Unclear communication path when uncertainty arises. Engineering unit not involved in CGI-process.
Knowledge sharing	Low knowledge sharing between the sales organization and the R&D organization.
Organizational relations	High degree of shared organizational relations within the sales organization. Medium and low between the sales organization and the supplier, and R&D organization respectively.

The first consequence of the challenges described above is the impact it has on lead times. E.g., if time is spent to extract a CAD-module that is proved to be insufficient by the supplier, another CAD-module is needed and time is wasted.

Second, as a direct affect of increasing lead times is that cost increases. Whenever the supplier spends time to fix an issue as a result of the case company's error, they get billed for those hours. Furthermore, as part of recent delays the project coordinator estimated the total extra time spent to fix the issues. The result show the project was already 10 percent over budget, although still being in an early stage of the project.

"There is of course a lot of money spent on CGIs if there are delays." - Orderer

Several examples showing the consequences of failed orders were presented during the interviews, often sharing similar characteristics. One of the examples was in regard to producing a CGI for product information content. Although only showing a limited part of the product, the uncertainty of the CAD-data lead to continuous loops attempting to find correct information. Actors from different departments and organizations was included but could not solve the issue. As a result, several hours were spent both within the sales organization, the R&D organization and the supplier resulting in increased lead time, cost and no finished content. In the end, another low quality picture was used as substitute. The total duration from inception until the decision was made to use a low quality picture was five and a half months.

4.5 Benchmark interview

As mentioned, an interview was conducted with a company operating in the similar business field to gain insights into their CGI-process. This company has a dedicated department that manages all aspects of their CGI projects to keep everything consistent and under the same umbrella. The department possess the knowledge to oversee the various stages of the CGI-production and strive to maintain a standardized approach. In addition, this department is responsible for the entire CGI budget.

To mitigate the risk of discovering errors too late in the process, technical reviews are done regularly throughout a project. This approach aligns with the earlier mentioned quote from one of the orderers, who stressed the importance of starting with the right bricks when building a house, rather than having to start over halfway through due to wrong bricks.

The challenges for this company arise when there are new products or features, and when the website need to be updated or if there are any last minute changes. This results in unnecessary time added into the project and repetition of reviews which is costly. However, the process works rather well when there is an existing product, i.e., not a product that is just under development.

This company has the same supplier as the case company. However, the contact between the supplier and this company is mainly done between another department at the benchmarking company, i.e., not the department responsible for the CGI projects. Mainly because they have similar understanding and vocabulary, and could therefore have deeper conversations which makes it easier to understand each others needs. They also have a design team who is responsible for the CAD-modules, and these represent a complete file with versions of the product which could be used as a CGI. However, this early stage CAD-module only have the correct geometry with correct textures but everything else is built up in subsequent steps.

4.6 Focus groups

This section include the results from the two focus groups, which are challenges and actions for improvements. The mentioned challenges and improvements concerned three areas, namely CAD-data quality, the need for a structured process and integrated communication. These challenges and suggested improvements are also visually presented in table 4.2 and 4.3. Excluding overlaps in the two focus groups regarding challenges and improvements, it resulted in 13 challenges and 13 improvements.

4.6.1 Challenges

Some challenges brought up at the focus groups are similar to the ones provided in the interviews, such as unreliable CAD-data extraction from the engineering data, unclear responsibility and role description. However, it was brought up that not all CGIs are produced through the use of a sales tool specification. Moreover, the ordering system does not have the prerequisites for creating possibilities for good review as a first step. In regard to the first review step there seems to be a flaw in the working methods, which further down in the chain make it more time consuming.

There are different ways to extract the geometry connected to the CAD-data, furthermore, to verify the data one needs to extract it as opposed to only looking at the sales tool specification. However, it is possible to manually compare the sales tool specification with the information provided by the R&D organization but is not a sustainable work task in the long term. Furthermore, the two product series also have different project layouts which is more described in the section Product complexity and create a sense of uncertainties. Moreover, the extracted engineering data from the R&D organization lacks a specific timeline for delivering the finalized geometry of the parts requested from the sales tool specification.

Two additional challenges were discussed during the second focus group. First, it is difficult to verify color, material and texture for the rendered CGIs due to different environments at the supplier compared to the case company. E.g., using different monitors or lights in different rooms plays a critical role in how the CGI is perceived since these factors affect the color. Second, the setting or environment in which the product is situated in the CGI is not explicitly stated in the beginning of the production. To clarify, different settings or environments could be in different conditions, such as weather, countries or contexts. If this information is provided in a later stage, rework might be inevitable.

Table 4.2: Summary of the challenges from the focus groups

CAD-related	**Challenge description**
1.	No clear timeline for deliveries/releases from the R&D organization.
2.	Low virtual trust when extracting CAD-modules which leads to insufficient CAD-modules.
3.	Hard to verify colors due to differences in equipment (e.g., screens).
Communication	
4.	Only possible to verify CAD-modules after extraction.
5.	The ordering system can not handle some functionalities (e.g., reviews)
6.	The needs are identified too late in relation to the development process.
7.	Changes during the project and finding information regarding those changes leads to difficulties in verifying CAD-modules and images.
Structure	
8.	Several pathways to order CAD extraction, feels unstructured.
9.	Inadequate working methods in the first review step.
10.	Unclear needs, responsibilities, requirement and orders. (Especially in the smaller product series)
11.	Different team structures for the two product series
12.	A sales tool specification is not done for every CGI.
13.	No requirement to put the product in context after the image is produced, which also does not get reviewed before publishing.

4.6.2 Improvements

The groups' discussions and insights informed several key actions for improving the CGI-process. Specifically, make the R&D organization aware about the use of CGI and the impact of their work, hence, understand the necessity for providing dates for when the correct engineering data is available. This improvement was meant to be accomplished by communicating its importance with the R&D organization. They also highlighted the need to define each stakeholders role and responsibility and implement a review process to reduce ambiguity. The groups' input also led to the decision to integrate a receive system confirmation for the sales tool specification so the extracted data is proved to be correct before subsequent steps are executed.

An improvement suggested was also to specify the ordering systems limitations and thereafter introduce features or changes to improve the system. Another long term improvement was to synchronize the R&D organization with the sales organization. Furthermore, the group´s perspective were crucial in comparing the project organization and working methods between the product series to find an optimal work procedure. Lastly, ensure the geometries quality, aggregating CGI-orders and introduce review gates to the ordering system.

Invest in monitors and set up the same lightning and environment as the supplier have when reviewing the CGIs would make it easier to verify the images was brought up by the second focus group. Furthermore, it is also mentioned that the necessity to add a role that thoroughly could verify the CAD-data is important. This would ensure the correctness when the supplier unpack the files.

Table 4.3: Summary of the suggested improvements from the focus groups

CAD-related	**Improvement description**
1.	Create an overview of the CAD-systems and the construction system*
2.	Equip the case company and supplier with an identical monitor to improve CMF review accuracy.
3.	Understand what dates parts are updated in the CAD-data to be able to extract products with updated parts.
4.	Create a method for receiving receipt of part status when making a sales tool specification.
5.	Define specific product variants to be made into correct CAD-modules by the R&D organization.
Communication	
6.	Introduce a role that specializes in reviewing CAD-modules to ensure correctness.
7.	Improve the ordering system with new functionalities.
Structure	
8.	Define clear role descriptions and a clear process map
9.	Define clear delivery descriptions towards the R&D organization
10.	Make the working methods of the smaller product series resemble the larger product series.
11.	Make the team structure of the smaller product series resemble the larger product series. (e.g, introduce a project coordinator)
12.	Aggregate all orders and introduce gates to the ordering system.
13.	Make a sales tool specification for each CGI to ensure the product can be built.

In figure 4.2, the improvements are placed in an impact/feasibility matrix. The higher an improvement ranks on each axis, the better. I.e., an ideal improvement would be in the top right corner while a poor one would be in the bottom left corner. Improvement number (1) and (6) were mentioned by both groups and therefore show up in both matrices. Moreover, the arrangement of the suggested improvements in the matrices was determined through discussions between the participants in the focus groups.

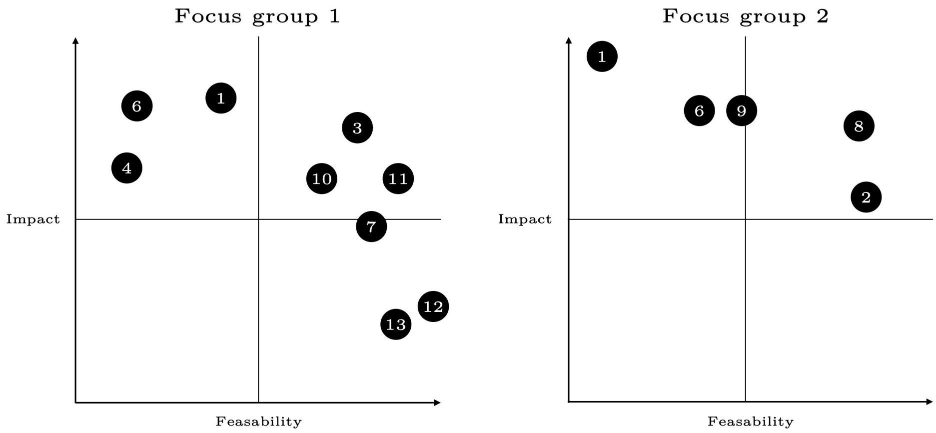

Figure 4.2: Improvements placed in an impact/feasibility matrix

In sum, the case company experiences several challenges related to process- and practical challenges and organizational challenges. The former including CAD-data, product complexity, structure, geographical distance and variance. Furthermore, the latter including communication, knowledge sharing and organizational relations. These challenges lead to increased lead time and cost. In addition, the benchmark interview showed differences in roles, responsibility, communication and reviews. Moreover, through the focus groups, challenges and improvement suggestions were collected and finally placed in a matrix depending on the impact and feasibility of the improvement. To fulfill the purpose and thereby answering the research questions the results needs to be analyzed. This is the focus of the following chapter.

5
Analysis

This section analyses the findings from the study, starting by reintroduce the framework provided in the Theory chapter. This is followed by analyzing the findings regarding challenges and suggested improvements connected to process management and process mapping. Subsequently, the different phases in the process map is analyzed and put in relation to different process types and their potential for modularization. Furthermore, the findings regarding the different proximity dimensions are analyzed. Lastly, the shared mental model is analyzed followed by how a process map could serve as a shared mental model.

5.1 Framework

The framework provided below (figure 5.1) restate how the theoretical concepts connect to each other. This will be used as a basis for analyzing the findings. The aim of this study was to investigate the multi-actor CGI-process and how it could be improved through support of process modularity and perceived proximity. Specifically, the study sought to answer three research questions. First, RQ1 focused on how process mapping could be used to increase understanding of work procedures in a multi-actor process. Second, RQ2 examined how process modularity could be used to improve efficiency and flexibility. Third, RQ3 elaborated on how a process can be designed to enhance perceived proximity in a multi-actor process.

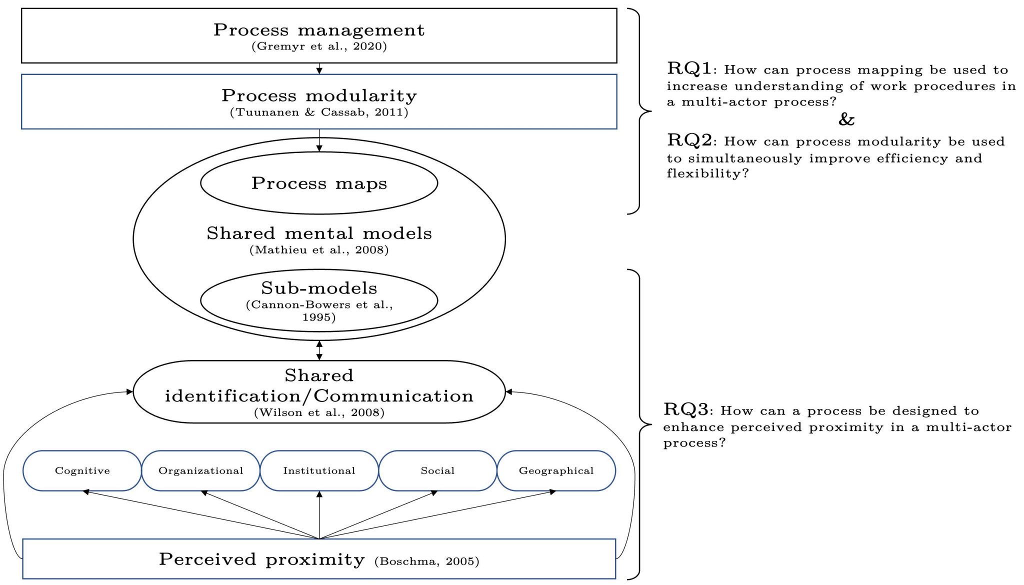

Figure 5.1: Research questions' relation to the framework, which connects process management, process modularity, process maps with perceived proximity and shared mental models

5.2 Process management

According to Gremyr et al. (2020), the aim of process management is to enhance the customer-centric approach and thereby increase efficiency and effectiveness. One way to achieve this goal is through process mapping. As noted by Damij, Damij, et al. (2014), process mapping is a technique to create a visual representation of the process, which tends to increase understanding of processes and the steps involved. However, the case company lack a visual representation of the CGI-process. Moreover, the findings about current challenges implies that the overall understanding for the workflow and information flow is limited. Specifically, the mentioned challenge regarding unclear process description, role description and responsibilities provided in table 4.1 entails this. Hence, there exist a knowledge gap within the CGI-production both in relation to the visual aspect of how the process looks like and the understanding of how things are done, including responsibilities and roles.

Madison (2005) argues that two factors influence effective process management. These are defining the scope clearly, and identifying relevant stakeholders and process variation to ensure that the view of the process is realistic. However, the findings indicate that both of these aspects are disregarded by the case company in relation to the CGI-process. The scope is broad and not clearly defined and there are many stakeholders, which makes it harder to understand who should do what. Also, due to inability to clearly define the responsibilities it is difficult to define and identify who is involved and should be involved. Furthermore, the involvement could vary depending on the purpose of the CGI. Moreover, it has been demonstrated that due to different demands of CGIs, variation in judgmental decisions could occur from one CGI to another. In addition, the absence of a documented process for producing CGIs is an additional factor that complicates the case company´s CGI operations. As mentioned by Gremyr et al. (2020), inability to describe the process implies a lack of understanding regarding the task at hand. Due to the lack of process description, role description and variation of involved stakeholders from one CGI to another imply an inability to clearly understand how things is done.

The case company experiences that the time used when producing CGIs varies to a great extent. This is due to several factors, such as the CAD-data is known to frequently be incorrect, requiring time consuming problem solving. Moreover, the time aspect is also affected because of the lack of delivery timelines from the R&D organization regarding when correct data is ready for extraction. Hence, the sales organization are unaware of when and if the extraction of CAD-data based on the sales tool specification is correct. Consequently, there is low trustworthiness in the accuracy of CAD-modules when the sales organization extracts CAD-data from the R&D organization. Furthermore, improving communication and coordination between functional boundaries is an important aspect (Kalman, 2002). Having a clear description of the steps and their sequence in the CGI-process could improve the aforementioned aspects as stated by several respondents. Moreover, the absence of a process description of the CGI-process complicates the actors' understanding of the work procedures.

To ensure successful process mapping, three critical factors are necessary to consider according to Graham (2006). First, accurate data must be provided from the involved individuals. Second, the map must be structured so everyone understands. Third, the collected information must be valid. The first aspect for acquiring correct data is assumed to be fulfilled based on the current process image (figure 4.1) and that the individuals provided as correct information as possible since it is in their interest to improve the process. However, the challenges highlighted by the focus groups, such as inefficient working methods during the initial review stage and difficulties in verifying CAD-modules due to changes made during projects speaks against the second factor. Furthermore, if a clearly defined process map would be created, it could improve the shared understanding of the CGI-process. To clarify, using the process map could enhance the shared understanding of how necessary tools are used, about what needs to be done and awareness of each others' skills (Cannon-Bowers et al., 1995). The third aspect relies on the verification from the case company on whether the process map visually represent how the stakeholders involved experience the workflow. This is also assumed to be fulfilled since the case company has verified the current process map (Figure 4.1).

Throughout the various stages of problem-solving and reviews, it may be necessary to go through several iterative steps to determine the right person with the required expertise to grant authorization. The authorization may pertain to the approval of a functional, technical, or design aspect of the CGI, or alternatively, the final image. Moreover, without a clarified role description, the time variation could be significant for these iterative steps which for some cases increase delays and expenses. Hence, due to many stakeholders from different areas, Damelio (2011) suggest a cross-functional flowchart as a suitable process map in order to understand a complex process such as the CGI-process.

According to Trkman (2010), standardization of processes is a success factor with the main idea of creating continuous improvement to sustain benefits within process management. Although, standardizing the whole CGI-process is proven to be difficult since the variation of CGIs is high. However, it is noteworthy that some aspects of the process can still be standardized. Furthermore, the high product complexity is affecting the CGI-production to a great extent due to high degree of customizability. This relates to the challenge of variance, which results in ambiguity and quality assurance problems regarding who should be responsible for verifying and determining when the CGI is good enough. Therefore, an alternative perspective to determine how to create an efficient and effective process is necessary.

5.3 Standardization vs modularization

A complete standardization of the complex CGI-process is judged to be difficult. Hence, using sub-modules when suitable could be useful in constructing a complex process from smaller, independently designed sub-processes that could function as a whole (Baldwin & Clark, 2003). The product at the case company is described as a world of its own and the complexity and customizability of the product affect the CGI-production. Furthermore, breaking down these modules into smaller systems could achieve customization on a higher level (Bask et al., 2011), which in the case of the complex CGI-production could be beneficial.

When modelling the structure of the sub-systems, having the benefits of modularization in mind, the modules need to be clearly defined (Carlborg & Kindström, 2014). Otherwise, the objectives with process modularization such as reducing complexity and efforts, and improving transparency is difficult to fulfill. As mentioned, the case company does not have a documented process description or a process map of the CGI-process. This lack of visual or descriptive representation of the process makes it difficult to realize how different modules could be connected to each other as well as not being able to reach the aim with modularization. Two methods could be used for creating modularized offerings according to Böttcher and Klingner (2011), these are the creation of new modules or decomposing existing offers/modules. The method choice is based on the suitability in a particular case. Modularizing parts of the CGI-process has been mentioned as a possibility. Furthermore, the R&D organization use target products, which has been proven to provide more accurate CAD-data. This leads to the consideration of possibilities to use sales tool specifications to develop a comparable target product, but for CGIs. Hence, adding a work method which entails that the sales tool specification is put into a project which is reviewed from the beginning to make sure that the underlying CAD-data is correct. Moreover, this would also make the R&D organization aware of how important correct CAD-data are for other departments and how their work is used in subsequent steps. This would increase the time and therefore money spent on making these target product. However, since the cost is for fixing poor quality CAD-modules is high there is a possibility that it would save money in the long run.

5.3.1 Modularization opportunities

The created process map (figure 4.1) alongside the current process description indicates that there exist opportunities for modularization. Moreover, certain steps in the process are consistently performed in a similar manner, while other parts of the process vary from time to time. Carlborg and Kindström (2014) categorize service processes into four distinct types (figure 2.2), depending on whether the process is fluid or rigid or whether the customer have an active or passive role, or if a supplier´s role is active or passive according to Droge et al. (2012). Additionally, it is possible to categorize the CGI-process into these types based on the process phases being analyzed separately. In turn, these types have a proposed modular approach for optimal operation. Furthermore, the modules for the CGI-process can be seen in Figure 5.3 where the variation in demand for CGI is the variable affecting the working procedure and actors involved. For this specific case company this will be elaborated on in the Managerial implications chapter.

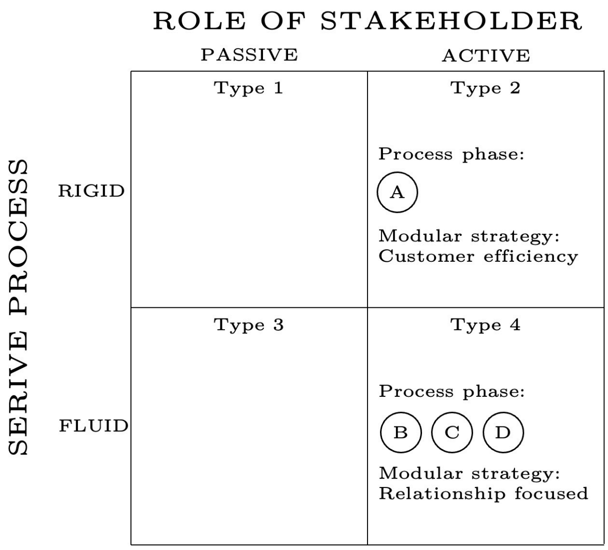

Figure 5.2: The phases of the CGI process in Carlborg and Kindström (2014)'s model for different types of service processes

The A-phase is characterized by relatively low information exchange compared to the other phases where the orderer is seen as the customer to the sales tool specification and have an active role. The tasks in this phase does not vary significantly, since updates/news are provided by product management, which the commercial managers collect and distribute into projects. These tasks are the basis for the sales tool specification and the orderer uses this specification to place an order. Hence, phase A can be considered to be categorized as a type 2, where the process is rigid and the role of the customer, in this case the orderer is active. For type 2, according to Carlborg and Kindström (2014), a modular approach that combines a higher degree of customization with standardized process modules is required. It is important to adopt a strategy that prioritize the customer efficiency and consider their available resources. Moreover, at the beginning of the process, the provider plays a crucial role in preparing and informing the customer about the necessary efforts and competencies required.

The B-phase on the other hand is characterized by more information exchange between different departments, where the CAD-extractor gets involved as well as the supplier towards the end of the B-phase. Moreover, there are several judgemental decision points which also require higher level of technical skills. Hence, high level of information exchange and technical skills alongside several decision points characterize a fluid process where both the CAD-extractor together with the orderer have an active role in the process with back and forth communication. Therefore, this phase is considered to be of type 4. These types are often complex and context-dependent, involving multiple resources from different departments within both the provider and the customer organization. According to Carlborg and Kindström (2014), it is important to create a good relationship, face-to-face interaction, and communication skills and build further on the already existing relationship between the customer and provider when the process is considered type 4. A modular approach with independent modules is needed for this type, as the customer requires a different combination of modules. The provider must also be aware of module interactions and resource requirements.

The C-phase have similar characteristics as the B-phase where different departments are involved during problem solving phases, providing input regarding CMF and product news document from the case company to the supplier. Hence there are several decision points and different technical skills needed with several steps of communication with high level of information exchange. Therefore, this phase could also be considered a type 4 and the modular strategy for this phase is similar as for phase B, where the strategy is relationship focused. Hence, the actors need to understand each other and communicate well and include independent modules which are combined into bundles (Carlborg & Kindström, 2014).

Lastly, the D-phase involve several review steps which could be seen as several judgemental decision points where the need for high level of technical skills and involvement from different departments is necessary. There is high level of information exchange between the supplier and the different individuals or departments that need to be involved when verifying the CGI. Therefore, this phase is also concerned a type 4 process. Hence, the modular approach need to concern good relationship between the stakeholders involved and have modules which are independent as the customer requires a different combination of modules (Carlborg & Kindström, 2014).

5.4 Perceived proximity's effect on process performance

Although not being spatially close to another actor, one can feel close through other dimensions of proximity (cognitive, organizational, social and institutional) (Boschma, 2005), as well as by having quality communication and shared identity (Wilson et al., 2008). In the case of the CGI-process, actors experience high perceived proximity to some actors, but not to other, which affect the performance of the process.

Since cognitive proximity cannot be substituted by other proximity dimensions, it is a requirement for learning, reducing uncertainty and solving coordination problems (Boschma, 2005). Actors in the CGI-process show high cognitive proximity with actors that work in similar domains. Within the sales organization, the actors have overlaps in their knowledge base making it easy for them to understand each other. Similarly, the supplier and the design department experiences high cognitive proximity as a result of being on a similar technical level. In both cases, it allows for information to be communicated and understood, which is in line with Boschma's (2005) arguments.

Where the cognitive distance instead hampers the process is between the sales organization and the R&D organization, specifically the engineering unit. Unlike the design unit, the engineering unit is not a part of the process but they provide the CAD-data. Although struggling with the insufficient CAD-data and being aware of the consequences it brings, the sales organization is unable to pinpoint reasons for the issue and solve it. This can be explained through the views' of both Boschma (2005) and Wilson et al. (2008) on too much and too little cognitive proximity as well as infrequent communication. First, between the organizations, too little cognitive proximity leads to misunderstandings (Boschma, 2005). In this case, the interactions that do happen between engineering and the sales organization does not result in apparent improvements. In addition, many actors from the sales organization say that they do not know what the R&D organization does, a sign of misunderstandings. Second, too much cognitive proximity can lead to lack of sources of novelty (Boschma, 2005; Cohendet & Llerena, 1997). This is apparent in the sales organizations efforts to improve the CGI-process. Although achieving improvements when, for instance, introducing the project coordinator, finding novel solutions to the problems of the CAD-data has proved difficult. Two actors having a similar knowledge base in relation to the CGI-process limits their ability to learn and innovate. Third, since there is no actor representing the engineering unit in the process, there is limited communication. One of the consequences of this is the out-of-sight-out-of-mind problem of low cognitive salience (Wilson et al., 2008). I.e., actors of the engineering unit does not think about or know about the struggles of the CGI-process. Only recently did the actors of the engineering unit became aware of that the CGI-process existed.

In contrast to most research on perceived proximity which features virtual teams

(Mathieu et al., 2008; Wilson et al., 2008; Zamani & Pouloudi, 2022), the majority of the case company's actors are spatially close to each other. All actors of the process are located in the same complex or same part of the city (supplier), except for the development unit for the smaller product series. Within the sales organization, where the actors work in the same building, this closeness does seem to improve coordination and problem solving. This is in line with the traditional view of geographical distance's affect on the ability to transfer knowledge (Audretsch & Feldman, 1996). However, the other actors in the process rarely meet face-to-face, instead they use Microsoft Teams to meet remotely. Even though only being separated by a few kilometers at most, there is no apparent positive effect of being close geographically. In contrast, the development team for the smaller product series does seem to suffer from being located in another country, but not necessarily from being far apart when it comes to distance. Boschma (2005) and Wilson et al. (2008) offers two explanations to this. First, institutional proximity refers to, for example, shared habits, language, and laws (Boschma, 2005). In the case of the development organization abroad, they do not share neither habits, practises or native language, which results in low institutional proximity. Furthermore, the same low cognitive proximity that exists between the R&D organization, also exist in the development unit abroad. Second, quality communication and shared identity are the two variables affecting perceived proximity according to Wilson et al. (2008). In the case of the development unit abroad, close to all communication goes through the product owner of the smaller product series. Furthermore, this communication is frequent and rich according to that product owner. However, the other actors in the process does not have direct contact with the development unit making their communication both infrequent and second-hand. Moreover, the absence of interaction leads to low shared identification (Wilson et al., 2008), since the actors does not even know what person is responsible for what in the development unit, apart from the product owner.

The actors in the sales organization was shown to share organizational relation, thus experiencing high organizational proximity. This reduces opportunistic behaviour and facilitates feedback (Boschma, 2005). The same cannot be said about the actors in the R&D organization and the actors in the sales organization. The closest organizational tie they share is through the CEO. It could explain the insufficient CAD-modules the sales organization tries to extract from the system is a result of opportunistic behavior. However, the results rather shows that there is no prerequisite to have updated CAD-modules of every product variety. Another consequence of the low organizational proximity is the absence of communication channels. Since several steps in the process require input from people not directly connected to the process, such as someone to verify CAD-modules, there is no clear way of both finding and contacting that person. This relates to feedback being difficult to achieve when the organizations do not share relationships (Hansen, 1999).

5.5 Shared mental models

One way to achieve quality communication and shared identity, thus increasing the perceived proximity between actors is by establishing a shared mental model of the CGI-process (Cannon-Bowers et al., 1995; Zamani & Pouloudi, 2022). The four sub-models to achieve a shared mental model are presented in table 5.1.

Table 5.1: The four sub-models of shared mental models (Cannon-Bowers et al., 1995)

Models	Definition	CGI-process
Equipment model	Shared understanding of the tools necessary for the completion of the task.	CAD system is not shared, but the ordering system is shared on a basic level.
Task model	Shared understanding about what needs to be done for the completion of a task or a project.	Shared between the active actors, but not the inactive.
Team member model	Awareness of each other's skills, desires, habits, beliefs etc.	Shared by actors that work together closely, but not between all actors in the process
Team interaction model	Shared understanding of what is known and/or believed about team processes.	Not shared, as a result of not having a clear process.

First, in the case of the CGI-process the tools necessary to complete the task of producing CGIs (*equipment model*) are the ordering system, the sales tool (to create specifications) and the system used to extract CAD-modules. The ordering system is understood by all actors on a basic level, furthermore, the orderers and the CAD-extractor has a deeper understanding due to both extensive use and coming with suggestions on how to improve it. The sales tool is only fully understood by the product owners, however, it is not a part of the process that experiences difficulties as opposed to the system used to extract CAD-modules. The latter system is only used and partly understood by the CAD-extractor. Although having the most knowledge about the system, the CAD-extractor does not comprehend why some errors occur. Hence, the equipment model is not shared between the actors of the process

Second, the *task model* refers to understanding what tasks or steps is required to produce CGIs, but not in what order or how they are done. That is instead the *team interaction model.* The actors in the sales organization that work close to the process have a shared understanding of the tasks needed. However, the actors not directly connected to the process (e.g., the engineering unit or development unit for the smaller product series) are not aware. In addition, actors only participating for reviewing content are not aware of tasks outside the ones they participate in. Moreover, the absence of a process map contributes to some actors not sharing the understanding of the tasks in the process (Damij, Damij, et al., 2014). In sum, the actors most active in the process share an understanding, while the less active does not.

Third, the *team member model* is about knowing your peer's competences. In the context of the actors in the CGI-process, there exist both high and low awareness. Competences are well known between the actors that work closely together (e.g., the orderers and the project coordinator, or the CMF-responsible and the heads of design), but not between organizations (e.g., sales and R&D). Zamani and Pouloudi (2022) say that it is crucial to understand each others' competences, and this motivates the difficulties in verifying CAD-modules and reviewing renderings. However, since the process is characterized by a large number of actors it differs from the studies by Zamani and Pouloudi (2022) and Cannon-Bowers et al. (1995), which examined smaller size teams. The number of actors limits the ability for each actor to be aware of all other actors competences simultaneously.

Fourth, as aforementioned the *team interaction model* refers to the actors' shared understanding of the team processes, in this case it refers to the entity of the CGI-process. The result show that their process is perceived as unclear both in structure and responsibilities. Moreover, this is further highlighted by the absence of a documented process or process map.

The more shared understanding the actors have, the better they will communicate, thus increasing perceived proximity. In the case of virtual teams, all sub-models need to be shared to have a shared mental model (Zamani & Pouloudi, 2022). However it is unclear if that is the case for actors in a complex, multi-actor, inter-organizational process. Cannon-Bowers et al. (1995) argues that the equipment model only needs to be understood at a basic level. In the case of the CGI-process, the CAD-system in the equipment model is not shared and the task model is shared by the most active actors but not the less active ones. Furthermore, the team member model is not shared with actors that do not work closely together, although the large number of actors might limit the possibility to achieve this awareness. Finally, the team interaction model is not shared between actors since the process is thought of as unclear.

Cross-functional process map and perceived proximity

A process map enables teams to gain a clearer understanding of the process and steps involved (Damij, Damij, et al., 2014; Kalman, 2002). Understanding the steps/tasks and the process corresponds to the task model and the team interaction model (Zamani & Pouloudi, 2022). Hence, the introduction of a process map that fulfills those requirement would increase the shared mental model of the actors and thereby improve communication and perceived proximity. Moreover, the cross-functional process map is suitable for complex processes involving multiple actors and organizations (Damelio, 2011). Moreover, understanding an organization´s/actor's capabilities in a specific step in the process, increases the understanding of their skills and competences. As a result, it would also increase the team member model.

5.6 Synthesis

In sum, the challenges reported for the CGI-process are a result of lack of structure, non-defined responsibility, high product complexity and non-optimal perceived proximity. Furthermore, the low perceived proximity between some actors and organizations contribute to the difficulties in solving upcoming challenges (e.g., CAD-data problems). The challenges are not independent, but rather a breakdown of the challenges discovered in the Result Chapter. A cross-functional process map could increase the perceived proximity through establishing a shared mental model. In addition, it would also contribute to clearer structure and responsibility. Finally, modularity allows for flexibility and efficiency to cope with high product complexity. A summary of this reasoning is found Table 5.2 as well as the purposed modular and cross-functional process map in Figure 5.3. Further detail about the changes in the process map can be found in Chapter 8, Managerial implications.

Table 5.2: The envisioned impact of a modular, cross-functional process map on the challenges of the CGI-process

Challenges	**A modular, cross-functional process map's envisioned impact**	**Contributions of process mapping**
Lack of structure	Mapping the process leads to an increased understanding of the steps involved, thus providing structure (Damij, Damij, et al., 2014).	Figure 4.1 and Figure 5.3 show how the current structure looks like and purposed structure could look like respectively. Thereby visualizing the path of the process and reducing uncertainty.
Non-defined responsibility	Recognizing the cross-functional nature of the process and defining responsibility accordingly in the process map, leads to increased responsibility of the actors in the process (Marriott, 2018).	Formalizing the process steps and assigning responsible actors leads to higher accountability. Especially in the case of the R&D organization which are not direct users of the output (CGI).
High product complexity	A modular process allows for customization and flexibility (Bask et al., 2011), while being efficient as a whole (Baldwin & Clark, 2003), thus coping with the complexity of the product and CGI-demands.	Choosing modules depending on the CGI-need allows for coping with the demand efficiently. Also, introducing modules that address the CAD-data problems in phase-B further increases process performance.
Non-optimal perceived proximity	Having a shared mental model increases quality communication and shared identification, hence a better state of perceived proximity (Zamani & Pouloudi, 2022).	By actors using the process map shown in Figure 5.3, they will share more of a mental model of the CGI-production, which facilitates quality communication. Consequently, it will increase the perceived proximity where it is low (e.g., between the sales and R&D organization).

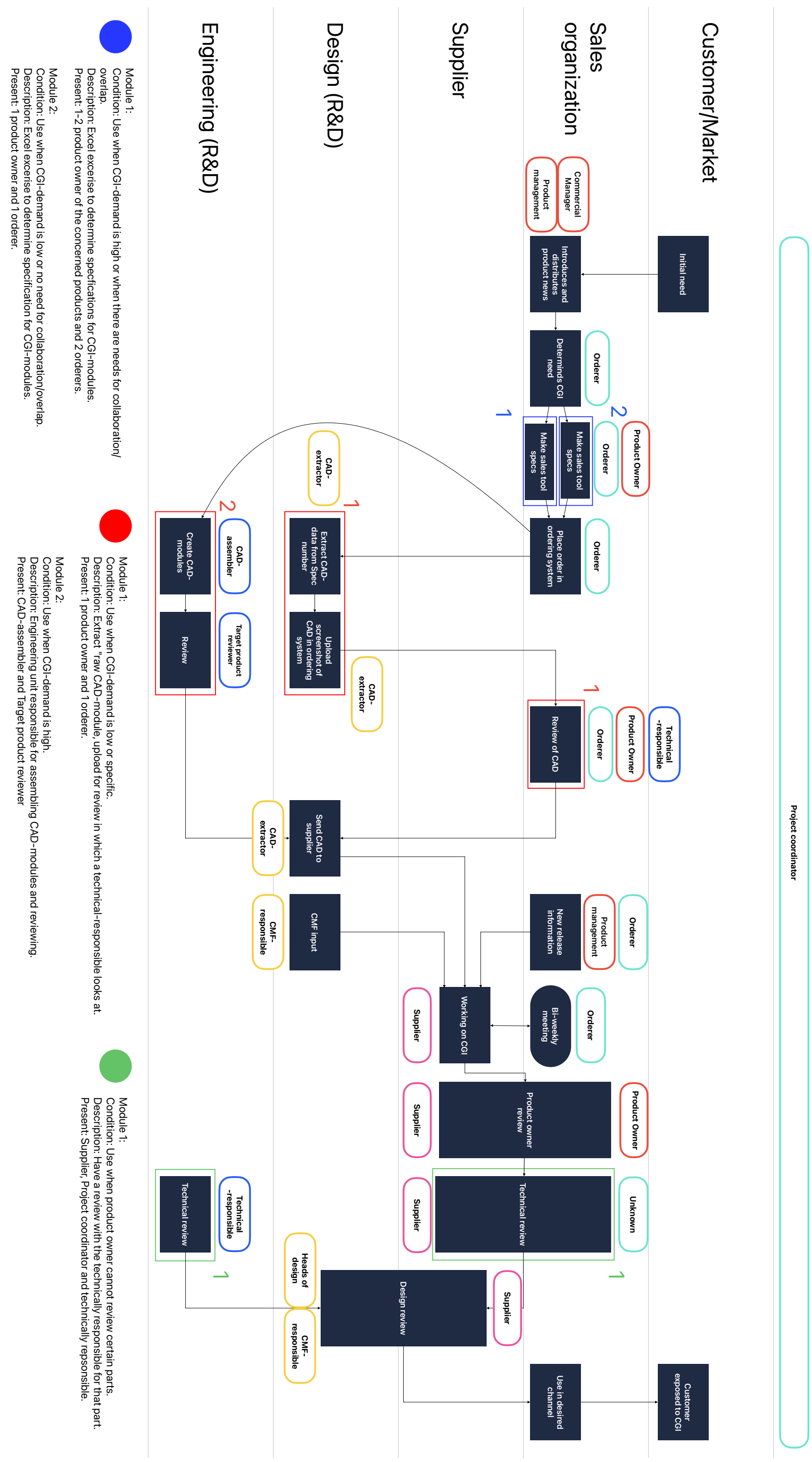

Figure 5.3: Proposed cross-functional modular process map

6 Discussion

This chapter answers and discusses the three research questions. Furthermore, it presents the limitations and areas for future research.

RQ1 - How can process mapping be used to increase understanding of work procedures in a multi-actor process?

Our study confirms that process maps could help in visualizing the work that gets done in an organization. Furthermore, visualizing processes proves to increase the understanding of the steps involved (Damij, Damij, et al., 2014). Moreover, having a clear process description in the form of a process map clarifies the process responsibilities in each step, which results in improved clarity of how communication and coordination between functional barriers should be handled (Kalman, 2002). Therefore, in terms of the case company´s challenges regarding inadequate work methods, unclear needs, responsibilities and requirements it could be argued that a process map clarifies the multi-actor CGI-process. Hence, increasing the understanding between stakeholders, including the degree of cognitive proximity, especially between the R&D organization and the sales organization. Since the current knowledge sharing is low, a cross-functional process map contribute to identify who possess the necessary and wanted information. Therefore, it is reasonable to assume that the organizations increase knowledge sharing of roles, which could contribute to that an actor in previous steps know how their outcomes is utilized in subsequent steps. However, an important aspect before using the proposed cross-functional process map as a work method is to make sure that all steps in the process map is verified regarding responsible individuals or departments. Otherwise, the multi-actor CGI-process will remain ambiguous, leading to uncertainties in identifying appropriate individuals in cases when problems occur. Furthermore, Graham (2006) emphasized the three key factors for successful process mapping: obtaining accurate information, ensuring that the structured map is understood by everyone, and the the compiled information must be valid. These factors could be considered a prerequisite for leveraging process mapping to enhance understanding of the CGI-process.

RQ2 - How can process modularity be used to simultaneously improve efficiency and flexibility?

This study shows that either modularizing or standardizing a whole process is challenging. However, the use of different service process types mentioned by Kalman (2002) allows for segmentation of the different phases in the CGI-process, thereby enabling modular strategies for each phase. Thus, with regards to the challenges for structure, product complexity and considerable variation in CGIs, it is assumed that enhanced efficiency could be achieved by breaking down specific segments of the process into modules. Hence, decomposing certain process steps into modules or creating new steps for ensuring the possibility to have accurate requirements and prerequisites from the beginning could improve the efficiency while allowing a high degree of flexibility. Moreover, before constructing the modules in each phase, the existing resources (e.g., systems and personnel) must support the new modular process, hence evaluating the existing capacity for the affected individual, department or organization is needed before implementation. Also, findings from the study provided by Droge et al. (2012) support modular architectures to enhance service performance, and modularity to enhance integration within the supply chain. Therefore, we can assume that a modular strategy can have a positive effect on the delivery performance of the CGIs towards the supplier, given that resources are available. Hence, by increasing the level of performance, subsequent steps could lead to improved quality, reduced iterations for problem solving and decreased costs for unnecessary corrections in late stages.

RQ3 - How can a process be designed to enhance perceived proximity in a multi-actor process?

The study confirms and extends the understanding of how perceived proximity affect an organizations performance, through understanding how it affects the performance of a multi-actor, inter-organizational process. First, the study confirms the theory of Boschma (2005) that different dimensions affect perceived proximity other than geographical, and that cognitive proximity is a requirement for coordination and problem solving. This is evident when actors in the R&D organization and sales organization experience high geographical proximity but low cognitive proximity and being unable to coordinate and solve issues related to the process together. Furthermore, as Boschma (2005) suggests, all dimensions are not independent. This study exemplifies this by showing that geographical proximity is linked with institutional proximity in the case of the development unit of the smaller product series experiencing low institutional proximity as a result of being located abroad. Second, the study confirms the model purposed by Wilson et al. (2008) on quality communication being a factor in perceived proximity. Quality communication was observed between the actors that also experienced higher perceived proximity, consequently, in the cases where perceived proximity was low, the communication was also infrequent and poor. In addition, shared identification between the actors was shown to be low where the perceived proximity was low, however, the study does not show that the shared identification was high when perceived proximity was high. Third, the study extends the knowledge on how perceived proximity can be enhanced using a modular, cross-functional process map to establish a shared mental model. Having a shared mental model facilitates quality communication and thus increases perceived proximity (Zamani & Pouloudi, 2022). This study shows that the degree of how shared the task model, the team interaction model and the team interaction model are increases by having a modular-cross functional process map. By having this shared mental model, the actors are able to convey rich and frequent communication, since they share understanding of the process. However, Zamani and Pouloudi (2022) argue that also the equipment model needs to be shared between actors to experience perceived proximity. On the one hand, our finding show that the lack of shared understanding of the tools necessary to complete the task is a limitation in the CGI-process. On the other hand, whether all actors in the a multi-actor process needs to share this understanding remains unclear.

Summary

In sum, process maps increase understanding, clarify responsibilities, and improve coordination across functional barriers. Implementing a cross-functional process map can address challenges in the case company, such as inadequate work methods and unclear needs. It promotes knowledge sharing, identifies key individuals, and reduces ambiguity in the multi-actor CGI-process. Furthermore, modularizing or standardizing the process is challenging, but segmenting phases with different service process types enables different modular strategies for each phase. Breaking down process segments into modules could therefore improve efficiency and flexibility. Moreover, the study emphasizes the importance of cognitive proximity for coordination and problem-solving. Quality communication and shared mental models contribute to increased perceived proximity.

Limitations

This study did not involve the implementation of the cross-functional process map. Consequently, there is lack of empirical evidence of the impact of implementing this process map at the case company. Moreover, there was a lack of insights in the R&D organization regarding working methods and respondents due to the focus on the internal process at the sales organization. In addition, only one case was examined which makes it hard to generalize. Furthermore, this study did not cover the entity of the CGI-process which spans across approximately one year, while this study was performed during five months. Also, the respondents were more focused on the current phase in the process, which could limit the possibility to follow the complete progression of the CGI-process. No respondents from the abroad development unit was interviewed. Lastly, since it is a large multinational organization, a limitation lead to that the sample of respondents could be consider small in relation to possible respondents.

Future research

Due to limitations in the insight in the R&D organization, one future research area is to study the perceived proximity between organizations. Furthermore, Balland et al. (2015) has suggested a dynamic framework of the proximity dimensions, which could be the basis of such research. Several authors discuss the importance of obtaining the optimal level of perceived proximity (i.e., neither too much or too little proximity) (Balland et al., 2015; Boschma, 2005; Wilson et al., 2008; Zamani & Pouloudi, 2022), however, how to achieve this level of proximity has not been studied. Therefore it also serves as an area for future research. Last, this report does not study the actual impact on perceived proximity from implementing a modular, cross-functional process map. As a result, future empirical research in this area is of interest.

7
Conclusion

The purpose of this study was to investigate how to improve efficiency and flexibility of a complex, multi-actor, inter-organizational process through process mapping and modularity in a way enhancing perceived proximity. Introducing a modular cross-functional process map could enhance mutual understanding amongst the actors regarding work procedures and the handling of steps in the process. This improvement in understanding leads to increased efficiency both within and between process steps. Since visualizing the process facilitates comprehension of the performed work, it thereby offer the possibility to develop a modular strategy to further improve efficiency while still having the flexibility aspect in mind.

Another conclusion is that modularizing specific parts of the process, achieved through decomposing and creating modules, will bring significant benefits. However, it is crucial to establish a clear understanding of the activities occurring at each step and assign responsibilities in advance. This is where the cross-functional process map proves valuable, as it establishes clarification of work procedures and responsibilities. Moreover, a complex process might need different modular strategies depending on the phase of the process. Depending on the process being fluid or rigid, different strategies can be applied to the same core process. As a result, the modules for one part of the process might differ from another due to being derived from a different modular strategy. An example of this is first module in phase-B and the technical review in the final phase. The former module contains moves a large part of the work from the sales organization to the engineering unit, to be able to save cost and increase efficiency. As a result it is a large change in the current working methods. However, the latter is a simple module used to increase the quality of the final image through an extra review, thus not being as large a change.

The conclusion regarding perceived proximity is that the cognitive level needs to be raised, as the current level results in coordination issues and problems with collaborative problem-solving. It can be concluded that the quality communication were higher in relationships when the cognitive level was high. Furthermore, when the cognitive level was low, it resulted in low quality communication. Therefore, utilizing a cross-functional process map that enhances understanding also leads to the development of a shared mental model. This, in turn, improves the quality communication and consequently enhances the perceived proximity, foremost in terms of cognitive and organizational proximity. Moreover, when utilizing a cross-functional process map, it becomes easier to establish a shared understanding of which tools to use, what tasks that need to be accomplished, who possesses specific knowledge, and different actors' needs.

8

Managerial implications

The multi-actor and inter-organizational nature of the process leads to complexity. Without a clearly defined process map, there is low level of understanding and a lack of clarity regarding the process flow. To address this, the first recommendation is to create a cross-functional process map that identify all relevant stakeholders and organizations involved. This map specifically focus on the people or departments closest to the process. Moreover, the ambiguous steps in the process should be highlighted for further clarification, and clear responsibilities should be assigned to individuals or departments for each step to promote accountability and efficient execution.

With regards to complex processes, it is important to recognize that they often require a balance between efficiency and flexibility. Therefore, it is recommended to explore modular opportunities to achieve this balance. In the case of processes with a large number of steps, a one-fits-all approach may not be suitable and it becomes crucial to avoid both over-standardization or excessive modularization. To tackle this, the second recommendation is to categorize the process phases according to service typologies and then modularize according to the modular strategy feasible for the specific service type. Furthermore, it is essential to provide education to users of the modules, ensuring they have a comprehensive understanding of how to effectively utilize the modules in the process. This approach will enable organizations to optimize their processes, balancing efficiency and flexibility while promoting engagement.

If a process step is complex and requires input from multiple actors, it becomes challenging to modularize the step. In such cases, it is necessary to consider a change in approach. This complexity can often be connected to low perceived proximity among the involved actors. To address this, the third recommendation is to redesign the process, aiming to increase the cognitive proximity and other dimensions of perceived proximity that may be low and achieve this through quality communication and identification. However, some types of proximity is difficult to affect such as institutional proximity, which is low in the case of the development unit of the smaller product series and the sales organization. In these cases our recommendation is to focus on the dimensions you can affect making them act as a substitute . Through increasing the degree of proximity and collaboration, the complexity of the process step can be reduced, assumingly leading to better overall performance and outcomes.

Example for the case company

As the process for producing CGIs is complex, the first recommendation is to map the process to increase understanding. This mapping corresponds to Figure 4.1, showing what actors are involved in each step. In addition it shows ambiguous steps by labeling the actors involved in those steps as unclear (e.g, the problem solving steps following a insufficient review). Without visualization it is hard to both pinpoint challenging steps and solve the issue that causes the challenges. Furthermore, it is necessary to examine if the process is suitable for modularization.

The CGI-process is divided into four phases: A,B,C and D. These phases correspond to the need phase, the CAD-extraction and dispatch phase, the rendering phase and the review and finalizing phase respectively. As aforementioned, phase A is categorized as a type 2 process, while the subsequently phases are categorized as type 4 processes. As a result, different modular strategies needs to be applied depending on the phase.

First, the modular strategy for phase A is customer efficiency. In the case of the CGI-process, the customer is the orderer. Moreover, the amount of CGIs needed depend on the amount of updates coming form the R&D organization. These updates either comes from quarterly updates or larger projects, the latter usually result in a high demand of CGIs. Therefore, two modules can be applied here depending on the amount of news introduced. The first would be used when the demand for CGIs is high and include both orderers and 1-2 product owners. The second would be used when the demand for CGI is low and only include one order and product owner. Both modules result in the sales tools specifications to cover the need of CGIs.

Second, the modular strategy for phase B is relationship focused and is also where the struggles with the CAD-data occur. The problems concern both the correctness of CAD-modules and difficulties in reviewing them. This is an example where the perceived proximity needs to be increased (see recommendation three). When the need for CGIs are high, which can be the case for a larger project, the first module should be used. The first module would include "CGI-target products" in the development projects to facilitate the CAD needs of the CGI-production. As a result, more resources would be needed from the R&D organization but the overall cost of the process would decrease since less time would be spent reviewing and correcting CAD images. The second module is to be used when there is a low demand or specific needs. In this case a technical responsible would be included in the "Review of CAD" step to verify things that the product owner and orderer cannot verify themselves. Otherwise the process looks like it does today.

Third, the changes in phase B would result in the reduction on time spent "Problem solving to adjust CAD" in phase C. The other issue in this phase is sending the "New release information", which is addressed through standardization of that step. This would include a member of the product management team sending a stripped down version of the "New release information" to the supplier. This clarifies responsibility and effectiveness.

Fourth, phase D should also have the modular strategy relationship focused. In this case, the two review steps can be modularized depending on the need for review. I.e., having one module for the "Product review" and one for the "Design review". This would prepare the actors that needs to review the images (Product owner, CMF-responsible, and Heads of design) on the extent of the review work. Moreover, it would also make the actors look at the same images at the same time and reach consensus, instead of having, e.g., two separate technical reviews with product owners that have different opinions. Also, a third module is added if needed called "Technical review", which should be used when the product owner cannot verify the module. The technical responsible is included in this step for the part of the product that is difficult to review.

Bibliography

Allen, T. J., et al. (1984). Managing the flow of technology: Technology transfer and the dissemination of technological information within the r&d organization. *MIT Press Books*, *1*.

Amason, A. C., & Sapienza, H. J. (1997). The effects of top management team size and interaction norms on cognitive and affective conflict. *Journal of management*, *23*(4), 495–516.

Araujo, L., & Spring, M. (2010). Complex performance, process modularity, and the spatial configuration of production. In *Procuring complex performance* (pp. 94–112). Routledge.

Audretsch, D. B., & Feldman, M. P. (1996). R&d spillovers and the geography of innovation and production. *The American economic review*, *86*(3), 630–640.

Baldwin, C. Y., & Clark, K. B. (2003). Managing in an age of modularity. *Managing in the modular age: Architectures, networks, and organizations*, *149*, 84–93.

Balland, P.-A., Boschma, R., & Frenken, K. (2015). Proximity and innovation: From statics to dynamics. *Regional Studies*, *49*(6), 907–920.

Barratt, M., Choi, T. Y., & Li, M. (2011). Qualitative case studies in operations management: Trends, research outcomes, and future research implications. *Journal of operations management*, *29*(4), 329–342.

Bask, A., Lipponen, M., Rajahonka, M., & Tinnilä, M. (2011). Framework for modularity and customization: Service perspective. *Journal of business & industrial marketing*, *26*(5), 306–319.

Bell, E., Bryman, A., & Harley, B. (2022). *Business research methods*. Oxford university press.

Blanc, H., & Sierra, C. (1999). The internationalisation of r&d by multinationals: A trade-off between external and internal proximity. *Cambridge Journal of Economics*, *23*(2), 187–206.

Boschma, R. (2005). Proximity and innovation: A critical assessment. *Regional studies*, *39*(1), 61–74.

Böttcher, M., & Klingner, S. (2011). Providing a method for composing modular b2b services. *Journal of Business & Industrial Marketing*, *26*(5), 320–331.

Bunnell, T. G., & Coe, N. M. (2001). Spaces and scales of innovation. *Progress in Human geography*, *25*(4), 569–589.

Burr, W. (2016). *Service engineering bei technischen dienstleistungen: Eine ökonomische analyse der modularisierung, leistungstiefengestaltung und systembündelung*. Springer-Verlag.

Campagnolo, D., & Camuffo, A. (2010). The concept of modularity in management studies: A literature review. *International journal of management reviews*, *12*(3), 259–283.

Cannon-Bowers, J. A., Tannenbaum, S. I., Salas, E., & Volpe, C. E. (1995). Defining competencies and establishing team training requirements. *Team effectiveness and decision making in organizations*, *333*, 380.

Carlborg, P., & Kindström, D. (2014). Service process modularization and modular strategies. *Journal of Business & Industrial Marketing*, *29*(4), 313–323.

Carter, N. (2014). The use of triangulation in qualitative research. *Number 5/September 2014*, *41*(5), 545–547.

Clark, H. H. (1992). *Arenas of language use*. University of Chicago Press.

Cohendet, P., & Llerena, P. (1997). Learning, technical change and public policy: How to create and exploit diversity. *Edquist, C., Systems of innovation, Pinter, London and Washington*, 223–241.

Cramton, C. D. (2001). The mutual knowledge problem and its consequences for dispersed collaboration. *Organization science*, *12*(3), 346–371.

Czarnecki, K., Østerbye, K., & Völter, M. (2002). Generative programming. *Object-Oriented Technology ECOOP 2002 Workshop Reader: ECOOP 2002 Workshops and Posters Málaga, Spain, June 10–14, 2002 Proceedings*, 15–29.

Damelio, R. (2011). *The basics of process mapping*. CRC press.

Damij, N., Damij, T., et al. (2014). *Process management*. Springer.

Davenport, T. H. (1993). *Process innovation: Reengineering work through information technology*. Harvard Business Press.

Davies, A., Brady, T., & Hobday, M. (2007). Organizing for solutions: Systems seller vs. systems integrator. *Industrial marketing management*, *36*(2), 183–193.

Davies, I. K. (1994). Process re-design for enhanced human performance. *Performance Improvement Quarterly*, *7*(3), 103–114.

DiCicco-Bloom, B., & Crabtree, B. F. (2006). The qualitative research interview. *Medical education*, *40*(4), 314–321.

Diener, E., & Crandall, R. (1978). *Ethics in social and behavioral research*. U Chicago Press.

Droge, C., Vickery, S. K., & Jacobs, M. A. (2012). Does supply chain integration mediate the relationships between product/process strategy and service performance? an empirical study. *International Journal of Production Economics*, *137*(2), 250–262.

Edquist, C., & Johnson, B. (1996). *Institutions and organizations in systems of innovation*. Univ.

Frohlich, M. T., & Westbrook, R. (2001). Arcs of integration: An international study of supply chain strategies. *Journal of operations management*, *19*(2), 185–200.

Gao, T., Ma, H., Yen, I.-L., Khan, L., & Bastani, F. (2006). A repository for component-based embedded software development. *International Journal of Software Engineering and Knowledge Engineering*, *16*(04), 523–552.

Graham, B. (2006). The key to good process mapping. *The Ben Graham Corporation, Available at: http://www. worksimp. com/articles/the key to good process mapping. pdf(accessed 05 August 2015)*.

Gremyr, I., Bergquist, B., & Elg, M. (2020). *Quality management: An introduction*. Studentlitteratur AB.

Grönroos, C. (2011). Value co-creation in service logic: A critical analysis. *Marketing theory*, *11*(3), 279–301.

Hackman, J. R. (1990). *Groups that work and those that don't*. Jossey-Bass.

Hansen, M. T. (1999). The search-transfer problem: The role of weak ties in sharing knowledge across organization subunits. *Administrative science quarterly*, *44*(1), 82–111.

Harrington, H. J., et al. (1994). *Business process improvement*. Association for Quality; Participation.

Hayes, R. H. (1979). Link manufacturing process and product life cycle. *Harvard business review*, 133–140.

Hsiao, S.-W., & Chou, J.-R. (2004). A creativity-based design process for innovative product design. *International journal of industrial ergonomics*, *34*(5), 421–443.

Hyötyläinen, M., & Möller, K. (2007). Service packaging: Key to successful provisioning of ict business solutions. *Journal of Services Marketing*.

IBM. (2023). *What is process mapping?* Retrieved February 6, 2023, from https://www.ibm.com/topics/process-mapping

Jacobs, M., Vickery, S. K., & Droge, C. (2007). The effects of product modularity on competitive performance: Do integration strategies mediate the relationship? *International Journal of Operations & Production Management*, *27*(10), 1046–1068.

Kalman, H. K. (2002). Process mapping: Tools, techniques, & critical success factors. *Performance Improvement Quarterly*, *15*(4), 57–73.

Katunzi, T. M. (2011). Obstacles to process integration along the supply chain: Manufacturing firms perspective. *International Journal of Business and Management*, *6*(5), 105.

Kegan, R., & Lahey, L. L. (2001). *The real reason people won't change*. Harvard Business Review Boston, MA.

Khoong, C. M. (1997). Business process reengineering: Breakpoint strategies for market dominance.

Kirat, T., & Lung, Y. (1999). Innovation and proximity: Territories as loci of collective learning processes. *European urban and regional studies*, *6*(1), 27–38.

Lincoln, Y. S., & Guba, E. G. (1988). Criteria for assessing naturalistic inquiries as reports.

Lundvall, B.-Å. (1990). Explaining inter-firm cooperation and innovation-limits of the transaction cost approach.

Madison, D. (2005). *Process mapping, process improvement, and process management: A practical guide for enhancing work and information flow*. Paton Professional.

Mantere, S., & Ketokivi, M. (2013). Reasoning in organization science. *Academy of management review*, *38*(1), 70–89.

Marriott, R. D. (2018). Process mapping–the foundation for effective quality improvement. *Current problems in pediatric and adolescent health care*, *48*(7), 177–181.

Martin, K., & Osterling, M. (2012). *Metrics-based process mapping: Identifying and eliminating waste in office and service processes*. CRC Press.

Maskell, P., & Malmberg, A. (1999). The competitiveness of firms and regions: 'ubiquitification'and the importance of localized learning. *European urban and regional studies*, *6*(1), 9–25.

Mathieu, J., Maynard, M. T., Rapp, T., & Gilson, L. (2008). Team effectiveness 1997-2007: A review of recent advancements and a glimpse into the future. *Journal of management*, *34*(3), 410–476.

McKnight, D. H., Cummings, L. L., & Chervany, N. L. (1998). Initial trust formation in new organizational relationships. *Academy of Management review*, *23*(3), 473–490.

Miller, J. G., & Roth, A. V. (1994). A taxonomy of manufacturing strategies. *Management Science*, *40*(3), 285–304.

Narasimhan, R., & Carter, J. R. (1998). Linking business unit and material sourcing strategies. *Journal of business Logistics*, *19*(2), 155.

Osanloo, A., & Grant, C. (2016). Understanding, selecting, and integrating a theoretical framework in dissertation research: Creating the blueprint for your "house". *Administrative issues journal: connecting education, practice, and research*, *4*(2).

Ostrom, A. L., Bitner, M. J., Brown, S. W., Burkhard, K. A., Goul, M., Smith-Daniels, V., Demirkan, H., & Rabinovich, E. (2010). Moving forward and making a difference: Research priorities for the science of service. *Journal of service research*, *13*(1), 4–36.

Paananen, H., Irrmann, O., & Smeds, R. (2013). Perceived proximity and paradoxical tensions in an innovative industry-academia consortium. *2013 46th Hawaii International Conference on System Sciences*, 4617–4624. https://doi.org/10.1109/HICSS.2013.446

Palmberg, K. (2009). Exploring process management: Are there any widespread models and definitions? *The TQM Journal*, *21*(2), 203–215.

Pekkarinen, S., & Ulkuniemi, P. (2008). Modularity in developing business services by platform approach. *The International Journal of Logistics Management*.

Petersen, K. J., Handfield, R. B., & Ragatz, G. L. (2005). Supplier integration into new product development: Coordinating product, process and supply chain design. *Journal of operations management*, *23*(3-4), 371–388.

Rahikka, E., Ulkuniemi, P., & Pekkarinen, S. (2011). Developing the value perception of the business customer through service modularity. *Journal of Business & Industrial Marketing*, *26*(5), 357–367.

Rummler, G. A., & Brache, A. P. (2012). *Improving performance: How to manage the white space on the organization chart*. John Wiley & Sons.

Rust, R. T., & Huang, M.-H. (2012). Optimizing service productivity. *Journal of Marketing*, *76*(2), 47–66.

Säfsten, K., & Gustavsson, M. (2019). *Forskningsmetodik: För ingenjörer och andra problemlösare*. Studentlitteratur ab.

Salvador, F., Forza, C., & Rungtusanatham, M. (2002). Modularity, product variety, production volume, and component sourcing: Theorizing beyond generic prescriptions. *Journal of operations management*, *20*(5), 549–575.

Sametinger, J. (1997). *Software engineering with reusable components*. Springer Science & Business Media.

Seol, H., Kim, C., Lee, C., & Park, Y. (2007). Design process modularization: Concept and algorithm. *Concurrent Engineering*, *15*(2), 175–186.

Shaw, A. T., & Gilly, J.-P. (2000). On the analytical dimension of proximity dynamics. *Regional studies*, *34*(2), 169–180.

Skinner, W. (1980). Manufacturing and technological strategy. *Journal of Business Strategy*, *1*(2), 69–72.

Smith, R. P., & Morrow, J. A. (1999). Product development process modeling. *Design studies*, *20*(3), 237–261.

Sundbo, J. (2002). The service economy: Standardisation or customisation? *Service Industries Journal*, *22*(4), 93–116.

Sutrop, U. (2001). List task and a cognitive salience index. *Field methods*, *13*(3), 263–276.

Szyperski, C., Gruntz, D., & Murer, S. (2002). *Component software: Beyond object-oriented programming*. Pearson Education.

Tang, D., Zheng, L., Li, Z., Li, D., & Zhang, S. (2000). Re-engineering of the design process for concurrent engineering. *Computers & Industrial Engineering*, *38*(4), 479–491.

Trkman, P. (2010). The critical success factors of business process management. *International journal of information management*, *30*(2), 125–134.

Tuunanen, T., & Cassab, H. (2011). Service process modularization: Reuse versus variation in service extensions. *Journal of Service Research*, *14*(3), 340–354.

Ulkuniemi, P., & Pekkarinen, S. (2011). Creating value for the business service buyer through modularity. *International Journal of Services and Operations Management*, *8*(2), 127–141.

Vakola, M., & Rezgui, Y. (2000). Critique of existing business process re-engineering methodologies: The development and implementation of a new methodology. *Business process Management journal*.

Wheelwright, S. C., & Clark, K. B. (1992). *Revolutionizing product development: Quantum leaps in speed, efficiency, and quality*. Simon; Schuster.

Wilson, J. M., Boyer O'Leary, M., Metiu, A., & Jett, Q. R. (2008). Perceived proximity in virtual work: Explaining the paradox of far-but-close. *Organization studies*, *29*(7), 979–1002.

Xue, M., & Harker, P. T. (2002). Customer efficiency: Concept and its impact on e-business management. *Journal of Service Research*, *4*(4), 253–267.

Yassine, A., Falkenburg, D., & Chelst, K. (1999). Engineering design management: An information structure approach. *International Journal of production research*, *37*(13), 2957–2975.

Yin, R. K. (2003). Designing case studies. *Qualitative research methods*, *5*(14), 359–386.

Zairi, M. (1994). Benchmarking: The best tool for measuring competitiveness. *Benchmarking for Quality Management & Technology*, *1*(1), 11–24.

Zamani, E. D., & Pouloudi, N. (2022). Shared mental models and perceived proximity: A comparative case study. *Information Technology & People*, *35*(2), 723–749.

A

Appendix 1

Introduction:
What is your role at the company?
What are your background at the company and previously?

Explain what we are investigating, and limitations.
Explain anonymity, right to record and transcribe.

What is the concrete output of your work, do you have anything you could show us?

Questions regarding process management/mapping:

How would you describe the process to product CGIs?
What is your connection to the process?
In what steps are you active in?
What and who are you dependent on, and vice versa?
How often do you interact with the process?
Can you describe what steps in the process you know well?

Questions regarding process modularity:

Does the process to produce CGIs vary or does it always stay the same? How does the complexity between orders di er?
Can you describe a situation or example when an order worked well and reasons?
Can you describe a situation or example when an order worked poorly and reasons?
What steps in the process works well and what works poorly?

Questions regarding perceived proximity:

Social: How is the social relations between actors in the process? (Meetings, friends, AW)
Cognitive: How much knowledge overlap do you feel exist between you and other actors connected to the process?

Institutional: How well do you feel like the reliability to other organizations in the process is in terms of deliveries and following what has been agreed on?

Organizational: How close are you to the other actors in the process organizationally? Are you part of the same group, department or organization?

Geographical: Where are you located in relation to the other actors in the process? How much do you meet face to face, and with who?

We have discussed the process, variants, the collaboration between the actors of the CGI-process. Is there anything you would like to add, or anything you would like to emphasize?

B

Appendix 2

Table B.1: Respondent table

Role	**Department**	**Organization**
Orderer	Product Information	Sales organization
Orderer	Marketing	Sales organization
Orderer	Marketing	Sales organization
Product Owner	Commercial	Sales organization
Product Owner	Commercial	Sales organization
Product Owner	Commercial	Sales organization
Product Owner (smaller product series)	Commercial	Sales organization
CAD-extractor	Design unit	R&D organization
CMF-responsible	Design unit	R&D organization
Head of design 1	Design unit	R&D organization
Head of design 2	Design unit	R&D organization
User of CGI	Marketing	Sales organization
Project Coordinator	Markering	Sales organization
Head of CAD-assembly	Engineering unit	R&D organization
Product integrator	Engineering unit	R&D organization
Supplier	-	Supplier
Senior engineer	-	Aftermarket organization
Content creator	Product Information	Sales organization
Product information administrator	Product Information	Sales organization
Project leader	Commercial	Sales organization

DEPARTMENT OF TECHNOLOGY MANAGEMENT AND ECONOMICS
DIVISION OF SERVICE MANAGEMENT AND LOGISTICS
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden
www.chalmers.se

CHALMERS
UNIVERSITY OF TECHNOLOGY