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Process Improvement

Of Mechanical Product Design for Customer Delivery projects

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ABSTRACT:
As a result of fierce competition, today's companies need to improve their competitiveness continuously, where customer satisfaction has a significant role. Organizational performance is increased by focusing on different aspects of process management, redesign of business processes providing the possibility to reduce cost and throughput time, and thus increase customer satisfaction. Constant change in the case company of this study has led to the situation where the process of mechanical design in the scope of customer delivery projects has not been defined, and because of this never improved. Due to this, multiple parallel procedures exist within the current process together with an unclarity of milestones and responsibilities.

This study aims to define the current process, and to provide an improvement suggestion for the future. This objective is reached through combining theoretical findings from literature to the practical steps of business process re-engineering research method. Theoretical framework consists of the basics of process improvement in the context of mechanical product design in customer delivery projects. As-is to-be comparison is conducted through three steps: data collection, document, and analysis. The data utilized in this study to form the process model and improvement areas is collected through interviewing key expert stakeholders of the process.

The findings reveal that the current process consists of multiple subprocesses with a high number of stakeholders. The recognized improvement areas are considered in the to-be proposal which consists of a process model proposal and practical improvement suggestions. Primary improvement suggestions are related to themes of accountability, clarity, and milestones.

The findings are in line with several previous findings, although process improvement in this scope has not been researched previously. Thus, this study provides a beneficial starting point and basis for further research considering its limitations. The limitations include low number of interviewees and not being able to include process descriptions or metrics in the studied data. Due to this it is recognized that data does not consider all possible viewpoints and the study may not be generalized to all similar companies as the context may significantly impact the results.

KEYWORDS: Business processes, Process management, Design Management, Development, Project Management

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TIIVISTELMÄ:
Voimakkaan kilpailun seurauksena yritysten tulee nykyään parantaa kilpailukykyään jatkuvasti, missä asiakastyytyväisyydellä on merkittävä rooli. Yrityksen suorituskykyä voi parantaa keskittymällä prosessinhallinnan eri puoliin. Liiketoimintaprosessien uudelleensuunnittelu mahdollistaa kustannusten ja läpimenoajan laskun, mikä puolestaan johtaa asiakastyytyväisyyden kasvuun. Jatkuva muutos tämän tutkimuksen case-yrityksessä on johtanut tilanteeseen, jossa asiakastoimitusprojektien mekaanisen suunnittelun prosessia ei ole määritelty, eikä tästä johtuen ikinä kehitetty. Tästä johtuen nykyisessä prosessissa on monta rinnakkaista toimintatapaa, sekä epäselvyyksiä aikataulutuksesta ja vastuualueista.

Tämän tutkimuksen tavoitteena on määritellä nykyinen prosessi, sekä tarjota tulevaisuuden parannusehdotus. Tämä tavoite saavutetaan yhdistämällä kirjallisuuden teoreettisia löydöksiä liiketoimintaprosessin uudelleensuunnittelun tutkimusmenetelmän käytännön askeleisiin. Teoreettinen kehys koostuu prosessikehityksen perusteista asiakastoimitusprojektien mekaanisen tuotesuunnittelun yhteydessä. As-is to-be vertailu toteutetaan kolmen askeleen kautta: datan keruu, dokumentointi ja analyysi. Tässä tutkimuksessa prosessikaavion laatimisessa ja kehitysehdotusten muodostamisessa hyödynnetty data kerätään haastattelemalla prosessin sidosryhmien asiantuntijoita.

Tutkimuksen tuloksista paljastuu, että nykyinen prosessi koostuu useista aliprosesseista, joilla on monta sidosryhmää. Tunnistetut kehityskohteet otetaan huomioon to-be ehdotuksessa, joka koostuu prosessikaaviohahmotelmasta ja käytännön parannusehdotuksista. Pääasialliset parannusehdotukset liittyvät vastuullisuuden, selkeyden ja aikataulutuksen teemoihin.

Tämän tutkimuksen tulokset ovat linjassa useiden aiempien tutkimustulosten kanssa, vaikka prosessikehitystä tässä yhteydessä ei olekaan aiemmin tutkittu. Tästä johtuen tämä tutkimus on hyödyllinen lähtökohta ja perusta jatkotutkimukselle, rajoitukset huomioon ottaen. Rajoituksia ovat haastateltujen pieni lukumäärä ja aiempien prosessikuvausten ja -mittareiden puuttuminen tutkitusta datasta. Tästä johtuen tuloksia tulee pitää suuntaa-antavina, sillä asiayhteys voi vaikuttaa saatuihin tuloksiin merkittävästi.

AVAINSANAT: Business processes, Process management, Design Management, Development, Project Management

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Abbreviations

BPR Business Process Re-Engineering

CN Change Notice

EBOM Engineering Bill of Material

ETO Engineer-to-Order

ExW Date when engine exits production

FAT Factory Approval Test

IDEF Integrated Definition for Function Modelling

IOS Internal Order Specification

IPI Installation Planning Instruction

KPI Key Performance Indicator

MoM Minutes of Meeting

NSR Non-Standard request

NVA Non-Value Added

OR Operations Research

POA Plan of Action

RDE Research & Development and Engineering

SOA Start of Assembly

WIP Work in Progress

WoW Way of Working

1 Introduction

This chapter provides an introduction of the thesis. Background of the study, case company, research problem, scope, and structure of the study are presented in this chapter to create a description of the research structure.

1.1 Background and case company

The competition in technology industry today gives companies no other options than to continuously improve their competitiveness. If a company does not improve, it is certain that its competitors will, and there are always eager newcomers ready to enter the market (Andersen, 2007). Companies have been revising their strategies, and customer satisfaction has been considered as a secret to survival (Ashtiani & Bosak, 2013). Modern customers are demanding, and the quality of supply is on continuous rise (Andersen, 2007). If a company is not able to exceed customer expectations, or at minimum meet, it is guaranteed that the customer is lost (Andersen, 2007).

For a company to be able to withstand rapid changes in the market, and fierce competition, an increasing level of organizational performance is required, which in turn is made possible by a higher level of focus on aspects of process management (Hermkens, 2008). Redesigning business processes has the potential to drastically reduce cost and throughput time, and increase customer satisfaction (Vanwersch et al., 2016).

The case company is a global leading company providing sustainable technology solutions. The Research & Development and Engineering (RDE) department of the case company is responsible for the research and development of new products, technologies, and concepts, and for the engineering of parts. This study focuses on the mechanical design process in customer delivery projects.

1.2 Research problem and objectives

Due to almost continuous change in the case company, the process of mechanical design for customer delivery projects has never been defined, and thus has never been improved. This has led to the current situation, where Ways of Working (WoW) are a result of practicalities optimized for factories located in different countries. The lack of process modelling, and WoW improvement has caused unclarity of milestones, and responsibilities together with a clearly recognized need for improving the process. Thus, the research problem of this study is: “How can the process be defined and improved?”

Viewing the situation from efficiency point of view for instance, the definition of a process is crucial for having a guiding principle for all stakeholders to follow. Unclear scope of responsibilities and milestones leads to wasting time and making it impossible to conduct process improvement when the process does not even exist in practice.

In addition to a non-existent process, the current WoWs differ for different product sizes and organizations. This leads to further unclarities and makes improvement efforts even more challenging. Thus, harmonization of WoWs would be beneficial, and there is already a proposal made for this, but it has not been taken into use. The exact reason for this is not identified in the company, and for this to happen further investigation of possibly existing bottlenecks for example is required.

The objective of this study is to create a definition of the current process. By creating an understanding of the current situation, it is possible to draft improvement proposals for the future. As a result of this study further studies are able to continue with taking into use the improved process, since the functionalities of the design process will be clarified for all parties involved and clear improvement suggestion presented. The objective is reached by utilizing already existing research methods and combining this to findings from literature and data acquired during this research. By doing this the functionality of already existing research methods is proven and possible further contributions to theory are formed.

In order to answer the research problem, two research questions can be presented:

1. What is the current process model and what are the benefits and challenges of it?
2. How can the process model be improved in the best possible way?

The research questions are a direct result of the research problem, and by answering these research questions a solution for the research problem is provided.

1.3 Research scope

When conducting an academic study, the researcher should consider the balance of rigor and relevance in their paper, which is a classic dilemma in academic fields with practical implications (Glass, 2001). In practice, this means making the decision whether it is more relevant in a study to focus on making flawless research (rigor), or if the focus should be on the potential practical use of research (relevance) (Glass, 2001). Both aspects being useful and relevant in research, the main emphasis of this study is relevance. This is due to nature of the research problem, and the fact that this study is executed for a case company based on their requirements stemming from an actual business purpose.

This research is an as-is to-be analysis of the mechanical design process. The analysis consists of illustrating the current process and identifying improvement areas of it. In practice this is done by collecting data from stakeholder interviews, analyzing this, and drafting an improvement suggestion by comparing identified areas for improvement to the as-is situation and findings from literature. Practical implementation of to-be analysis, which would be taking the suggestion into use in practice, or other further actions, is excluded from the scope of this study.

The analyzed process belongs to the whole case company to certain extent, due to the number of stakeholder organizations involved. This study is limited to focus on the

subprocesses and tasks of the process which are related to the mechanical design procedures of RDE department of the company. Procedures only related to other departments are out of this study's scope, and therefore excluded from the final process model. Multiple stakeholders outside of the RDE department are included in the process charts due to their high level of involvement in mechanical design procedures. By this inclusion, the multiple interfaces of responsibilities in the process are illustrated more thoroughly. All gathered data in this study is from the current situation of the case company.

1.4 Structure of the study

This research is constructed of five chapters beginning with the introduction chapter consisting of the study background, research problem, and scope. Theoretical framework of the study is portrayed in the second chapter, focusing on concepts of process, its improvement and modelling together with the context of mechanical design and customer delivery projects, and possible challenges occurring in this context. After the theoretical framework, the third chapter consists of explaining and justifying the methodological approach of this study, presenting the chosen research methodology, its empirical implementation, and the validity and reliability of this study. Fourth chapter continues with presenting the results and findings of the research, conducting an as-is to-be analysis for the current process. That is followed by the fifth and final chapter which discusses and concludes the key findings, as well as explores the theoretical contributions, and practical implications. The final chapter finishes with explaining the limitations of this research, and suggestions for future research.

2 Process improvement

This chapter forms the theoretical framework of the thesis including a literature review considering the topics related to this research. The chapter begins with an introduction to the theoretical framework of this study and presenting the topics discussed in this chapter, and after this focusing to the main theoretical concepts of this study one at a time.

2.1 Theoretical framework of the study

Process is a set of related activities turning input into output (ISO, 2008). The main advantage of a process is seen to be the possibility to manage interaction happening within a process, and for this functionality to happen, a tool is usually required to support the process (ISO, 2008). A process can be evaluated by investigating it on different levels, through the evaluation of what is achieved with the process, how the process is organized, and how work inside the process is executed in practice (Roberts, 1994). In a business process, repetitiveness of functionalities within a process tends to be one of its characteristic features (Andersen, 2007). Another characteristic feature of a process should be the co-operation of different functions when handing over the project to another function, at all process steps (Sandhu & Gunasekaran, 2004).

To be able to execute a process improvement activity, documentation of current state is required (Andersen, 2007). Creating a process model is beneficial also because of multiple other reasons, for instance it facilitates forming a specific description and understanding of the current process state, possibly leading a higher degree of stakeholder involvement (Andersen, 2007).

Maintenance of a process ought to be an active part of its existence, and if aiming to improve or renew a process, efforts beyond the regular are needed (Andersen, 2007). Both experience and context from the process are taken into consideration, when process improvement is executed based on the concerns of parties having the highest level

of process awareness (Schonberger, 2018). Thus, suitable organizational structure and strategy are crucial for successful process improvement (Andersen, 2007). It has been argued that business process re-engineering, being based on major structural change, might be too demanding for companies operating in engineer-to-order nature of business (Cameron & Braiden, 2004). Key element in the success of process improvement efforts is culture, which understands its importance (Antony et al., 2019).

Customer demand for products to be perfect means that the output of internal processes needs to be flawless for the sake of avoiding customer dissatisfaction (Freiesleben, 2010). The objective of mechanical design process is the best possible compromise between technological and economic aspects, aiming to maximize lifecycle and performance while minimizing cost (Abd Elaziz et al., 2022). Also, the performance of supply chain as a whole has a remarkable role in company competitiveness, especially in the context of profitability (Ashtiani & Bosak, 2013).

This chapter will continue by first introducing the concept of a process, after this discussing process improvement, modelling, presenting the context of mechanical product design and customer delivery projects, and challenges related to these topics. These concepts are included in the theoretical framework since this study focuses on improving a process by utilizing process modelling. The environment for this research is mechanical product design in customer delivery projects, which is why these are also discussed, and the challenges of conducting process improvement in these surroundings.

2.2 Process

A general definition of a process is that it is a set of activities, which are either interrelated or interacting, and this way turning inputs into outputs (ISO, 2008). A remarkable advantage of the process way of working, comparing to other possible approaches, is the management and control of process interactions, and interfaces existing between different functional units and hierarchies within an organization (ISO, 2008). To function properly, a process needs a tool to support its functionality. There ought to be a system

gathering data for providing information of the performance of a process, and this information should be studied to determine if improvement or corrective activities are required (ISO, 2008).

Processes can be categorized in three levels: process, sub-process, and task (Roberts, 1994). According to the author, sub-processes are the processes of a smaller scale, which need to be executed before the main process. A main process can for example be a delivery process, and main processes tend to have multiple sub-processes, depending on their complexity. Finally, task level includes the activities which need to be executed to provide required outcome for the sub-processes (Roberts, 1994). Main difference of sub-process and task level is that task is usually done by an individual when sub-process requires a whole department for its execution (Roberts, 1994). Roberts suggests that these levels can be evaluated by investigating the achievements of the process, the way of organizing the process, and the way of executing work within the process.

According to Sandhu and Gunasekaran (2004), from the business point of view, a process can be defined as the study of work tasks. This is described as a functional unit transforming input into output, utilizing certain mechanisms and controlling information (Sandhu & Gunasekaran, 2004). The authors say that in order to accomplish a complete work package of the project, an approach similar to the earlier described can be utilized. According to Andersen (2007), a process can be defined as transactions turning input to results or output. These transactions ought to be in a logical series and related to each other, according to the author. Considering a business process, repetitiveness is often named as an important characteristic of it in literature (Andersen, 2007). From this perspective, repetitiveness occurs when working according to the process, an exception from this can be seen as deviations to the business process.

Process can be seen as a holistic way to approach executing a function and can be divided into four stages (Sandhu & Gunasekaran, 2004). These stages describe the role of a function within a process and according to the authors, the stages are first, co-operation of

functions in certain steps of the process, and second, co-operation of functions when handing over the project to another function at all process steps. Third, in order to meet the objective set by customer requirements, the co-operation of functions is expected to vary from project to project. Last step presented by Sandhu and Gunasekaran (2004), the approval done against requirements of the end customer is required when passing a project from a phase or a function to the next.

When describing process generation, Sandhu and Gunasekaran (2004) present a set of criteria which can be utilized for evaluation. Naturally, non-value-adding processes ought to be avoided, and the aim should be adding value to the business process. Design of a process, and a set of processes, should be able to represent the entire project's substance. Finally, every process of a certain project needs to be in coherence with the whole. According to Andersen (2007) processes can be divided to primary and support processes. Primary processes can be described as central and value-creating, crossing the whole company, when support processes are activities supporting the execution of the primary processes (Andersen, 2007).

When evaluating the state of a process, Key Performance Indicators (KPIs) can be used in defining it (Van Der Aalst et al., 2016). The authors suggest that the choice of KPIs utilized in measuring ought to effectively reflect the strategic objectives of the organization. When evaluating a process through KPIs, a process can be seen as a product or a function of the company, and by this process improvement can be seen as parallel to product and functionality improvements.

2.3 Improvement

Andersen (2007) says that over time, the performance level of processes tends to decrease, unless actively maintained. If the aim is in improving or renewing processes, efforts beyond the regular maintenance are required (Andersen, 2007). Vanwersch et al. (2016) claim that redesigning business processes potentially reduces cost and throughput time and creates an increase in customer satisfaction (Vanwersch et al., 2016).

Coming to the organizational structure, Andersen (2007) says that structure which provides motivation, abilities, and attitudes is vital in enabling improvement work. Organizational learning can be described as a problem-solving process which tends to be motivated by a detected gap between actual and potential levels of performance (Dosi & Marengo, 1994; Iansiti & Clark, 1994; Von Hippel & Tyre, 1995).

Schonberger (2018) suggests that employee frustrations are a beneficial target for process improvement since through them the concerns of those with most significant process awareness, and those facing the greatest impact of a failing process, are taken into consideration. In this way, both experience and context are included in the improvement proposals (Schonberger, 2018). This is why the author suggests that process improvement ought to be frustration-driven, employees recording their work-related frustrations and management attempting to remove these factors.

Andersen (2007) describes that the framework for process improvement, especially in business environment, consists of factors such as the organization's strategy and stakeholders, understanding of the current processes, and suitable organizational structure. They say that framework can be utilized in directing the improvement work, understanding current processes, and aiding the running of improvement projects. Stakeholders and strategy tend to define organization's critical priorities, and thus improvements should be assessed against them (Andersen, 2007). The author suggests that understanding the current functionality of a process, and how it is performed, is crucial in its improvement.

Also, Vanwersch et al. (2016) present a framework consisting of six methodological decision areas, which they suggest utilizing in innovating process improvement work. These six areas are aim, actors, input, output, technique, and tool. Aim defines the target in process improvement, usually in line with the organization's vision and strategy, and can be viewed through performance dimensions and improvement's degree (Vanwersch et al., 2016). The authors define actors as daily involved actors, executing or managing the

process, and advising actors, who are for example customers. Vanwersch et al. (2016) say that input and output as decision areas describe the factors utilized in the re-design of a process, and the artifacts that are expected as a result. The authors suggest that there are three different techniques that can be used to generate improvement ideas. These are unstructured, like brainstorming, semi-structured, which specify as-is and to-be factors, and structured techniques, which provide a work procedure for defining current and future situations. Finally, tool is defined as a software used in process improvement idea generation, providing increased efficiency and effectivity (Vanwersch et al., 2016).

According to Ponsignon et al. (2014), a crucial principle of process improvement is the removal of non-value added (NVA) work tasks and flow optimization by task re-sequencing. This is done by recognizing and removing NVA tasks and organizing the remaining tasks in the most sensible execution sequence (Ponsignon et al., 2014). The authors also suggest that in customer-oriented processes it is important to maintain contact with the customer, since it is proven to result in improved quality and fulfillment of customer expectations. Ponsignon et al. (2014) propose that companies offering customized solutions should follow an employee-focused approach in process improvement, giving employees a high level of authority in decision-making.

Hinckeldeyn et al. (2014) say that bottlenecks decrease the level of performance in design and engineering processes. According to the authors, one of the most common bottlenecks identified in literature is workforce capacity, usually due to work overload or lack of appropriate resource management. Bottlenecks can be prohibited by utilizing bottleneck management concepts, used in manufacturing, also in design and engineering processes (Hinckeldeyn et al., 2014). The case study by Hinckeldeyn et al. (2014) resulted in an increase of throughput, which was measured by completed work, most likely to occur with each bottleneck management concept utilized in all case companies.

According to van der Aalst et al. (2016) the improvement of processes can be done by applying Operations Research (OR) techniques to business processes, since many process improvement complexities can be viewed as a typical problem in OR investigation (Van Der Aalst et al., 2016).

2.4 Process modelling

Andersen (2007) suggests that in order to execute an improvement activity for a business process, it is essential to document the current state. Process modelling can be seen as the most significant factor in any organization, considering the management and control of activities (Holt, 2009). In addition to this, modelling a process carries several other advantages (Andersen, 2007). Being able to draft a model of a process requires eliminating possible disagreements, assumptions, and ambiguities. Andersen (2007) continues that modelling also results in a more specific description of a process, taking into account factors like surroundings and objectives. The author suggests that successful modelling can result in greater level of involvement and enthusiasm among different stakeholders.

According to Andersen (2007), most commonly used process model type is individual flowchart, which is also seen as the most useful in process improvement work. An issue with the use of flowcharts is that they tend to view only one aspect of a process, even though effective and coherent process modelling requires multiple views (Holt, 2009). According to Aguilar-Savén (2004), the integration of a business process modelling tools does not provide a solution itself. Modelling tools ought to be used to assist in designing and controlling the processes by providing support in the communication and understanding of different stakeholders. The best suited business process modelling techniques for learning and development are flow chart, Gantt chart, integrated definition for function modelling (IDEF), data flow diagram, and role interaction and activity diagram (Aguilar-Savén, 2004).

Like Aguilar-Savén (2004), also van der Aalst et al. (2016) argue that a better process model does not guarantee an improved process, which is why according to them the

research focus should be on improving the actual process instead of the process model describing it. When the process is being modelled, the focus ought to be determined by the strategic objective of the specific business process management initiative in question (Van Der Aalst et al., 2016). Through this, the authors define an improved process as one that more successfully meets organization's strategic objectives, or at minimum assists in reaching those.

Holt (2009) suggests that reaching an appropriate level of detail in the process model is important, but also challenging. Another challenge the author recognizes is creating a model which actually reflects the real-life processes, the so-called process instances (Holt, 2009).

2.5 Mechanical product design

The design process of any mechanical part of a product aims in obtaining the best possible compromise between technological and economic aspects (Abd Elaziz et al., 2022). The objective of this compromise is to maximize the product lifecycle and performance, but to minimize cost (Abd Elaziz et al., 2022). The need for companies to meet or exceed customer expectations and needs, leads to the necessity of answering the customer demands to produce perfect quality products (Freiesleben, 2010). Products ought to live up to the highest of standards, which together with the previously mentioned causes challenges for companies (Freiesleben, 2010).

The demand for products to be perfect quality and live up to standards, means that the internal processes should yield flawless output to prohibit faulty products being delivered to the customer causing dissatisfaction (Freiesleben, 2010). Also, products should be able to address all customer needs as precisely as possible, which would maximize sales and be beneficial for the competitive standing of the company (Freiesleben, 2010). Product design is increasing its significance in market success, when poor design quality is seen to be connected to negative economic effects in a manner similar to poor quality of production (Freiesleben, 2010).

In the competitiveness of manufacturing companies, engineering design plays a crucial role (Boudouh & Bendada, 2017). During product development, optimal scheduling of the design process is critical in time-to-market completion (Boudouh & Bendada, 2017). Research implies that it is especially challenging for design-driven businesses to be productive while simultaneously maintaining customization and innovativeness at high level (Hinckeldeyn et al., 2015). The involvement of designers in sales process is important for the business, since they are usually able to provide product information that is not of general knowledge (Uusitalo & Lidelöw, 2015). It is also beneficial because by being a part of sales process, designers are immediately able to start the decision process about what are the best options the company has to offer for the specific product (Uusitalo & Lidelöw, 2015).

2.6 Customer Delivery project

According to Sandhu and Gunasekaran (2004), a project can be defined as a certain set of inter-linked activity with defined start and finish points. The authors continue that for a project resources of human, financial, and material nature are utilized to reach a certain pre-determined scope with time and cost constraints, directed by a central figure (Sandhu & Gunasekaran, 2004).

Project management can be executed through multiple existing approaches and standards, according to the empirical approach adopted by several companies (Sandhu & Gunasekaran, 2004). The authors say that processes and knowledge on how to define, execute, control, and successfully complete them can be found from European Foundation for Quality Management (EFQM), and standards like ISO 9000, ISO 10006 (1997), and the Project Management Body of Knowledge (PMBOK) (1996, 2000).

Supply chain performance is important in the competitiveness of a company, especially profitability (Ashtiani & Bosak, 2013). This is because supply chain management and integration create competitive advantage for the company, when done effectively

(Ashtiani & Bosak, 2013). Due to the high value of customer satisfaction in today's market, performance in customer delivery, and the competitive advantage possible to gain from this are important (Ashtiani & Bosak, 2013).

There is an increasing trend of recognizing culture as one of the central factors influencing and being influenced by business process management (Hammer, 2010; Llewellyn & Armistead, 2000; Spanyi, 2003). Cross-functional integration can be defined as interaction and collaboration between different departments of an organization (Kahn & Mentzer, 1998). When organizations are demonstrating ability to understand, attract and retain customers, market orientation is present in their business, deepening their relationship with customers and other stakeholders (Murillo et al., 2020). These statements are related to each other by the fact that market orientation is reached by three antecedents which are support from top management, interdepartmental dynamics – which is in the end equal to cross-functional integration, and organizational systems (Jaworski & Kohli, 1993).

2.7 Obstacles in process improvement

Agarwal (2009) defines business process re-engineering as re-thinking fundamentals and radically re-designing a business process to highly improve factors in quality, cost, performance, speed, and service (Agarwal, 2009). According to Cameron and Braiden (2004) the radical nature of business process re-engineering, based on major structural change, is found to be impossible for companies functioning in engineer-to-order business. This is due to the complex and unique nature of products, and the significant role of company networks in technological and systems innovation within both design and manufacturing (Cameron & Braiden, 2004). Gosling and Naim (2009) suggest that some strategies are more suitable for engineer-to-order type of supply chains than others, and for example research concerning business process re-engineering within supply chain integration has resulted in different conclusions (Gosling & Naim, 2009).

Van der Aalst et al. (2016) say that Key Performance Indicators (KPIs) are often mentioned in process improvement research, but it remains to be unclear whether research results and process management technologies related to it in fact contribute to the improvement of KPIs. Also, organizational resistance may prohibit the implementation of business process management initiatives (Van Der Aalst et al., 2016).

Adrodegari et al. (2015) propose ten main characteristics of engineer-to-order (ETO) strategy. The authors say that depending on the customer, the product structure and configuration can change. In addition, there exists a chance that the market as a whole might change due to operating in a volatile environment. The most significant core competencies of a company operating in this environment are design, engineering, project management, assembly, and logistics (Caron & Fiore, 1995; Wikner & Rudberg, 2005). ETO strategy tends to implement a pull approach, stressing flexibility and responsiveness, and aiming for a low WIP and finished product inventory (Adrodegari et al., 2015). This tends to create difficulties with processes and resource planning. The main risks in an ETO strategy are knowledge sharing and capacity utilization (Anderson et al., 2000), when competitive advantages include factors like process coordination, production planning and high level of technological knowledge (Amaro et al., 1999; Caron & Fiore, 1995; Gosling et al., 2014).

Antony et al. (2019) suggest that failed process improvement projects can lead to loss of resource in the form of significant amount of time and manpower. According to the authors, culture which understands the importance of improvement efforts is a key element in their success (Antony et al., 2019). Antony and Gupta (2019) say that in order to make a project improvement initiative successful, commitment from top management is required. In addition, leadership at all levels is needed in the actual implementation of process improvement (Antony & Gupta, 2019).

Antony and Gupta (2019) suggest that communication is a vital driver of change when improving a process. Complexities in communication tend to be due to organizational

and technological issues, power politics, and semantics (Gillard, 2005; Neill & Jiang, 2017). The role of employees is remarkable in the success or failure of process improvement initiatives, which is why it is important for management to be able to convince resistant employees to enhance culture which is able to take sustainable advantage of process improvement (Antony & Gupta, 2019).

3 Methodology

This chapter begins with discussing the methodological approach, then discussing the data and its analysis in this study. Finally, the chapter finishes with discussing the validity and reliability of this study. The aim of this chapter is to provide a description of the research structure. The goal of this study was to establish an understanding of the current customer delivery process and give proposals for the future based on this. To achieve this goal, the two objectives for this study were to model the current process together with its pros and cons, and to draft an improvement suggestion for the future way of working.

3.1 Business process re-engineering

This thesis work studies data which is qualitative, and the used research approach is business process re-engineering (BPR). The research problem of this study is a combination of nomothetical and normative nature, since nomothetical aims to define the current situation, and normative drafts the way the situation ought to be in the future (Helo et al., 2019). From the two research objectives of this study, the first is nomothetical, and the second is normative.

Business process re-engineering tools and techniques will be used to achieve the research outcome. As-is to-be comparison will be utilized to find the solutions for the set research questions. In practice, this research was divided to following sections:

1. Data collection: Interviewing stakeholders
2. Document: Creating as-is process maps
3. Analysis: Defining improvement suggestion for the future to-be process

The usefulness of interviews as data collection method has been recognized for a long time (Alshenqeeti, 2014). According to the author, qualitative research provides descriptions of individuals and events in their characteristic setting, which is why interviewing

has been seen as a key factor. Due to interviews being interactive, it makes the acquiring of complete answers possible and provides the chance to discuss emerging topics (Alshenqeeti, 2014). Still, interview has its own disadvantages. Interviews are mainly possible to be utilized in small scale studies, due to their time consuming nature (Alshenqeeti, 2014). Since interviews are basically the interaction of individuals, they are never completely anonymous and are always subject to the potential of inconsistencies, and subconscious bias (Alshenqeeti, 2014).

The data is collected by interviewing different stakeholders of the process, either individually or in pairs. The interviews are semi-structured and in-depth, conducted with open-ended predetermined questions (DiCicco-Bloom & Crabtree, 2006). In this style of interview, follow-up questions emerge from the interaction between the interviewer and interviewee/s. By using open-ended questions with neutral word choices, the interviewees are not being led to answer in a certain way. The use of this interviewing style suits the topic of this research, since the questions could be defined beforehand, but the answers of different stakeholders could not be predicted (Popping, 2015).

The interviewed stakeholders were considered as process experts, which can be defined as an individual working on a daily basis on the sub-process level and thus has the most coherent knowledge of the current process (Roberts, 1994). The interviewees were chosen from different functional areas of the process, in order to comprehensively describe the inter-functional nature of the process (Gorla et al., 2007).

Qualitative research aims to describe the experiences of people, and what they consider important (Patterson & Silverman, 2021). The data was collected with in-depth interviews, which are common in qualitative research. Interviews were necessary in this study, for being able to collect the experiences of multiple stakeholders across the process. Cross-functional perspective is seen essential when re-engineering the fundamental level of business processes (Hammer, 1990).

With the use of thematic analysis, complex qualitative data can be approached flexibly and like this, ease the analyzing process (Nowell et al., 2017). First step of thematic analysis is to familiarize oneself with the collected data (Nowell et al., 2017), which in this study means listening to interview recordings, creating and reading transcripts, and based on this creating a clear view of the data collected. After this, the interview results can be coded based on related subject, which can then be divided into defined themes in order to simplify the data (Nowell et al., 2017).

3.2 Empirical implementation

This paper was limited to focus only on one department's customer delivery process in the case organization, even though the process exists to certain extent in the whole company. This limitation was set to meet the requirements of conducting a master's thesis. In total eight different stakeholders of the process being studied, from six different teams, were interviewed according to the schedule presented in appendix 1. In the results section collected data will be presented through six stakeholders even though the number of interviewees was eight, since there were two representatives from two of the interviewed teams. These stakeholders were considered to represent the key roles in the mechanical design for customer delivery projects process, defined by an agreement made with the thesis supervisor from the case company.

The number of interviewees in this study (n = 8) can be considered low. This number was intentional and seen as sufficient based on what already described above. All eight interviewed stakeholders were manager level parties of the process, and thanks to this able to describe the functionality of their whole department. The focus of this study was determined to be the investigation of the process on a general level, illustrating the situation as a whole, instead of focusing on minor details and single work tasks. As already mentioned, the interviewees were all considered as process experts since they are working daily on the sub-process level and managing the singular work tasks of their organization. The data acquired from the interviews was not supported by any other process descriptions in this study, since these do not exist. There was no established process

description, or follow-up tools such as KPI measures available that would describe the as-is process as a whole.

The interview invites were sent to all interviewees via email, and then executed in Microsoft Teams. Teams was considered as the best tool to use in the interviews due to the location of the interviewees being in different cities and countries, and because Teams offers the possibility of recording, which is useful in later transcription of the interviews. The duration of interviews varied from 30 minutes to one hour, and all interviews were held in February 2024. Interview language was either Finnish or English, depending on the interviewee's preferences. Interviews were recorded with consent from the interviewee/s and later transcribed on subject level. Interviewed stakeholders did not remain anonymous to the researcher, but the results were anonymized. Answers and stakeholder's title were documented and analyzed in this research. Thanks to anonymity, the results in the to-be analysis of this research, ought to be received unprejudiced.

First, interviews were transcribed, and then the collected data was skimmed through to gain a general understanding of the results. After this the collected data was thoroughly read and coded based on their subject. In this research, for the interview answers considering the as-is situation it was possible to create some general themes. Due to the fact that the as-is results were describing specific subprocesses, complete division to themes and analysis of these was not seen reasonable for the sake of preserving the essence of process description. Results about the to-be analysis were themed since it was possible to divide the answers to certain themes without losing their original meaning. Interview results were presented in tables ranking them based on the number of times they were mentioned during the interviews.

In the first step, as described above, data was collected by interviewing different stakeholders of the process. Based on the collected data, swim lane diagrams were created to illustrate the as-is situation, being the second step of this research. Swim lane diagram was chosen as the tool since it was seen as describing the responsibility areas within the

current process in the best possible way. In the diagram, some stakeholders were combined to one horizontal swim lane to increase the level of readability of the diagram. For this same reason vertical swim lanes were established in the diagram, according to process milestones. Due to the nature of the as-is process, these milestone dates are estimations since it is not always clear at which point certain work tasks take place. As a result of the first two steps, the first research objective was achieved, and a mapping of the current situation was created.

The results from the interviews were utilized in the third step, where the improvement suggestion for the future to-be process was drafted after identifying improvement areas in the current way of working. The interview results, including feedback and possible improvement ideas were analyzed by creating an understanding of the as-is situation, making it possible to draft the to-be proposal. Through open-ended questions various and genuine opinions were gathered, though the analysis of the diverse data was laborious.

3.3 Validity and reliability

Reliability refers to the stability and consistency of a study in different settings, and over time, when validity means how well a study measures what it was intended to. In this study, there were measures taken in ensuring validity and reliability. Research questions were defined and stated carefully, as well as data collection and analysis were thoroughly described. The validity of this study's results was also reached by interviewing multiple stakeholders of the process, and by their willingness to share their honest sights about the state of the process, including possible issues.

Since the data analyzed in this study is of qualitative nature, the evaluation of reliability and validity is challenging because they are connected to the researcher's and interviewees' perspectives. Only one company and one department within it is studied, which can be seen as a limitation, making the results and findings of this study only partially generalizable to different contexts. This is seen as a typical feature in a study where the

analyzed data is qualitative (Hirsjärvi et al., 2007). If there had been also quantitative data available, the findings of this study might have been more precise in terms of improvement suggestions. The relatively small sample size of this study, and the selection process of the interviewees also might have limitations impacting validity and reliability, which means that a bigger sample size might give different results. Also, the limitations set for this study by its scope meant that not all process parts could be investigated neatly, and the focus had to be limited to one department instead of studying the whole company, for instance. Due to the presented limitations, it is important to consider possible sources of bias when interpreting the findings of this study, even though the results may provide convenient insights.

4 Findings

This chapter includes the practicalities of the thesis according to as-is to-be analysis: research, document, and analyze. Research meaning interviewing different stakeholders about their experiences and expectations of the process, document meaning drafting the illustration of the current mechanical design customer delivery process, and finally analyze step describing the improvement suggestion for the practical conduction of future to-be analysis.

4.1 Stakeholder interviews

This chapter is the research step of as-is analysis, where stakeholders are interviewed, which was done in the aim of reaching a cross-functional perspective on the mechanical design process. Stakeholder interviews will be used in creating an understanding of the current process, and the feedback from stakeholders will be used to identify improvement areas of the process. As the mechanical design process of customer delivery projects is cross-functional involving multiple parties, it has many stakeholders. As described in the method chapter, interview invite was sent to six different departments considered to be key internal stakeholders of the process.

4.1.1 Defining interview questions

The goal of this chapter is to gain an understanding of the activities of the internal stakeholders of the mechanical design process in the case company today. It is important to make sure that the current way of working is understood thoroughly before forming improvement suggestions for the future. Another goal is discovering possible improvement ideas of stakeholders towards the current process. The opinion of different stakeholders is seen as vital to support the joint effort of participants of the process.

The predefined six stakeholder departments to be interviewed have a different viewpoint to the process due to being separate departments of case company. This is why

interview questions must be formed general enough, to suit all stakeholders and their different perspectives. Because of this interview answers might differ drastically and due to this reason semi-structured interview method was chosen. A semi-structured interview allows open-ended questions without pre-defining answer categories. The use of open-ended questions is also a way of ensuring that the interviewee is not encouraged to answer questions in a specific way.

After defining the objectives and method of the interview, interview questions can be shaped. The complete list of this study's research questions can be found in appendix 2. Posing the first question for the interviewee about their role in the company is a natural approach for the interviewer. It is supposedly the easiest question, which is why it is a great way to warm-up when the interviewees can talk about their own and their team's responsibilities in the mechanical design process. Secondly, this way the interviewer gains an understanding of the role of the stakeholder in the process and their connection to mechanical design.

After the interviewees have described their role generally together with their tasks, the focus will be on the actual process of mechanical design in customer delivery projects for the rest of the interview. The second question together with its sub-questions is similar to the first question but focusing on the role of the employee as a part of the process. This means the interviewee describes where in the process their work is located, what is their input, and what is the output they produce and move forward.

Question two is formed to consist of one main question and multiple sub-questions on purpose, so that they can be shown to the interviewee all at once but asked one by one. This is seen as the best way to raise thoughts about the process and the stakeholders sometimes diverse role in it. This is also the reason there are several questions relating to the same subject, to ease the thought process of the interviewee when describing all work tasks related to the process. Even though other improvement related questions are asked later in the interview, it is seen as beneficial to ask about improvements in how

the input is received together with asking about the input in general. This is because here the interviewee is already describing the input in detail, so it is easier to name improvement ideas in the same context.

When the attention of the interviewee is on the process after question two, the focus will be shifted to process improvement. The stakeholders will be asked to describe how they see the current follow-up of the process, if they have noticed any weaknesses, and how the process could be improved based on the experiences of the employees from their daily work. The opinion of stakeholders is also heard considering the number of ways of working within the same process, since currently the case company has multiple. Here the concrete examples of the improvement needs of the process are heard, and what different stakeholders expect from the way of working within the process.

Question number five is formed with multiple sub-questions for the same reason as question number two, to raise thoughts on improvement needs from multiple points of view. Like answers to the previous questions, varying answers are also expected to these questions due to the different needs and demands of process stakeholders. These questions are the most important in the scope of the thesis, because improvement proposal will be based on the answers to these.

After the above introduced official questions, the final question is posed to provide the possibility for the interviewee to mention anything they still have not had the chance to say but find important, for example more comments on previous questions or regarding the subject. Adding a question for free comments minimizes the risk of something essential remaining to be unsaid. The presented questions enable achieving the interview objectives. By stakeholders answering these questions, the current process and improvement needs for it can be understood.

4.1.2 Interview responses

In this chapter, answers to interview questions are presented. The answers to these questions are significant data when forming an understanding of the current situation and the improvement needs of it, i.e. the results of this thesis. The answers are also documented in the interview transcript in the background material of this study.

For the sake of clarity, answers are presented in this summary chapter in the form of table and text describing it. Tables illustrate the most common answer themes, which create a vision of the most common work tasks, improvement needs, and subjects brought up in the interview sessions. The themes are presented in decreasing order in the tables, according to the number of times they were mentioned in the interviews. Text description is added to explain the table contents in detail to create an unambiguous description of the results considering the as-is process.

The responses received to the questions were various due to the high number of stakeholders in the current process. Answers for the questions related to the current process are listed in table 1 below, right-hand column indicating the number of stakeholders naming the task in the description column on the left. Names of stakeholder departments are not shown in the tables of this chapter, since they do not affect the analysis of the process on the subjective level used here.

Table 1. Interview results about the current as-is situation.

Work tasks in the current process	Number of responses
Providing instructions and/or drawings	5
NSR	4
Providing support for other parties	4
Product structure	3
IOS and/or EBOM	3
Parts sampling and validation	1

Almost all stakeholders named providing instructions and/or drawings as their work task in the as-is situation, in the form of internal manuals, design drawings, and diagrams for example. Also, the majority of stakeholders mentioned that their work tasks are somehow related Non-Standard requests (NSR), and also providing support for other parties of the process in other ways. Support is provided to multiple different units in addition to internal support in RDE, for example production and sales.

Work tasks related to the upkeep of product structure was mentioned by half of the stakeholders. Product structure is maintained by organizing design modules and checking the structure of the engine being delivered. Also, tasks considering IOS (internal order specification) and/or EBOM (engineering bill of material) was mentioned by half of the stakeholder departments, related to their creation and validation. One stakeholder mentioned parts sampling and validation as their work task. They described this as for example checking new parts after releasing their design and before they get installed on the engine.

In below table 2, the interview responses about the future to-be situation are described in a manner similar to the responses about the as-is situation. The responses received to the questions considering the to-be situation were also various, but mostly considering the same themes. This can be seen from below table from all answer themes having two or more stakeholder responses.

Table 2. Interview results about the future to-be situation.

Improvement areas for the future	Number of responses
Quality of communication	6
Quality of documentation	6
Quality of scheduling	6
Number of Ways of Working	4
Number and integration of tools	4
Quality of follow-up	2

All six interviewed stakeholders mentioned quality of communication, documentation, and scheduling as improvement areas for the future. Quality of communication needs improvement according to multiple stakeholders due to an existing lack of commitment to provide necessary information to other parties. A stakeholder said: “People don’t come to meetings, and then we have issues with deliveries to production or issues with the vendor. These could be avoided if people came to meetings”.

Considering documentation, all stakeholders mentioned practicalities mostly related to the quality of documentation, such as high level of complexity, poor quality and structure, and scattered storing of documentation. According to a stakeholder “If you want to develop, you need to increase quality so that there are less changes. First time right would be a dream, now there’s continuous change going on”.

All stakeholders commented on the quality of scheduling within the process, for example considering non-existent milestones, delays, and poor scheduling of product changes. One stakeholder stated that “Clear milestones regarding dates would be needed, at the moment milestone dates are not followed”.

Almost all stakeholders mentioned the number of Ways of Working (WoWs) and number and integration of tools as improvement areas. The interviewees mentioned these factors leading to duplicate work tasks, unclarities and work time wasted on tool usage. A stakeholder mentioned that due to multiple WoWs the number of tools is even higher. A stakeholder argued that “First of all, we have different ways of working and second, people don’t even follow these different processes, when in a hurry people for example tend to step over steps”. Considering tools, another stakeholder claimed that “We have many different tools, SAP, Teamcenter, and Polarion. At the moment Polarion is in no way linked to Teamcenter and all tasks need to be created manually”.

A few stakeholders mentioned the quality of follow-up as something that ought to be developed, whole process level follow-up already being a recognized need in the

company. This situation was described a stakeholder saying: “It’s quite weak how changes are followed and overall, quite weak level of structurally going through the whole thing”.

4.1.3 Summary of stakeholder interviews

Questions considering the improvement needs for the future were answered in a similar manner by all stakeholders, even though their work tasks in the current process differ. Due to the nature of interview questions presented, some interviewees expressed their opinions on multiple topics throughout the interview, which lead to a high workload in the analysis of data acquired through interviews. For this reason, the interview questions could have been set to be more precise, but still the interviews provided fruitful information about the current situation and the improvement needs for it. The objective for the interviews was to gain an understanding of the current process and its improvement needs, and this objective was reached.

4.2 Defining current mechanical design process

In this chapter, the process chart of the current mechanical design process is established based on the process descriptions gathered during the stakeholder interviews, the result of this chapter being an as-is swim lane diagram of the current design process. By documenting the current Ways of Working, it is possible to identify existing deficiencies and bottlenecks, and analyze these.

4.2.1 Defining main processes

As the responsibility of the design process is to produce the needed designs for customer delivery projects, there exists multiple sub-processes where many stakeholders are involved. Below listed are the main processes existing within the design process. They are defined as main processes due to their essentiality in producing the output of the process, which is again the needed designs.

- Product structure maintenance
- EBOM creation and revision
- NSR evaluation
- Product configuration
- Internal manuals upkeep
- Activity organization
- Missing mechanical design, wiring diagram and product description delivery
- Supporting other stakeholders

Product structure maintenance is a work task for multiple stakeholders of the process. Stakeholder 1 is responsible for organizing design modules received from stakeholders 3 and 4 into standard register tool. Stakeholders 3 and 4 are responsible for going through the engine structure brought to the system to ensure that it responds to the product requested by the customer. After receiving the design input from either stakeholder 3 or 4, stakeholder 2 is responsible for updating the product structure according to these, this process being called EBOM revision.

Stakeholders 1 and 2 are responsible for the creation and release of EBOMs for the product being designed and delivered. EBOM is the document including all data for the customer delivery project, acting as a basis for ordering engine parts and tracking missing designs. The structure of the EBOM is checked with other stakeholders to ensure that it is correct, since it is automatically generated by a system which might make mistakes. To be exact, these system errors stem from the human mistake happening when giving input to the system, based on which EBOM creation happens. When EBOM is created and checked, stakeholder 2 sends requests to stakeholders 3 or 4 to produce their input needed to finalize the EBOM structure. After the input from stakeholders 3 and 4 is produced, these are added to the EBOM, and EBOM revision executed by stakeholder 2 takes place.

Stakeholder 1 is responsible for giving acceptance for the NSR to either the customer or the shipyard. NSR means a request coming from the customer about a feature that does not exist in a standard engine in the company's product catalogue. NSR also needs approval from the delivery center, and business control, which are stakeholders that are not included in this study. The evaluation of NSR is also requested from stakeholder 2. Stakeholder 2 evaluates the cost of implementing the request in production, and the amount of time it requires in throughput.

Stakeholder 1 is responsible for product configuration in customer delivery projects and stakeholder 6 is responsible for the configuration of engine automation software. From the product configuration maintained by stakeholder 1, stakeholders 3 and 4 are able to know the needed design variants, for example. Considering customer delivery projects, stakeholder 1 is also responsible for tasks such as the creation and upkeep of internal manuals related to product installation and performance. These are shared to the sales unit for describing the product to customer.

After the order has been received, stakeholder 1 will start organizing activities to produce required deliverables for the product. After the creation of EBOM's first draft is done, stakeholder 2 invites a plan of action meeting. There all relevant stakeholders for the product size designed by stakeholder 4 are present to go through what needs to be done to finish the order, for example identifying the missing designs. Due to this, it is also the responsibility of stakeholders 3 and 4 to define the amount of time resources their team needs to produce the missing output required from them. The schedule for design activities is scheduled based on this, counting backwards from the start of engine's assembly date. Stakeholder 2 invites a design release meeting where different organizations are invited, and the release of the new design happens through a change notice. After the design is released, stakeholder 2 makes the decision in which projects and when the new design will be taken into use.

The missing mechanical design, wiring diagram, and product description delivery are the main deliverables of the mechanical design process. Stakeholder 5 delivers installation planning instructions, which are used for the installation of the delivered engine, and manufacturing drawings for production. The main responsibility of stakeholders 3 and 4 is to deliver missing designs for the engine's EBOM, and upkeep of existing designs. Stakeholder 6 delivers the automation design work for the product in the form of wiring diagrams and their electric mechanical design.

Supporting other stakeholders of the process can also be defined as one of the main processes within the design process, since it is essential in the production of deliverables. Role of stakeholder 1 in the customer deliveries is highly connected to supporting sales in negotiations with the customer. Stakeholder 5 also provides support for sales, and occasionally to shipyard. The role of stakeholder 2 in general is to support other stakeholders of the process since they are for instance responsible for management of design releases. Stakeholder 6 provides support from their area of expertise to multiple other parties: supply management, production, and commissioning. Stakeholder 3 provides support for production in certain areas.

4.2.2 Establishing Mechanical Design as-is process charts

In this chapter, as-is process chart of mechanical design is illustrated. This chapter is the document section of as-is analysis, where the current process is illustrated as a swim lane diagram. The diagram includes all inputs, procedures, and outputs of the design process from Research and Development department's perspective. All involved departments are illustrated in swim lanes, some interviewed stakeholders combined to one lane, to increase consistency of the graph. Below figure 1 is the swim lane diagram as a whole, but for the sake of clarity it will be introduced divided to three sections in this paper.

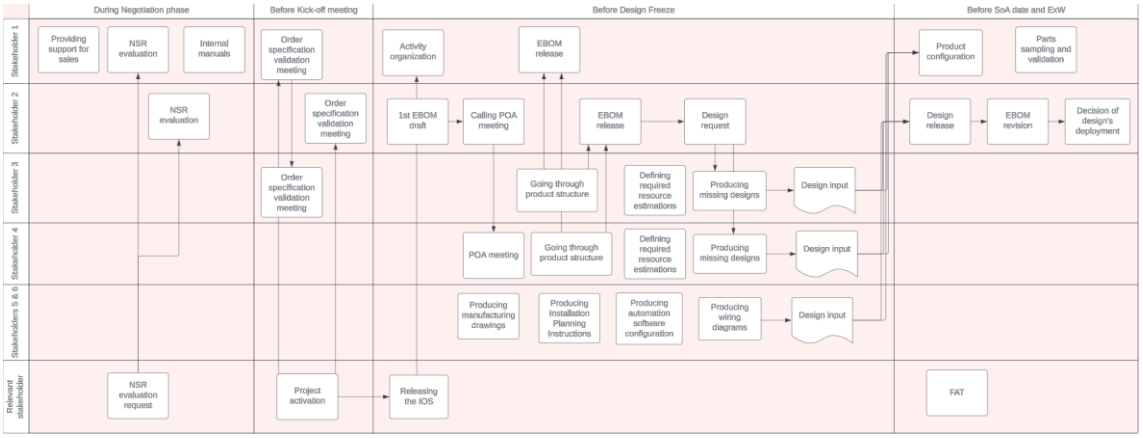

Figure 1. As-is process chart.

Below figure 2 represents the as-is process before the Kick-off meeting. When the future product is being negotiated with the customer, Stakeholder 1 actively provides support for sales for example in the form of Non-Standard request (NSR) evaluations, and internal manuals which are used to describe a product to the customer. NSR evaluation requests are also sent to stakeholder 2 from sales unit.

After it has been agreed together with the customer what the product will include, the project will be activated in project management unit, and an order specification validation meeting will be held. In this meeting the Internal Order Specification (IOS) will be defined, stakeholders 1 and 2 being involved in this process. Also stakeholder 3 is involved in this meeting, receiving information of what design input needs to be produced for their product size.

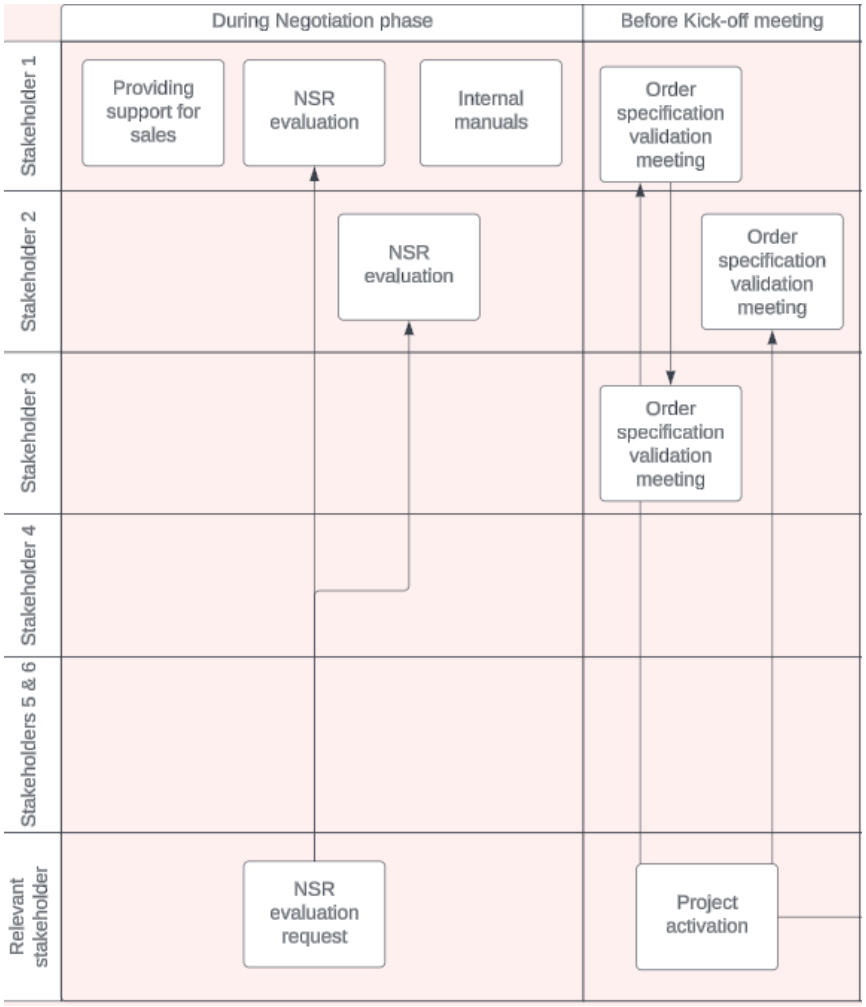

Figure 2. As-is before Kick-off.

In below figure 3 the process steps are described, which tend to take place between Kick-off meeting and Design Freeze. After Kick-off, the IOS release can take place, and stakeholder 1 can start organizing activities. After stakeholder 2 has released the first draft of the Engineering Bill of Materials (EBOM), stakeholder 2 invites the POA meeting held together with stakeholder 4, where EBOM definitions will further continue, and project schedules can be defined together will all relevant stakeholders, for the product size of stakeholder 4. Due to the nature of the as-is process, clear milestones that would always be followed do not exist in practice, and this is the reason for the timing of these steps being estimations in these diagrams. Before the release of EBOM by stakeholders 1and 2, stakeholders 3 and 4 are requested to go through the engine structure brought to the EBOM automatically from the system, to ensure the structure is correct. Ideally this

engine structure check ought to take place before the POA meeting for stakeholder 4, but this is not how it is done always in practice. Stakeholders 3 and 4 are required to define the number of resources they need for producing the missing parts of engine structure. After the EBOM structure is ensured to be correct, stakeholder 2 is able to send design requests for stakeholders 3 and 4 for them to produce the missing designs to the engine structure in question.

The responsibility of stakeholders 5 and 6 is to produce manufacturing drawings, installation planning instructions (IPI), configuration for automation software, and wiring diagrams. Stakeholder 5 is not located in the R&D unit of the company, but the IPI produced by them is utilized by stakeholders 3 and 4 to some extent. Stakeholder 6 produces engine automation software configuration, and wiring diagrams. Wiring diagrams and their electric mechanical design is highly linked to the design work produced by stakeholders 3 and 4, and these need to be synchronized without any conflicts existing between them.

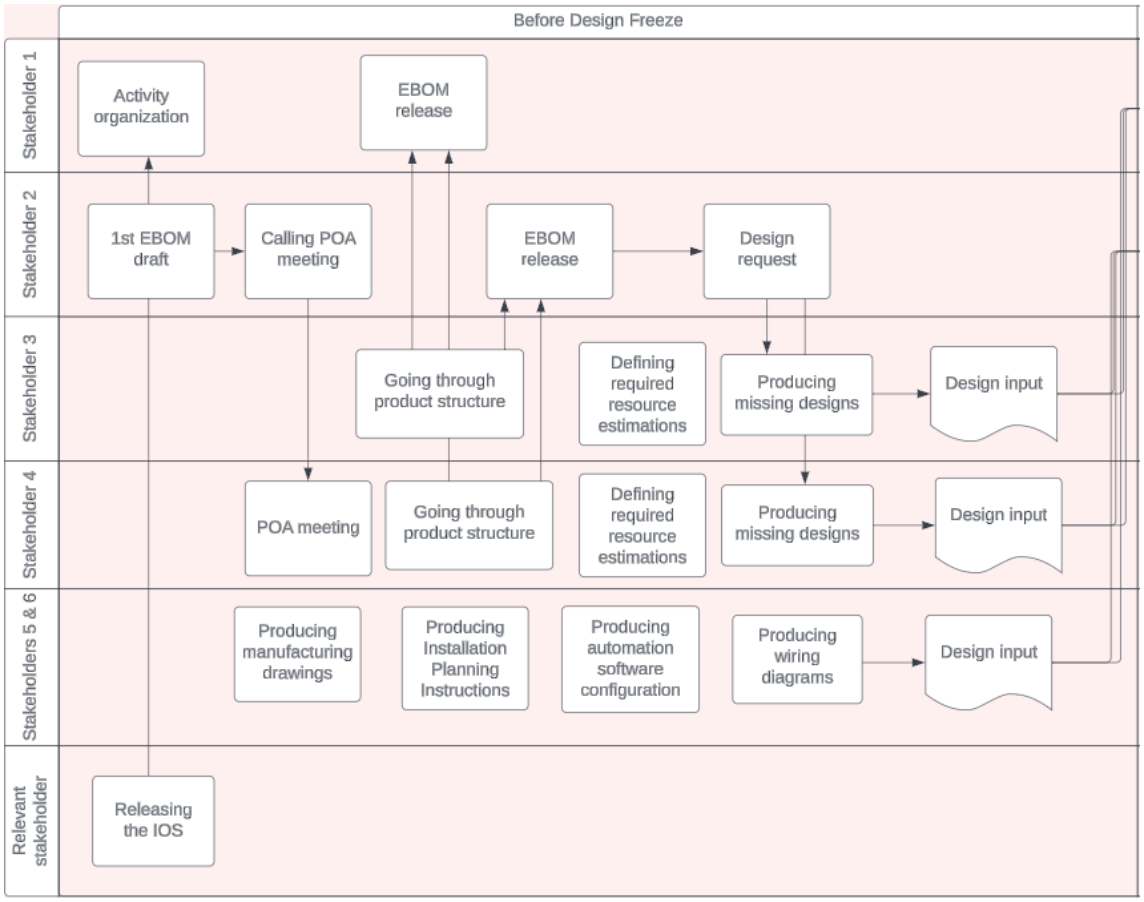

Figure 3. As-is before Design Freeze.

Below figure 4 represents the final steps of the process ideally taking place after Design Freeze date. Both the input of stakeholders 3 or 4 and stakeholder 6 is called a design input, which are released by a change notice (CN). Change notices are received by stakeholder 2, and then released in a design release meeting. After this stakeholder 2 produces a new revision of the EBOM of the engine where the new design is included and makes a decision about the deployment of the design. This means deciding when and in which projects the new design will be taken into use. Stakeholder 1 organizes the design modules received into standard register tool, and checks parts of the newly released designs before they are installed on the engine. The missing designs need to be finished before a date called Design Freeze, which is a date defined by when the Start of Assembly (SoA) of the engine ought to take place in production. When the engine is assembled, customer can view the engine in a Factory Approval Test (FAT), which takes place before the engine exits the factory (ExW).

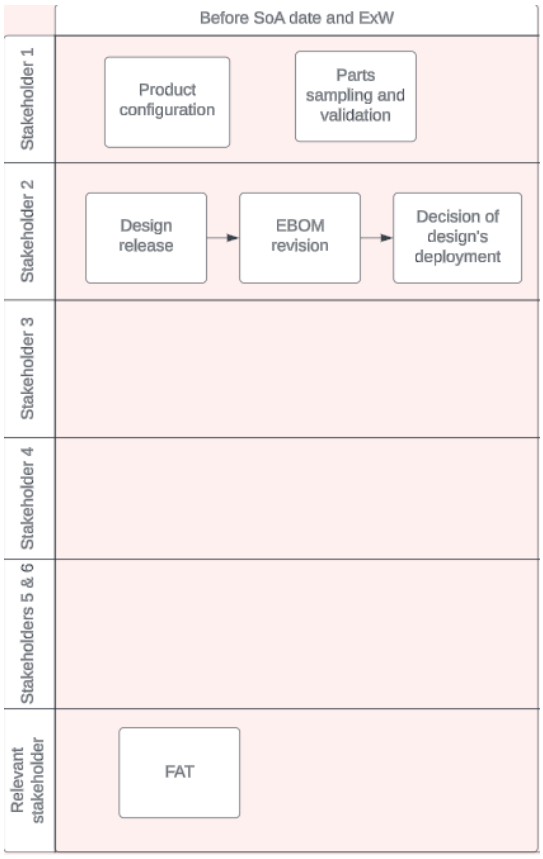

Figure 4. As-is before SoA and ExW.

4.2.3 Summary of the as-is situation

In conclusion of this chapter, it is clear that the current as-is process of mechanical design has multiple stakeholders together with multiple sub-processes. The above illustrated process diagrams are valuable to all process stakeholders. These charts picture the responsibilities of different parties on task level, which should create clarity of who is responsible for certain outputs of the process. From the company perspective, the clarity reached by defining the process is valuable due to likely increased efficiency and smoother operations eventually even leading to an increase in gross profit. Modelling the as-is situation is also a contribution to the future process improvement, presented next in this study.

4.3 Identifying improvement proposals for the future process

This chapter is the analysis part of the as-is to-be analysis, where improvement needs for the as-is process are identified and themed based on the data acquired in stakeholder interviews, improvement proposals for the future Way of Working are identified, and to-be suggestion drafted.

4.3.1 Identified improvement themes of as-is situation

It was possible to identify multiple different improvement themes from the stakeholder interviews, as already presented earlier in the interview results chapter of this study. All identified themes can be connected to quality related issues: communication, documentation, scheduling, Ways of Working, tools, and follow-up all received feedback mainly considering their quality during the interviews.

Starting from the quality of communication, one stakeholder mentioned that purchasing is not always able to provide order to delivery times for parts which are included in the missing modules of the engine being delivered to customer. According to the stakeholder this is due to the fact that purchasing in the company is divided to multiple segments, and there exists a lack of commitment from supply management to provide necessary information to the POA meeting. Generic leadtimes for parts are defined and exist, but for some reason they are not delivered when requested. The lack of awareness of order to delivery times leads to unnecessary pressure on design management departments. This issue also relates to the quality of documentation since it could be debated that why the use of defined order to delivery times is not mandatory in the process.

Continuing with communication related issues, a stakeholder mentioned that even in so called easy products that do not include challenging NSRs for example, delays in the beginning are due to notifications not arriving to different parties because of changes in the project for instance. The communication of what has been agreed in meetings should be improved so that people who were not able to participate would also get the

information. According to a stakeholder this could be improved by creating shared notes and sharing the MoM. Another stakeholder mentioned that there exists a lack of commitment from different organizations to participate in crucial weekly meetings. When stakeholders do not attend meetings, this leads to issues in production and with vendors due to missing information.

Considering documentation, a stakeholder mentioned that project creation phase, which takes place in project management department after sales, tends to take a high amount of time. This leads to delays already in the start of the process, meaning that when actual work can be started, the process is already late. The stakeholder estimated that these delays might be because the documentation received from customer is complex, requiring plenty of resources for taking into use internally.

The quality of input received from internal stakeholders within the process needs improvement according to multiple interviewed stakeholders. Three stakeholders criticized the IOS from multiple viewpoints: according to the first interviewee the structure, availability, and delivery of the document need improvement. The second interviewee stated that the handover of the project from sales to project creation sometimes causes challenges, leading to not actually knowing what has been sold to the customer and making it impossible to draft the IOS. Sometimes an internal order arrives to the stakeholder without the IOS, making them unable to start working. Third stakeholder mentioned that the IOS does not always include all the necessary information of engines parts.

When describing current issues considering scheduling, a stakeholder mentioned that clear milestones within the process would be beneficial. According to them, the current milestones set in the process are not being followed, leading to delays in EBOM release or POA meeting execution. These delays lead to further delays in purchasing and manufacturing, causing unnecessary pressure in later phases of the process since the delivery date to customer always remains the same.

According to a stakeholder, it would be important that different parties would be provided with the time to do their work that they have estimated. The previous as-is description presented certain milestone dates, based on which due dates ought to be defined. For example, design activities should be scheduled by counting backwards from the SoA date but according to a stakeholder, in reality there usually just arrives a request to define a date when design input could be finished. Usually, some parties are unsatisfied with this provided date, thinking it is too late. According to the stakeholder, this dynamic stems from the lack of aligning scope and schedule with available capacity in subprocesses. Another instance of poor milestones is the concept of design freeze date also presented earlier. The delivery of missing designs is not possible to happen before this date if the process has been delayed already in the beginning of its lifetime. A stakeholder suggests that this is how the lack of a process is demonstrating in reality.

The current situation consisting of multiple Ways of Working exists because in history different engine sizes have been built in different factories located in different countries. Because of recent changes in the company, all product sizes will be manufactured in the same location in the future, not taking into account one joint venture factory. The current process consisting of multiple WoWs leads to same parties participating in the functionalities of both but needing to follow different procedures. Multiple WoWs also lead to a higher number of tools and reports in use within the process, since different product sizes are currently utilizing different tools.

A stakeholder mentioned that first of all there exists multiple WoWs for similar work but second, employees are not following even these defined procedures. When time is limited people tend to step over process steps. On the other hand, another stakeholder mentioned that it is necessary to have these “fast lanes” exist for situations when it is necessary to produce the outcome quickly, for example in “hot products”. This need can be argued against with the fact that since we have defined delivery times for products, there should not be urgency to proceed faster. It would need further investigation to define the problematics behind the need for proceeding fast and off-process.

Continuing with the quality issues considering tools which actualize as a high number of tools and poor integration between them, multiple interviewed stakeholders mentioned that they are currently wasting time by filling information to multiple tools, when it would be more beneficial to use this time on actual work.

One stakeholder mentioned that engine configurator tool, supposed to provide correct design modules for the engine, needs improvement. It has errors especially in one of the product sizes, causing the purchasing of incorrect parts to production. The functionality of this tool is essential since a single engine has such a high number of parts that it is impossible to check the engine configurator's output manually.

Finally, follow-up of the process was also criticized during the interviews. Change management is currently on a weak level causing issues since modifications made by one party tend to affect the work of others, since different aspects of the engine design need to match. Also, it was brought up that if changes are made to the IOS, i.e. the internal order, the change is not always informed to all necessary parties.

Structurally going through the whole process of this supply chain and managing it, regarding schedules and changes for example, is currently on a weak level. More precise process follow-up would be seen beneficial because it would increase the level of transparency and make it easier to follow what factor in fact is causing delays in the process. A stakeholder mentioned that it has been clear that a whole process level follow-up has been missing for years, but it has been seen as hard to implement due to the number of organizations involved in the process. This makes it laborious to implement whole process level follow-up in practice.

4.3.2 Improvement proposals

In the spirit of a root cause analysis, it is seen as beneficial to form the improvement proposals based on the improvement need themes presented above. Since the results

of this study are clearly limited to quality related topics among certain subjects, the most effective manner in tackling these issues is to identify the root causes behind these themes, and after that providing improvement proposals for these. From this, suggestions for further research of this study are formed, proposing to investigate how these improvement proposals could be implemented in practice.

During the interviews it became evident that there already exists a business case related to the high amount of time wasted on filling different tools. As a result of this business case, a solution for the coherent WoW including integration between two essential tools, has already been developed. The use of this tool solution would also result in one common WoW across different engine sizes. When this was discussed further during the interviews, the reason for this not yet being taken into use is the lack of resources especially from one of the stakeholders of the current process, and the low priority of this issue. According to the interviewed stakeholder this low level of priority is because the current WoW works, even though the improvement need is clearly recognized in the company. For sure, the statement that the current WoW is working can be argued against with the claim that can a WoW be seen to be functioning if there are always general delays in the process causing dissatisfaction in many stakeholders, this actualizing in delays with parts deliveries and production activities for example.

In addition to resources, defining a WoW and the process where it functions demands perseverance. All the key stakeholders need to be mapped neatly and their opinions and requirements heard. A stakeholder mentioned that there is already happening an operational excellence stream for creating improvement in the design to release process, and that the creation of BOMs has also been under development for a while. This stakeholder mentioned that for development to happen, the quality of output from the current subprocesses needs to increase. First-time-right level of quality would be ideal since currently there is continuous change happening due to poor quality of output.

Having only one WoW within the process would also be beneficial since having a clear and defined WoW within the company makes it easier to follow join venture factories and to function in co-operation with them. Currently the company is operating in one joint venture factory, but there exists a possibility that in the future several could be needed. In the ideal situation there would exist one defined process together with its tasks, responsible parties, and milestones. This would ease the creation of resource estimations when the level of predictability of work tasks would increase. Also, having a defined process provides the possibility for escalation of work tasks since having a guideline to follow eases the recognition of situations not following the protocol.

A clearly defined process and one WoW within it would also ease the creation and maintenance of process level follow-up. Improved follow-up would in turn improve the quality of change management, making it possible to track the output quality of subprocesses, providing chances for escalation as already mentioned, and increasing the level of transparency. The follow-up of a defined process would make it possible to track the instances when the process steps are not being followed. Through this, it would be possible to identify the situations where stakeholders are required to proceed off-process, and by this solving the issues leading to these situations. Clearly, one WoW and taking into use the already developed integrated tool would decrease the number of tools, and most likely improve the quality of process documentation.

During the interviews, one stakeholder raised the concern that there is no singular party with responsibility or ownership of the customer delivery design process. One defined responsible party would be beneficial, for instance due to the fact that all departments in the company have separate budgets and own responsibilities for profit and loss. If issues in the process supply chain lead to a delay from the delivery date, there usually exists a certain financial penalty that must be paid to the customer which can be nearly of the same value as the product's gross profit. The penalty is taken from one department's budget but in the end, it affects the common company budget, and financial result of the case company. Due to all departments having only the responsibility of their

own budget, the main interest is maintaining this. Thus, it would be a financial benefit for the case company to improve the process and assign some level of ownership of the process to a certain party, to increase the sense of responsibility and to establish accountability and authority. When sense of responsibility would increase by creating ownership of the process, this would together with increased level of resources improve stakeholder commitment in the process. By the means of committed process stakeholders, the quality of communication within the process would be likely to experience an increase.

Another positive outcome of a defined process with ownership and improved follow-up, would be the improved level of scheduling within the process. Multiple stakeholders brought up their concern about the poor quality of milestones in the current process. A defined process would also bring defined milestones, and ownership would bring the sense of commitment to actually follow these milestones. Through this, the process would have a certain start and end point with certain procedures happening between them by defined milestones.

Based on the situation described above, the key improvement proposal of this study is increasing the level of resources available for maintaining and developing this process. The increase in resources would first of all make it possible to take into use the already developed tool, unifying the current WoWs into one. Second, with a higher number of resources actual process development would be possible, and for example a to-be analysis as continuation of this study could be executed. This study suggests that in this process improvement initiative, process ownership would be defined. With the support of this assigned leadership an improved process description would be created. Compared to the process earlier illustrated in this research, the to-be process should include clear milestones and responsibility areas for subprocesses and tasks. After assigning leadership, defining the process, and unifying WoWs, it is expected that output quality, follow-up, and communication would improve.

Based on the above argumentation, the root cause creating the improvement needs identified in this research, is lack of resources. Therefore, the improvement proposals are:

1. Increase the level of resources available for process development and maintenance.
2. Start performing process development by executing a to-be analysis as continuation of the as-is analysis presented in this study.
3. Define the ownership of the process.
4. Unify the current Ways of Working.
5. Create a definition of the improved process which includes clear milestones and responsibility areas.

4.3.3 To-be suggestion

This chapter continues from the above formed improvement proposals, providing a suggestion for future to-be situation. This study identified bottlenecks, gaps, and weaknesses by analysing the as-is situation. Based on these, the changes needed for improving the process can be mapped, and the to-be state can be planned. After this, it is possible to start researching how the to-be situation can in practice be achieved.

Bottlenecks, i.e. the cause of stalls, in this process are the quality of tools and the quality of documentation. High amount of time is used on manual work of upkeeping tools or extra work caused by low quality of input received from other stakeholders. This low quality of output is also a weakness of the current situation leading to poor handoffs, which then again lead to continuous change due to corrections. Another identified weakness is the quality of communication tied together to the quality of process follow-up. Poor communication and follow-up lead to issues with transparency, accountability, and change management to name a few. Finally, gaps which hinder the desired performance and outcome, are number of resources, process and WoW quality, and scheduling. Lack of resources prohibit conducting process development, leading to the existence of

multiple parallel WoWs and an undefined process. These result in the low level of scheduling in the current situation.

To actually tackle the above presented bottlenecks, gaps, and weaknesses, practical changes to the current state are needed. For elimination of the bottlenecks, tools used in the process need to be coherent, and output quality increased. This ought to happen when closing the gaps in the current situation, i.e. increasing resources which makes it possible to unify WoWs, define the process, and thus improve scheduling. In practice, the increase in resources would mean the recruitment of a new full-time employee. It should be considered if this new resource should also be assigned the ownership of the process, which was also seen as a gap in the process earlier in this paper. Last, this increase in resources should make it possible to increase the general quality of output in the process, improving handoffs, and eliminating the current continuous change. It should also aid in enhancing communication, and the creation of process follow-up.

When modelling the future to-be process, no drastic changes to the as-is process map presented earlier in this study are done. This is because the development of this process happens mostly on its quality, instead of its structure. But still, some of the development also affects the process mapping thus a new to-be process chart is now presented. This study suggests that the increase in resources would happen within the stakeholder 2 department, due to their current role in the process being already highly related to coordination of activities. For this reason, it is proposed that also the newly established ownership of the process would happen in the department of stakeholder 2. The department of stakeholder 2 is recommended for this based on the same argumentation as for the increase in resources, but it is understood that this may not be possible since stakeholder 2 is not located in RDE organization, where most of the functionality of this process occurs. Thus, it might be that the ownership needs to be established within RDE organization. This should be further investigated when mapping how to achieve to-be situation in practice.

Nevertheless, the increased resource should be located in the stakeholder 2 department. This way, stakeholder 2 could be completely responsible for EBOM related procedures and activity organizational, freeing resources from stakeholder 1 to other activities, such as increasing their level of support provided for sales organization. Also, in the improved process with higher quality of output and tools, stakeholders 3 and 4 would no longer be required to go through product structure to ensure it is correct, since the system output could be relied upon to always be correct. Also, thanks to an existing process description and clear milestones stakeholders 3 and 4 would be able to define their required resource estimations earlier in the process, easing the planning of workload. It is also suggested that stakeholder 3 would adapt the current POA meeting functionality already in use with the product size of stakeholder 4. This would eliminate duplicate work tasks from stakeholder 2 and be further unify the WoWs of stakeholders 3 and 4. A process flowchart with these modifications is presented in below figures 5 and 6.

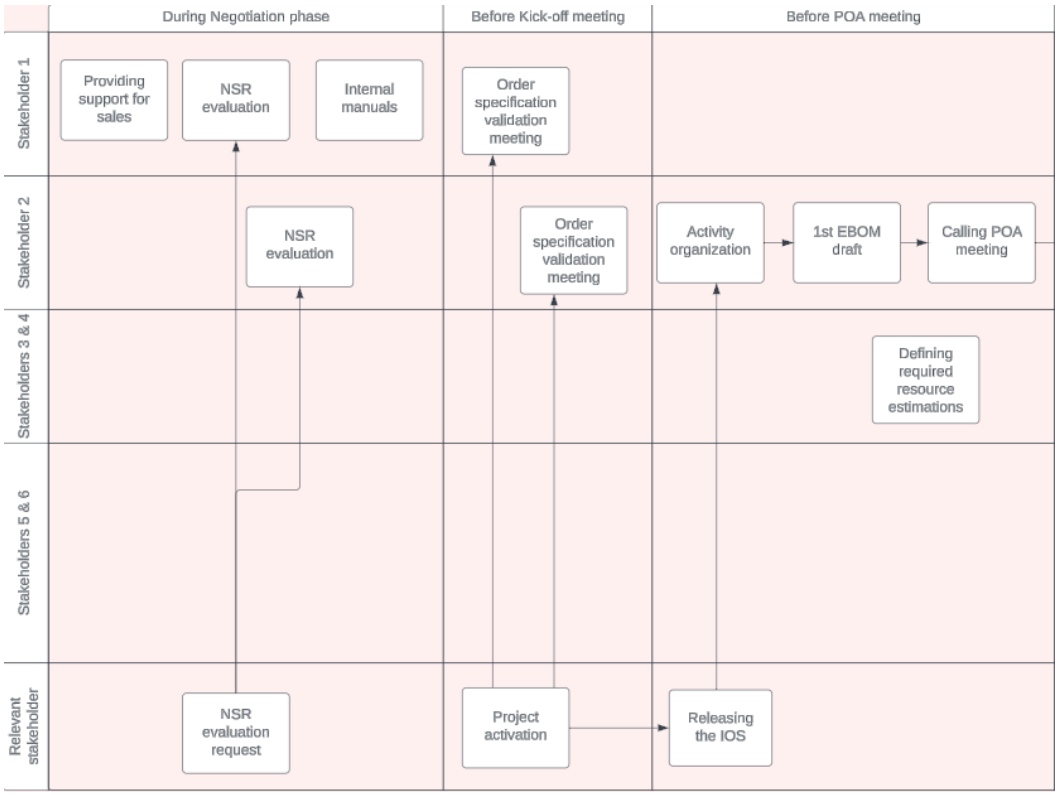

Figure 5. To-be before POA.

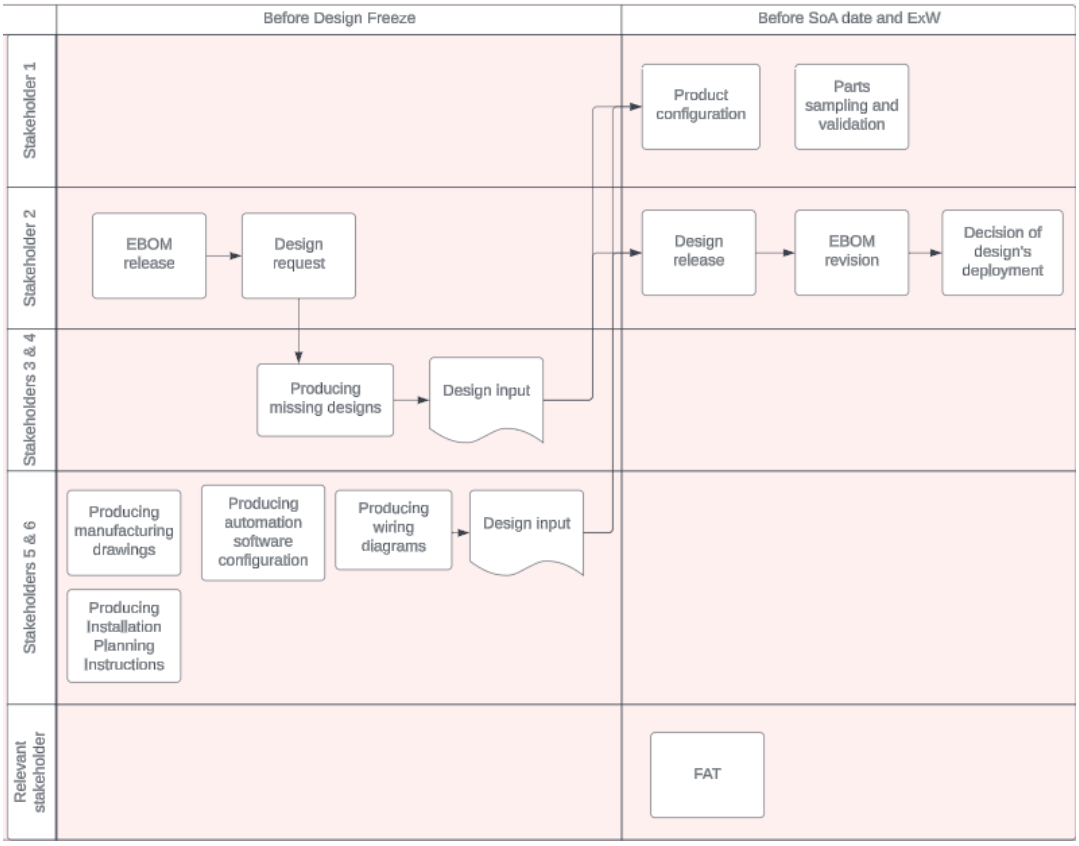

Figure 6. To-be after POA.

4.3.4 To-be summary

It is possible to see it as a positive conclusion that all improvement themes were related to quality of already existing aspects of the process. This means that from the point of view of stakeholders nothing essential is in fact missing, only the quality of current situation needs improvement. The interview results considering future improvement areas justified the fact that process improvement is necessary. All stakeholders mentioned multiple improvement needs, some criticizing the process as a whole while others found only small precise areas to be in need of improvement.

Due to the lack of existence of current process, it is understandable that multiple improvement areas are recognized since it is not possible to maintain or improve something non-existent. Obviously, further actions are needed to reach the situation where an improved process would in practice exist. The improvement proposals resulting from

the research conducted in this study are presented in summary in below figure 7. This way of proceeding is what this study suggests to research further.

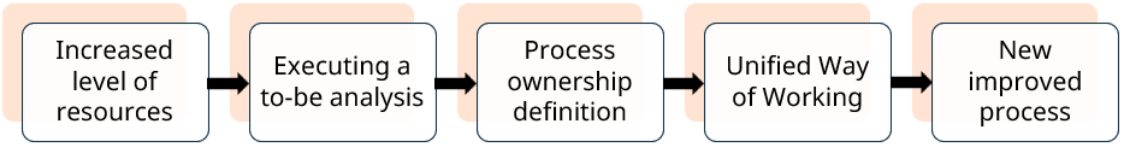

Figure 7. Proposal for conducting improvement.

The presented suggestion for the to-be process aims to execute needed changes for improving the process. This study contributes to the process improvement initiative by mapping the current process and providing a suggestion for the structure of the future process. With the support from the new resource, it is possible to achieve the situation of the to-be process with assigned ownership, and defined milestones and responsibilities. Also, one common WoW can be taken in use when it is assigned with sufficient resource and priority.

Implementation of the above described will improve the quality of output produced in subprocesses, leading to better handoffs, and thus stopping the trend of continuous change currently happening in the process. One WoW with integrated tools functioning in coherence for all stakeholders will also increase quality and save time for actual expert work. The clearly defined process provides the chance for better scheduling, follow-up, and communication. Process ownership raises the sense of authority, accountability, and commitment within the process. By the elimination of the currently existing bottlenecks, gaps, and weaknesses the case company is in the end able to improve their financial result together with higher level of customer satisfaction, made possible by employees operating in a well-functioning, supportive environment.

5 Discussion

This chapter starts by concluding the key findings of the study, after this continuing with presenting the theoretical contributions, and practical implications of these findings. Finally, the chapter and this thesis finishes with discussing limitations of applicability of the results and providing suggestions for further research.

5.1 Conclusion

Due to nearly continuous change and development in the case company and its products, the mechanical design process in customer delivery projects has never been defined, and thus never maintained or developed. This has caused inefficiencies and low quality in the process, and the existence of multiple parallel Ways of Working. The purpose of this thesis was to illustrate the mechanical design process as it currently is, and to identify how it could be improved. These were in practice done based on the data acquired from interviews held with the key stakeholders of the process.

This thesis consisted of two main sections: theoretical framework and empirical implementation of chosen research method. Theory constructed the background of the study by introducing relevant aspects of process as a concept, the improvement and modelling of it and possible challenges appearing in this context of mechanical product design and customer delivery projects. The empirical section of this paper consisted of conducting an as-is to-be analysis with three steps: data collection, document, and analysis. Through these steps, answers to the two research questions set for this study were possible to be formed.

First research question was *"What is the current process model and what are the benefits and challenges of it?".* It was carefully addressed by illustrating the current process as a swim lane diagram and hearing the opinion of stakeholders considering the state of the process. The result of this step made it evident that the process has multiple

stakeholders and subprocesses, due to the nature of business where the company operates, and the wide range of activities required to produce the process output.

The second research question was *"How can the process model be improved in the best possible way?"*. This question was addressed in step three of as-is analysis, where the improvement proposals gathered from stakeholder interviews were analyzed, themed, and their root cause identified. The third step, analysis of the process, justified the need for this study. Many concerns considering the state of the process were raised, and a clear need for definition and improvement expressed. Data collection through expert stakeholder interviews succeeded, proved by the comprehensive understanding gained of the current situation and future expectations.

After conducting the empirical research and forming results, it was clear that further actions are needed to execute process improvement efforts. The process would need to be defined from other aspects in addition to the subprocess level process charts formed during this study. Moreover, to-be analysis would be needed to implement in practice, to take into use the new improved process. The proposals for conducting improvement in practice which were defined in this study, ought to be carefully considered during to-be analysis for best possible outcome of practical process improvement.

5.2 Theoretical contributions

A process is a set of interrelated activities, turning inputs into outputs. For proper functionality, process need a supporting tool, for example to gather data of process performance. (ISO, 2008) A process is usually a series of subprocesses, the outcome of which is produced by task level activities (Roberts, 1994). In addition to this, process functionalities utilize certain mechanisms and controlling information in the production of their outcome (Sandhu & Gunasekaran, 2004). Logical series of repetitive transactions are characteristic to a business process (Andersen, 2007). In a project, various kind of resources are utilized to reach the predetermined scope, these actions directed by a central figure (Sandhu & Gunasekaran, 2004). This study is in line with these findings as the

value of tools became evident during result analysis. Also, the level of relevance considering the logical order of tasks and their repetitiveness was highlighted multiple times in this paper. This study also brings novelty value which is in line with the finding of Sandhu and Gunasekaran (2004), where they state the meaning of a central figure. Lack of central figure in the as-is process analyzed in this study was recognized as an issue, thus being an important part of the to-be proposal.

Co-operation of functions happens during a process: in certain steps and in the handover of the project. To meet customer requirements co-operation of functions vary in different projects, and project approval is made against customer requirements. (Sandhu & Gunasekaran, 2004) This study contributes to this with the finding that approval of the project can be continuously done against customer requirements, since in the process analyzed in this paper, changes to the product can be made almost during the whole project lifetime.

When defining a process, non-value-adding activities should be avoided, and all processes should be in coherence with the whole (Sandhu & Gunasekaran, 2004). This study complements this finding, since time wasted on non-value-adding tasks was defined as a clear issue, and non-coherent subprocesses were seen as a factor to be eliminated. Products of perfect quality, living up to standards set by customer demands require internal processes to produce flawless output (Freiesleben, 2010). This study is in line with this finding, also related to the nature of internal processes since the relevance of high-quality output was highlighted multiple times in the results.

Performance level of processes declines unless actively maintained (Andersen, 2007). When going beyond maintenance, renewing a process might reduce cost and throughput time (Vanwersch et al., 2016). This study is in line with these two findings and can even be seen contributing to these due to the fact that in the current situation investigated in this study, a process definition does not even exist. There is a business case already proving how improving the WoWs within the process would reduce cost and

time used on manual maintenance of systems. The level of process performance received a high amount of criticism in this study, the maintenance of the process currently being non-existent.

An organizational structure providing motivation and abilities to conduct process improvement work is vital (Andersen, 2007). This study found that resources and committed stakeholders are the two key elements of a well-functioning process. Collecting the frustrations of those with most significant process awareness is a beneficial database for process improvement work since by doing this, experience and context are both included in improvement proposals (Schonberger, 2018). This study complements this finding by Schonberger, since also the modelling of the process was successful based on data collected from key stakeholders who are experts of the studied process. Also useful improvement proposals were able to be drafted based on the viewpoints of these experts. Vanwersch et al. (2016) also recommend the inclusion of daily involved actors in innovating process improvement work, and Ponsignon et al. (2014) recommend following an employee-focused approach.

Process improvement should be executed by recognizing and removing non-value-added work tasks, and after this organizing the remaining tasks in the most sensible execution sequence (Ponsignon et al., 2014). This study supports this finding since multiple work tasks were found to be irrelevant but still mandatory due to inefficient solutions used in the current process. Evaluating the execution sequence of tasks is something this study would propose to investigate in future to-be analysis.

Using input and output as decision areas in process improvement describe what is expected from the process (Vanwersch et al., 2016). This finding is supported since even though the process analyzed in this study lacks a clear definition, the provided input and required output were clear to all stakeholders, and thus these are the main focus area of all parties involved.

Bottlenecks decrease the performance level of processes, workforce capacity being among the most common, due to work overload or inappropriate resource management (Hinckeldeyn et al., 2014). This study is in line with this finding and contributes to it. Bottlenecks such as demanding work tasks due to low quality of documentation for example, were seen as causes for inefficiencies in the process. Workload capacity was often recognized as an issue due to challenges in resource management. This study found that resource management was challenging due to low quality of scheduling and continuous change happening in the process.

In process improvement, the understanding of the current functionality of the process is important. Drafting a process model eliminates for instance disagreements and takes into account surroundings and objectives of a process. (Andersen, 2007) Modelling should be used in providing support for communication and understanding of different stakeholders (Aguilar-Savén, 2004). These findings by Andersen and Aguilar-Savén are supported by this study. For being able to form improvement proposals, it was necessary to model the current state. Drafting the model was also beneficial in this study since it provided an understanding of the interconnectedness of different stakeholders, and their surprisingly coherent opinions of the process.

Conducting business process re-engineering which is based on major structural change, is found impossible in companies functioning in engineer-to-order business (Cameron & Braiden, 2004). This study could not provide supportive or contrary evidence for this finding since only the as-is analysis of business process re-engineering was conducted in this study. It remains unclear whether process improvement research results or management technologies related to it contribute to the improvement of KPIs (Van Der Aalst et al., 2016). Neither this study could bring further clarity to this finding, since follow-up of the current process does not exist, and its performance is not measured by any KPIs.

Flexibility and responsiveness are stressed in the strategy of engineer-to-order companies utilizing pull approach and operating in a volatile environment. This creates

difficulties with processes and resource planning. (Adrodegari et al., 2015) This finding is supported because the issues with resource planning were raised in this study, and the need to sometimes proceed off-process was recognized. This study also contributes to this finding since also quality of communication and documentation were found being affected by the nature of business.

During product development the successful scheduling of design processes is in the essence of time-to-market completion (Boudouh & Bendada, 2017). By being a part of sales process, designers are able to start pondering the best options for a specific product already in the early stages of the project's lifecycle (Uusitalo & Lidelöw, 2015). This study found similar results, highlighting the meaning of proper scheduling in a process generally, and its design activities. The cruciality of sufficient amount of time resources assigned for design activities was also found to be meaningful for the project's success.

Commitment from top management, and leadership at all levels is needed in the success and implementation of process improvement (Antony & Gupta, 2019). This study complements this finding since it was found that leadership is required also in defining the process, and after taking improvement measures. Commitment from top management is vital in all business areas but especially in improvement work, as found by this study that improved solutions are not possible to be taken into use due to the lack of high enough priority.

Competitiveness of a company, especially from the profitability point of view, is enhanced by good supply chain performance (Ashtiani & Bosak, 2013). This study has similar findings, suggesting that taking into use the to-be proposal formed in this study would bring remarkable financial benefit to the case company.

5.3 Practical implications

The findings of this study can be utilized by many kinds of organizations, since many companies especially in the technology industry are conducting their business

constructed by processes. Particularly, the findings are useful for organizations operating in engineer-to-order business, utilizing pull approach. Based on the findings, those organizations should consider defining and modelling their process with a sufficient number of resources, conduct an as-is to-be analysis and comparison, and creating an improvement initiative for the defined process. Additionally, ensuring the existence of process ownership and good quality of milestones is recommended.

Moreover, this research is proof how beneficial it is to hear the opinions of process stakeholders. Even if the situation might appear contradictory, giving the chance to different parties to express their opinions might help seeing the situation in a different way, and it can be assured that genuine experiences are taken into account in future initiatives. Use of this qualitative data based on the sights of stakeholders might result in even a more comprehensive result than expected and create a useful base for further studies.

5.4 Limitations and suggestions for future research

Because the number of stakeholders was limited, and process descriptions or measures were not available this study has considerable limitations that should not be overlooked. Although the process model and improvement suggestion were established, they are based on the personal experiences of employees. Numerical or historical data about the process, or process descriptions, could not be studied as they are not currently existing. Thus, this study is limited to results based on data acquired from stakeholder descriptions. Moreover, the process model and proposal were defined solely based on the process of a singular company. Because of that, the findings cannot be generalized to all companies or industries as procedures may significantly differ and affect the outcome of the study.

This study provides a great basis for future research, even if there are limitations. Process improvement in engineer-to-order business should be further researched in general but to provide something more exact adding to this study, conducting a to-be analysis for this type of situation should be examined further. Furthermore, as-is analysis with

process descriptions and measures in addition to the data utilized in this study would be useful for the case company. Also, the need for process ownership discovered in this study and the effects of the complexities of human interaction on process performance would be interesting be researched further. Another possibility for further research especially in the case company would be to investigate how current capacity is utilized, and the prioritization of work tasks. This would also work as further research for the need of this study's conclusion, where it was suggested to increase the level of resources. All in all, process improvement being of continuous nature as stated in this paper, there will always be perspectives and circumstances to choose from for further research regarding this topic.

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Appendices

Appendix 1. Interview schedule

Date	Interviewee	Number of participants
15.2.2024	Stakeholder 1	1
15.2.2024	Stakeholder 5	1
15.2.2024	Stakeholder 4	1
16.2.2024	Stakeholder 2	2
20.2.2024	Stakeholder 6	1
21.2.2024	Stakeholder 3	2

Appendix 2. Interview template

1. Please give a general description of your role in the organization and your work tasks regarding the mechanical product design for customer delivery projects.

Process

2. What is your role in the mechanical product design for customer delivery projects process?
    a. What are your/your team's work tasks, when do you do them, and why?
    b. What do you/your team receive to be further worked on in the process?
        i. What is the input you require in the process to be able to produce your output?
        ii. How would you improve the way you receive the input? What would you need to receive for example more of/better?
    c. What do you/your team produce within the process and move forward?
    d. What is the added value/benefit your/your team's effort brings to the end customer and/or process?
3. In your opinion, how are the operations within the whole process being followed?
4. What weaknesses or problems have you noticed in the process?

Improvement

5. In your opinion, what are the objectives of improving this process?
    a. What would your department/team need in the process to be able to work better/faster/more effectively in the future?
    b. How do you see that the process flow could be executed smoothly in the future?
    c. From your point of view, how could the flow of information/ communication in the process be developed?
    d. In your opinion, is it better to have just one process/way of working than multiple different WoWs/processes?

6. Would you still like to mention something regarding this topic that has not been discussed yet?